



# **TheSkyX Professional and Serious Astronomer Edition User Guide**



Revision 6.0, May 2018

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Portions of this document by Andre Bormanis and Woodrow W. Grizzle III.

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## Welcome to TheSkyX

Many of you have never seen the sky. Not really. If you live in a city or suburb, a pale blue or grey dome looms overhead while the Sun is up, and a darkish brown curtain hangs down at night, with maybe a few sparks of light poking through here and there if the clouds haven't gathered and the glare from buildings and cars and billboards isn't overwhelming. The Sun and the Moon are unmistakable of course, but the spattering of stars you glimpse are probably strangers to you. Some of them might even be planets – for most people, it's hard to tell the difference.

All of this is about to change. You have in your hands an extraordinary tool for revealing not just new worlds, but the entire universe. The night sky is an incredible wonderland of diverse and spectacular objects and phenomena. Some of these breathtaking sights are created by tiny particles that ply the fringes of our atmosphere. Others are immense, ancient structures, incomprehensibly far away.

*TheSkyX Professional Edition* or *TheSkyX Serious Astronomer Edition* will bring these amazing marvels and more to your desktop. It will help you learn the fundamentals of astronomy, the most ancient science, and teach you how to recognize just about everything in the real sky. Whether you're looking up from the streets of a light-polluted city, or taking in the view from a remote, pitch-black mountaintop, or controlling your distant observatory from Internet, *TheSkyX* will help you understand what you see and find what you're looking for.

You'll also enjoy experiences that are only possible through the magic of simulation and virtual-reality programming. Faster-than-light flights through the solar system, out-of-this-world views of the Earth and Moon, and the orbital tracks of hundreds of satellites are just some of the animations built into *TheSkyX*. Trips through space and time that were once possible only in the imagination will be vividly brought to life on your computer screen.

*TheSkyX* has something to offer everyone, from the absolute beginner to the most knowledgeable amateur astronomer. This User Guide will help you navigate the basic features and tools our unique program has to offer.

The sky is waiting for you. Let's get started!

### **Getting Started**

*TheSkyX Professional Edition* and *Serious Astronomer Edition* (hereafter referred to simply as *TheSkyX*) are available for either Mac or Windows operating systems. Operating system specific versions are sold separately, so please make sure you have the right product for your computer before proceeding.

Throughout this document, *TheSkyX Professional Edition*-specific features are accompanied by the Professional Edition graphic below.

PROFESSIONAL

## Hardware Acceleration

*TheSkyX* uses the latest operating system-specific hardware acceleration technology so that you can enjoy smooth Sky Chart zooming, panning, scrolling.

- *TheSkyX* for Mac uses *OpenGL* to speed chart rendering. OpenGL is built in to the Mac operating system, so no additional software or drivers are required.
- *TheSkyX* for Windows uses *Direct3D* to optimize graphic output. Direct3D is built in to the Windows operating system, so no additional software or drivers are required.

### ***Running TheSkyX without Hardware Acceleration***

*TheSkyX* can optionally be run without hardware acceleration. When *TheSkyX* is launched for the first time, it determines if a suitable hardware acceleration technology is available (OpenGL on Mac, or Direct3D on Windows), then configures the graphics rendering mode accordingly.

To manually configure *TheSkyX* to run without hardware acceleration, click the ***Preferences*** command from the ***Edit*** menu (Windows) or the ***Apple*** menu (Mac) to show the ***Preferences*** window. Select the ***No Hardware Acceleration*** option from the ***Graphics Rendering Mode*** list and then click ***Close***. *TheSkyX* must be restarted for this setting to take effect.

The following features are not available when the ***No Hardware Acceleration*** option is selected:

- 3D Solar System (page 182)
- 3D Stars (page 166)
- Milky Way photo (page 198)
- Object symbol transparencies (page 236)
- Photographic panorama horizons (page 259)
- Planets rendered using 2D ellipses instead of 3D-like photographs
- Satellites From Above Earth (page 195)
- Solar and Lunar Eclipse Viewer (page 184)
- Virtual Mount (page 372)

## ***Minimum System Requirements***

Please review the minimum system requirements before installing *TheSkyX* on your computer.

## Mac

*TheSkyX Serious Astronomer Edition* for Mac can run on any Mac desktop or laptop computer with OS X 10.7 or later with a 2 GHz or faster Core Duo processor. You also need at least 512 MB RAM, 64 MB video RAM, and 1.3 GB of free disk space, a mouse or other pointing device and a DVD ROM drive.

### PROFESSIONAL

*TheSkyX Professional Edition* for Mac has the identical minimum requirements, except that a total of 2.5 GB of free disk space is required.

## Windows

*TheSkyX* for Windows can run on any desktop or laptop computer running Windows 10, Windows 8.1, Windows 8, Windows 7, 32- or 64-bit Editions, with a 1.5 GHz or faster Intel Pentium 4, Pentium M, Pentium D, or AMD K-8 (Athlon) or better processor. You also need at least 512 MB RAM, 64 MB video RAM, and 1.3 GB of free disk space, a mouse or other pointing device and a DVD ROM drive.

### **Microsoft Windows N and KN Editions Note**

Microsoft Windows N and KN operating systems do not include the Windows multimedia player, so *TheSkyX* will not run “out of the box”. Install the Windows Media Feature Pack to allow *TheSkyX* to run on these scaled down Windows operating systems.

Windows Vista and Windows XP are not supported by *TheSkyX* version 10.5 and later.

### PROFESSIONAL

*TheSkyX Professional Edition* for Windows has the same minimum requirements, except that a total of 2.5 GB of free disk space is required.

## **Installing TheSkyX**

*TheSkyX* is normally distributed either on DVD-ROM or by downloading the full installer from the Software Bisque web site. (*TheSkyX Pro* installers are also distributed on a thumb drive that is included with Paramount robotic telescope systems.)

If you have purchased *TheSkyX* from the Software Bisque Store and want more information about how to download the full installer, see “How Do I Download My Software?” on this page:

<http://www.bisque.com/sc/pages/Download-Links-and-Serial-Number.aspx#Download>

## Mac

Like all Mac software, *TheSkyX* is easy to install.

- If you received *TheSkyX* on disk, insert the DVD in the DVD-ROM drive. *TheSkyX DVD* icon appears on your desktop once the media is recognized. Double click it to view the contents of the disk. To copy *TheSkyX* to your computer, first double-click *TheSkyX* volume to open it, then drag and drop *TheSkyX* application icon to the **Applications** folder.
- If you downloaded the full installer from the Software Bisque web site, double-click the *TheSkyX [Serious or Pro] for Mac Full Installer* disk image to view its contents (Mac OS X may perform this step automatically). To copy *TheSkyX* to your computer, drag and drop *TheSkyX* application icon to the **Applications** folder.
- If you received *TheSkyX* on a thumb drive as part of the Paramount Software Suite that is included with the purchase of a Paramount mount, follow the installation instructions in the *Paramount Quick Start Guide* that is included inside the Paramount shipping box.

To start *TheSkyX*, click **Go > Applications** from Finder (⌘U), then double-click on *TheSkyX* [Serious Astronomer Edition] or [Professional Edition] application icon.

To make sure you are running the latest release, click **Help > Check for Updates** and follow the instructions.

## Windows 10 or Windows 8

To install *TheSkyX* under Windows 10 or Windows 8 from the DVD-ROM:

1. Insert the DVD-ROM in the DVD-ROM drive.
2. From the **Start** window, right-click on a non-tiled region, then click the **All Apps** icon in the lower right corner of the window (Figure 1).

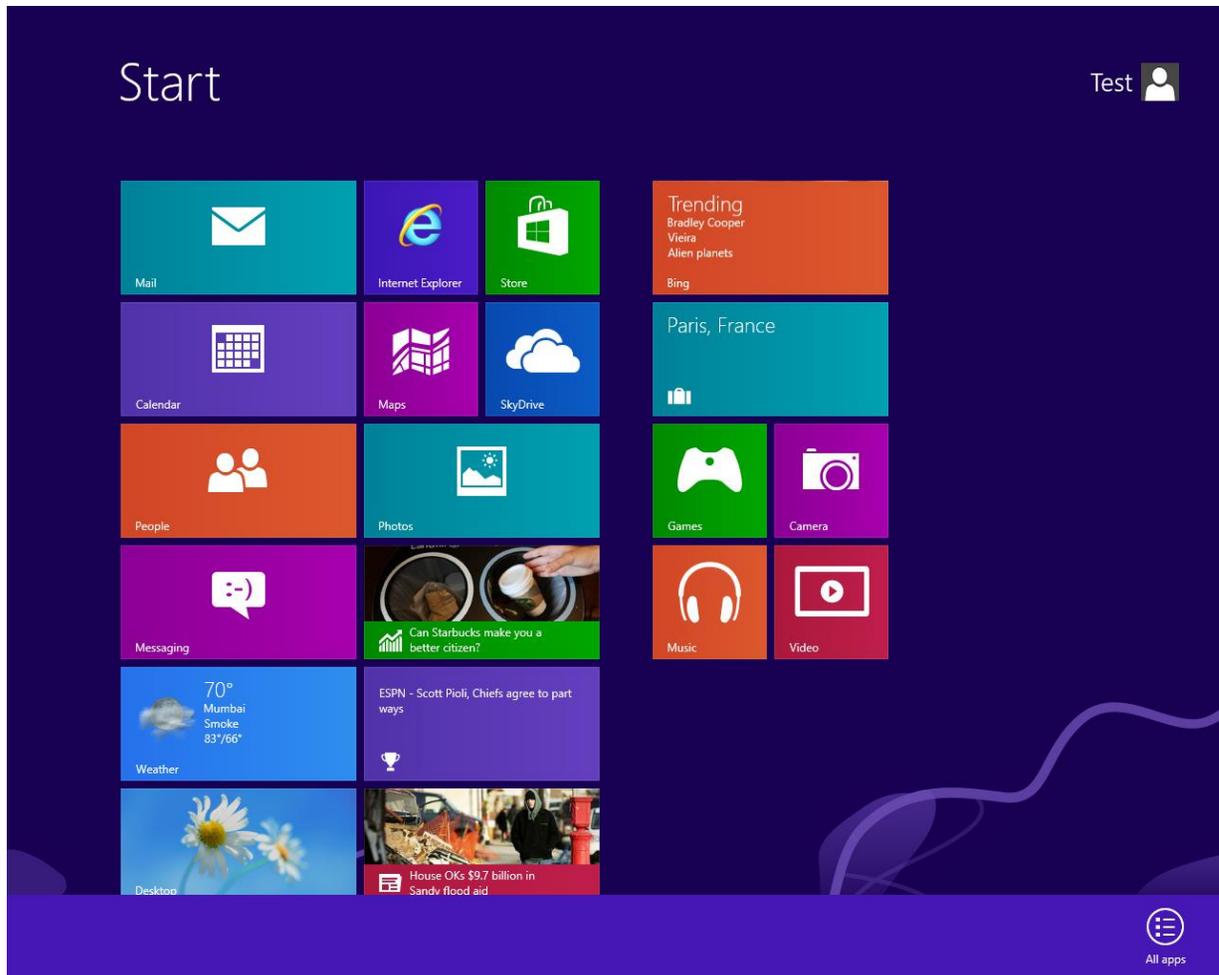


Figure 1: Windows 8 Start screen showing the All Apps icon in the lower right corner.

3. On the **Apps** window, click the **Computer** icon under the **Windows System** column on the right side of the screen.
4. On the **Computer** window, double-click **TheSkyX DVD** icon to view its contents.
5. Double-click the **setup** application icon to begin the installation. If you are signed into an account that does not have administrative privileges, you will need to enter an administrator's password to complete the installation.
6. Follow each step of the **Setup Wizard** to complete the installation.

## Windows 7

To install *TheSkyX* under Windows 7 from the DVD-ROM:

1. Insert the DVD in the DVD-ROM drive.
2. Click **Start > Computer**.
3. On the **Computer** window, select the removable storage device that holds *TheSkyX* media, and then click the **AutoPlay** button (it's located in the tool bar near the top of this window).

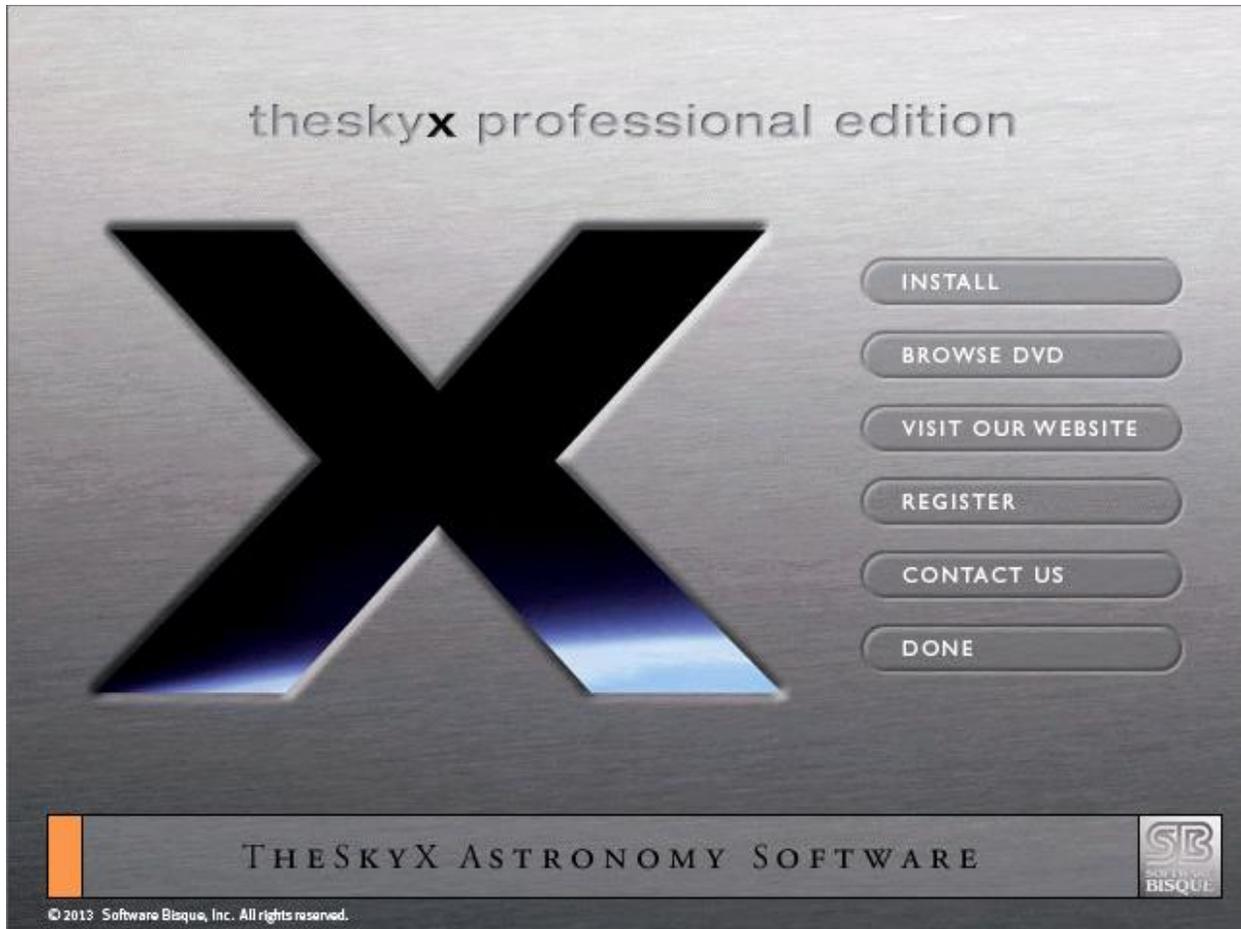


Figure 2: TheSkyX's AutoPlay window.

4. Click the **Install** button to begin the installation process.
5. Follow the on-screen instructions to complete the installation.

## Starting TheSkyX on Windows

### *Windows 10 or Windows 8*



Figure 3: TheSkyX's application icon.

To start *TheSkyX* on Windows 10 or 8, click TheSkyX's icon pictured above on the **Start** window. (Click the Windows accelerator key to show the **Start** window).

## **Windows 7**

To run *TheSkyX* on earlier Windows operating systems, click **Start > All Programs > Software Bisque > TheSkyX [Edition Name] > TheSkyX [Edition Name]**.

To make sure you are running the latest release, click **Help > Check for Updates** and follow the instructions.

## **TheSkyX Default Installation Folder**

*TheSkyX Professional Edition* and *TheSkyX Serious Astronomer Edition* are installed to operating system specific folders.

### **Mac**

*TheSkyX* is copied to the computer's **Applications** folder on Mac OS X. From **Finder**, choose the **Applications** command from the **Go** menu to view all the applications that are installed on your computer (⌘⇧A).

### **Windows**

*TheSkyX*'s default installation location varies slightly between 32- and 64-bit Editions of Windows.

#### **Windows 10, Windows 8, and Windows 7 32-bit Application Support Files Folder Example**

The default folder for *TheSkyX Professional Edition*'s application support files on Windows 7 32-bit Editions is:

```
C:\Program Files\Software Bisque\TheSkyX Professional Edition
```

The default folder for *TheSkyX Serious Astronomer Edition*'s application support files on Windows 7:

```
C:\Program Files\Software Bisque\TheSkyX Serious Astronomer Edition
```

For 32-bit Editions of Windows, you can determine the computer's *Program Files* folder from a Command Prompt by typing the bold letters below:

```
C:\echo %PROGRAMFILES% <Enter Key>
```

The default folder is: C:\Program Files

#### **Windows 10, Windows 8, and Windows 7 64-bit Application Support Files Folder Example**

The default folder for *TheSkyX Professional Edition*'s application support files on Windows 7 and Windows Vista 64-bit Editions is:

```
C:\Program Files (x86) \Software Bisque\TheSkyX Professional  
Edition
```

The default folder for *TheSkyX Serious Astronomer Edition's* application support files on Windows 8, Windows 7:

```
C:\Program Files (x86)\Software Bisque\TheSkyX Serious  
Astronomer Edition
```

Note that under 64-bit Editions of Windows, 32-bit applications are installed to the *Program Files (x86)* folder instead of the *Program Files* folder.

On 64-bit Editions of Windows, you can determine the computer's *Program Files* folder for 32-bit applications from a Command Prompt by typing the bold letters below:

```
C:\echo %PROGRAMFILES(x86)% <Enter Key>
```

The default folder is: C:\Program Files (x86)

## **Removing TheSkyX**

If you wish to remove or uninstall *TheSkyX* from your computer, please follow the procedure outlined below.

### **Macintosh**

1. From Finder, click **Go > Applications** to open the **Applications** folder.
2. Drop *TheSkyX Professional Edition* or *TheSkyX Serious Astronomer Edition* application to the trash. Note that you must empty the trash before re-installing. *TheSkyX's* settings are saved to the *Application Support* folder. See "Application Support Files" on page 26 for details how to remove them.

### **Windows**

1. Log on as an administrator.
2. Click **Start > Control Panel > Uninstall a Program**.
3. Select ***TheSkyX Professional Edition*** or ***TheSkyX Serious Astronomer Edition*** from the list of installed programs, and click the **Uninstall** button.

## Activating TheSkyX

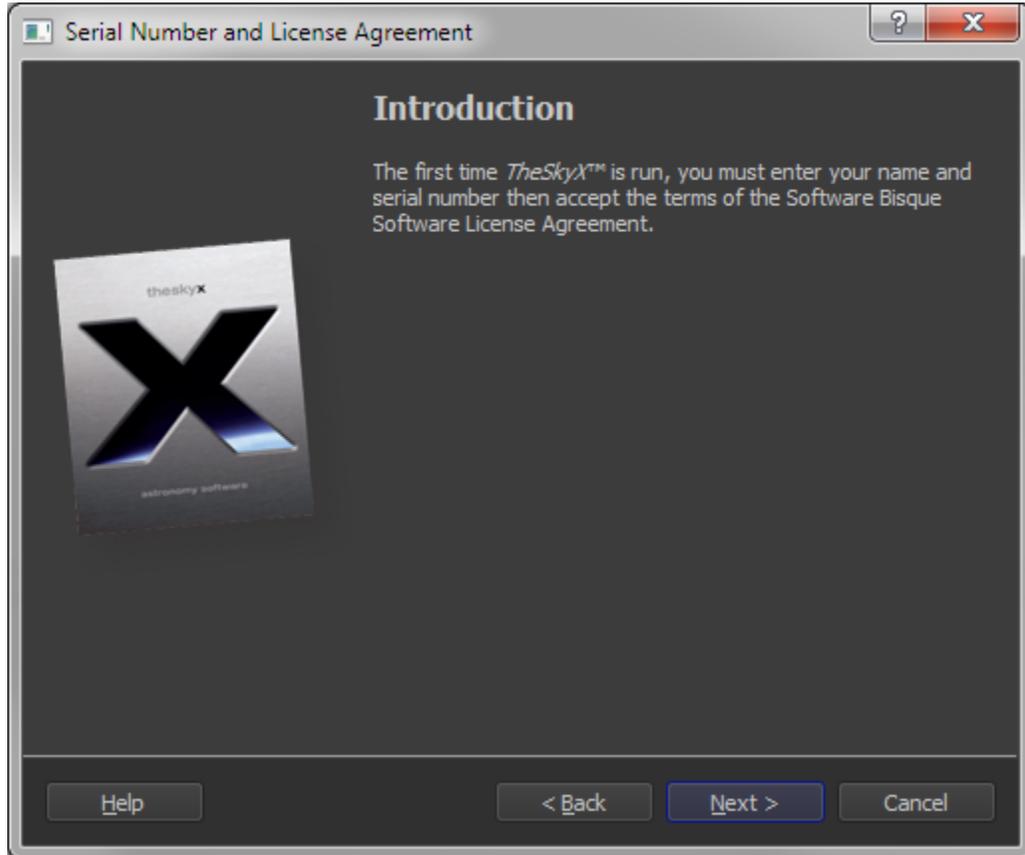


Figure 4: The Serial Number and License Agreement introduction page.

The first time *TheSkyX* is launched, you must enter your name and your serial number, then accept to the Software License Agreement. Click **Continue** from the introduction page (Figure 4) to get started.

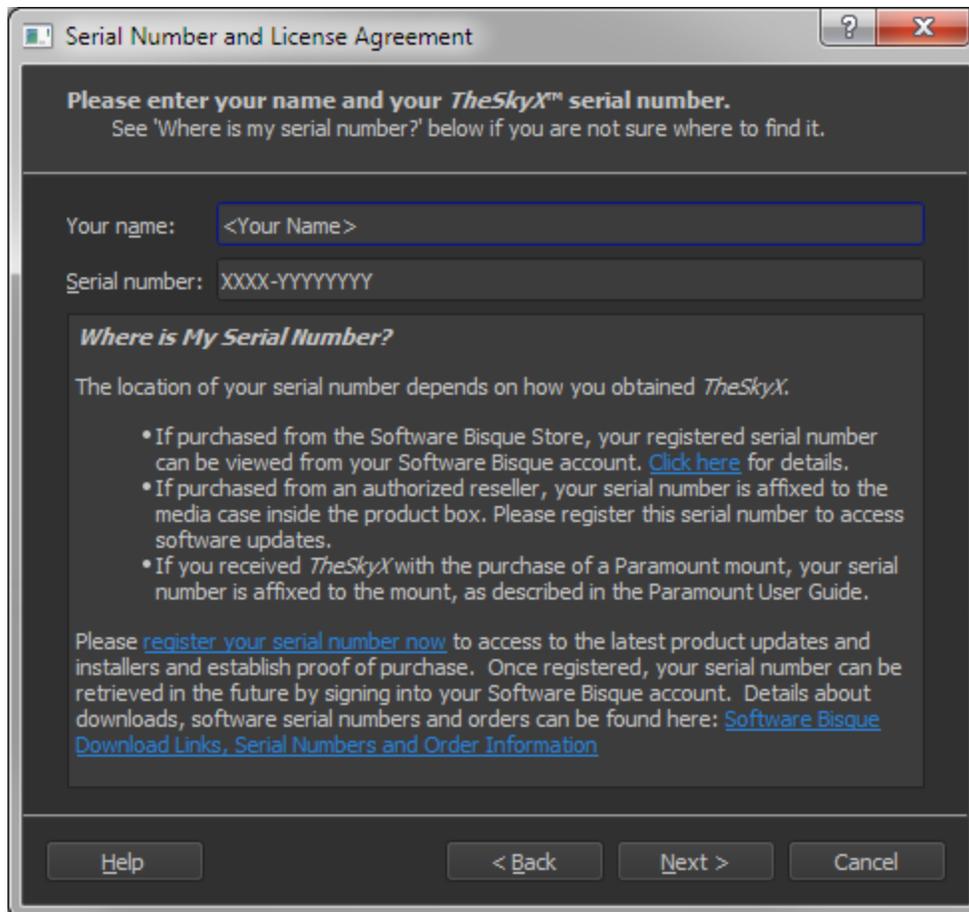


Figure 5: Activate TheSkyX to run on this computer by entering your name and a valid serial number.

Enter your name and TheSkyX serial number included with your purchase, then click the **Continue** button (Figure 5). If you cannot locate your serial number for any reason, please carefully read the, “**Where is My Serial Number?**” text immediately below the **Serial Number** text box. The **Continue** button will remain dimmed or inactive until a valid serial number has been entered.

Remember, the name and the serial number entered here are used to *activate TheSkyX to run on this computer, only*. Activation does not automatically register your serial number with Software Bisque. See “Registering Your Serial Number” on page 23 for details how to register your serial number if necessary.

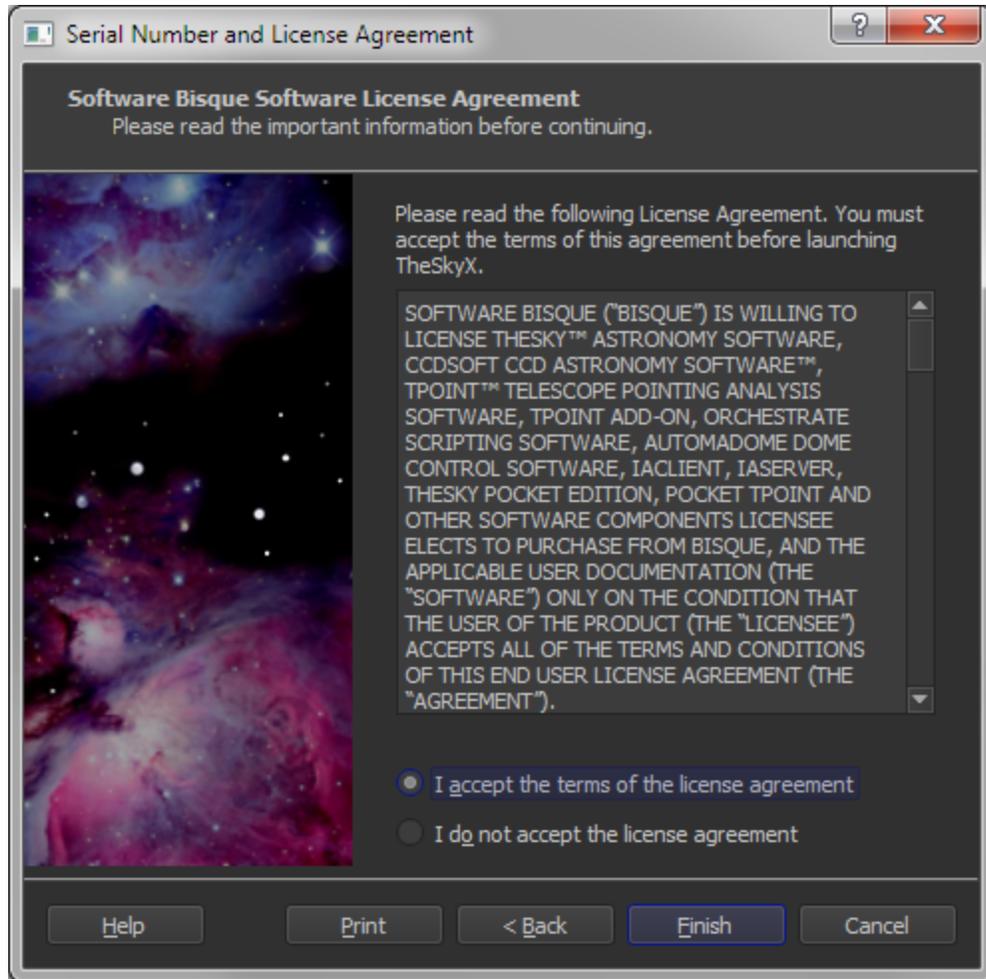


Figure 6: Software License Agreement.

The final activation step is to accept the terms of the [Software Bisque Software License Agreement](#) by clicking the ***I accept the terms of the license agreement*** option (Figure 6), then click the ***Done*** button. TheSkyX will now launch.

## Registering Your Serial Number

If you purchased TheSkyX from the Software Bisque store, your serial number is registered automatically, and included with your web order information. To view your registered serial number from your Software Bisque account, go to [www.bisque.com](http://www.bisque.com), then click ***Sign In*** on the upper right side of the page to sign in. Once signed in, click your sign in name in the upper right of the page to view your account profile. From there, click the ***Subscriptions*** link on the left side of the page (below your account's avatar).

If you did not purchase the product directly from Software Bisque, your serial number is located on the outside of the media case. We urge you to register your software at

[www.bisque.com/register](http://www.bisque.com/register). After you register your serial number, you will be able to download the full product installer and latest update.

If you received TheSkyX with the purchase of a Paramount mount, use your *Paramount Software Suite* serial number to activate TheSkyX and the Add On. See the *Paramount Quick Start Guide* included with the mount for details.

We also recommend that you keep a printed copy of your serial number for your permanent records. Your registered serial number serves as one form of proof of purchase for future updates, and you'll need it if you must reinstall *TheSkyX*.

## Software Subscription

When you purchase a software product from Software Bisque, you also receive a one (1) year *software subscription* to all major and minor updates. You can optionally renew the subscription each year afterward. Details can be found at [www.bisque.com/subscription](http://www.bisque.com/subscription).

## Small Computer Screens

When *TheSkyX* is opened on a Netbook computer or a laptop with a small screen, it automatically configures settings to maximize screen real estate.

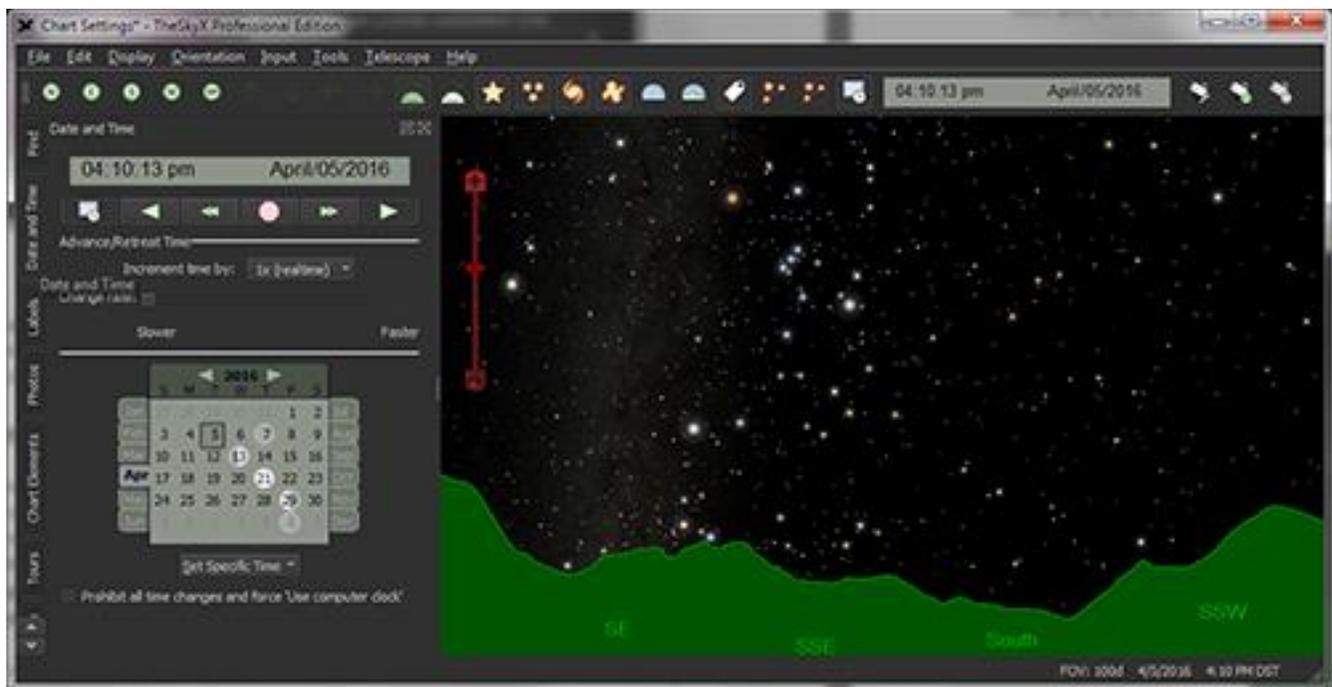


Figure 7: *TheSkyX*'s window optimized for a 1024 x 600 Netbook computer.

The following reminder message is displayed.

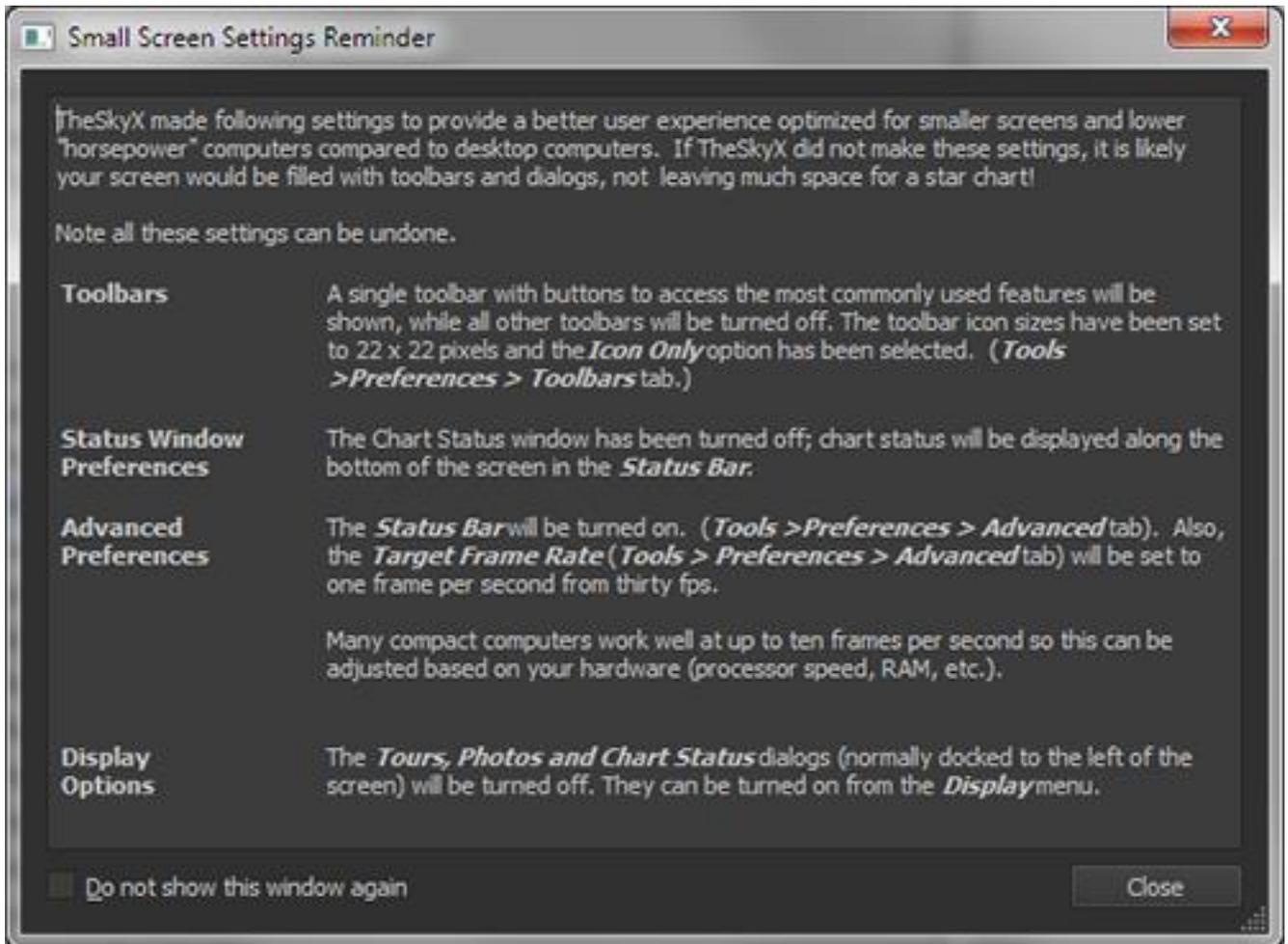


Figure 8: The Small Screen Settings Reminder window.

Turn on the **Do Not Show this Window Again** checkbox to prevent this window from appearing in the future.

Follow the instructions on the **Small Screen Settings Reminder** window to restore *TheSkyX*'s chart settings.

## Minimizing CPU Usage

By default, *TheSkyX* continuously computes and displays the positions of astronomical objects (stars, satellites, asteroids, comets, and so on) at a rate of 30 times per second (30 Hz). You may wish to minimize computational load on the computer's CPU when using an older model computer with a slower processor, or when running a battery powered laptop by using the **Sleep** command (page 216) to temporarily suspend *TheSkyX*'s computations, or set the **Target Frame Rate** on the **Advanced Preferences** window (225) to a value of 5 or less.

## **Application Support Files**

When *TheSkyX* is launched for the first time, a *user account-specific* folder, called *TheSkyX's Application Support Files Folder*, is created to save settings. Examples of *TheSkyX's* settings include:

- The serial number(s) you entered for *TheSkyX* and optional Add Ons
- Location, date and time settings
- Sky Chart preferences
- Positions of windows and dialogs
- Tool bar positions and configuration
- Field of view indicator databases
- Custom field of view indicators
- Custom panoramic horizon photos and custom drawn horizons
- Configuration of the telescope and other equipment
- Tour files
- *TPoint Add On* settings, pointing samples and models
- Any other *TheSkyX-related* files that you create and save in this folder or its sub folders

Each time *TheSkyX* is started, the settings from the previous session are automatically restored.

The Application Support Files Folder is named either *TheSkyX Professional Edition* or *TheSkyX Serious Astronomer Edition*, depending on the Edition that was installed. The exact location of this folder depends on the operating system, as described below.

### **Mac Application Support Files Folder**

*TheSkyX's* application support files are in the *Library/Application Support/Software Bisque* folder in your account's home directory.

#### **Notes**

- By default, Mac OS X versions 10.7 and later do not show the Library folder in the Finder menu. To reveal and open the Library folder, from **Finder**, press and hold the **Option** key, then choose the **Library** command in the **Go** menu (toggling the **Option** key shows and hides the **Library** command).
- *TheSkyX's* settings will remain until you send them to the trash. If you ever remove *TheSkyX* from your Mac (page 20), you will also want to delete these files and folders so that there's no trace of *TheSkyX* on the computer.

### **Windows Application Support Files Folder**

*TheSkyX's* settings are in the *Software Bisque* folder of the *Documents* (Windows 8, and Windows 7).

### **Windows 10, Windows 8 and Windows 7**

To navigate to the **Documents** folder, click the **Start** graphic and then click the **Documents** command in the **Start** menu.

Windows Explorer opens the Documents folder. Double-click the folder named **Software Bisque**, then either **TheSkyX Professional Edition** or **TheSkyX Serious Astronomer Edition** folder to view *TheSkyX's* application support files and folders.

*TheSkyX's* settings will remain in your *Documents* folder until you delete them. *TheSkyX's* uninstaller (page 20) *will not delete files or folders from your Documents folder.*

### **Restoring Default Settings**

*TheSkyX* has a broad-ranging set of features with literally hundreds of options. If you wish to restore *every* setting and *every* option to the “factory defaults,” do the following:

1. Exit *TheSkyX*.
2. Rename *TheSkyX's* Application Support Files folder. Renaming this folder, rather than deleting it, creates a backup of existing settings files, just in case you want to restore a setting from a file later. See “Application Support Files Directory Structure and Files” on page 27 for a list of, and explanation for, each folder and file, and how it is used by *TheSkyX*.
3. Launch *TheSkyX*. You’ll need to enter your serial number, just like the first time *TheSkyX* was launched.

Restoring the default settings is essentially the same as uninstalling *TheSkyX*, deleting the Application Support Files folder and then reinstalling. Remember, there’s almost never a compelling reason to uninstall *TheSkyX*, unless you want to permanently remove it from the computer.

### **Backing Up or Copying Settings**

To backup all your *TheSkyX* settings, copy the entire application support files folder, including files and sub-folders to your backup drive. You can also “replicate” *TheSkyX's* settings on multiple accounts or on another computer by copying the application support files folder and all the sub-folders to the appropriate folder on the second machine. (See “Mac Application Support Files Folder” on page 26 or Windows Application Support Files Folder on page 26 for details about the location of these files and folders).

### **Application Support Files Directory Structure and Files**

The table below describes each file and folder in *TheSkyX's* application support files folder

| Folder Name  | Files                      | Description   |
|--|----------------------------|---|
| <i>TheSkyX Professional Edition</i> or <i>TheSkyX Serious Astronomer Edition</i> |                            | This root folder stores all the files and folders for <i>TheSkyX's</i> settings.  |
|  | AppSettings.ini            | This text file stores <i>TheSkyX's</i> application-wide settings, including the product's serial number.  |
|  | ImagingSystem.ini          | This text file stores the configuration settings related to telescopes, cameras, focusers, filter wheels, and domes.                            |
|  | LastDocument.ini           | This text file stores the name and location of the last Chart Settings file that was opened.  |
|  | Locations.txt              | This text file stores the database of locations that are displayed in the <b>List of Locations</b> tab of the <b>Location</b> window (page 36). |
|  | LogFileOpen.txt            | This text file is a log of every file that TheSkyX opens or accesses when it is run. It can be a useful diagnostic tool for troubleshooting.    |
|  | LogVerifyFileResources.txt | This text file is a log of <i>TheSkyX</i> -related resources that are opened. It can be a useful diagnostic tool for "debugging" purposes.      |
|  | OutputSplash.txt           | This text file logs critical initialization points that can help diagnose startup problems.   |
|  | SDBState.inf               | This binary file saves stores which Sky Database is presently turned on.  |
|  | TheSkyXInstallPath.txt     | This text file stores the location or full path of TheSkyX on the computer. It  |

| Folder Name              | Files                 | Description   |
|--------------------------|-----------------------|---|
|                          |                       | is used by <i>TheSkyX</i> 's Daily Build installer.   |
|                          | WindowPositions.ini   | This text file stores the size, position and orientation of <i>TheSkyX</i> 's main window, toolbar windows and other windows.             |
| Asteroids                |                       | This folder is the default location for saving asteroid orbital element text files that are downloaded from the web.                      |
| Astrometry               |                       | This folder is the default location for saving photo-specific files related to astrometric solutions.                                     |
| Autocalibration          |                       | This folder is the default location for saving files related automated pointing calibration runs.   |
| Comets                   |                       | This folder is the default location for saving comet orbital element text files that are downloaded from the web.                         |
| Database Queries         |                       | This folder is the default location for saving supplied and custom database query files. These files end with the extension <i>.dbq</i> . |
| Documents                |                       | This folder is the default location for saving Chart Settings. These files end with the extension <i>.skyx</i> .                          |
| Exported Data            |                       | This folder is the default location for saving exported Sky Charts.   |
| Field of View Indicators |                       | This folder stores files related to Field of View Indicators.   |
|                          | Detector geometry.txt | This text file contains the database of cameras (or "detectors") that is  |

| Folder Name     | Files            | Description   |
|-----------------|------------------|---|
|                 |                  | displayed in the <b>Detectors</b> branch of the <b>Equipment Database</b> tree list on the <b>Equipment</b> tab of the <b>Field of View Indicators</b> window (page 120).   |
|                 | Eyepieces.txt    | This text file contains the database of eyepieces that is displayed in the <b>Eyepieces</b> branch of the <b>Equipment Database</b> tree list on the <b>Equipment</b> tab of the <b>Field of View Indicators</b> window (page 120).   |
|                 | My equipment.txt | This text file contains a list of the equipment added to the <b>My Equipment</b> list on the <b>Field of View Indicators</b> window (page 120).   |
|                 | Telescopes.txt   | This text file contains the database of telescopes that is displayed in the <b>Telescopes</b> branch of the <b>Equipment Database</b> tree list on the <b>Equipment</b> tab of the <b>Field of View Indicators</b> window (page 120). |
| Horizons        |                  | This folder stores custom panoramic horizon photographs and other Horizon & Atmosphere (page 259) related files.  |
| Movies          |                  | This folder is the default location to save movies generated in the Create Tour window.   |
| Observer Log    |                  | This folder holds XML-based observing logs generated by the <b>Add or Edit Observation</b> button (page 82).  |
| Observing Lists |                  | This folder stores custom observing lists that are generated from the Manage Observing List command.  |

| Folder Name          | Files | Description   |
|----------------------|-------|---|
| Orchestrate          |       | This folder stores Orchestrate-related files.   |
| Pocket Edition Files |       | This folder stores TheSky Pocket Edition-related files (this feature is not currently supported).   |
| Satellites           |       | This folder is the default location for saving satellite data (TLEs) downloaded from the web (page 190).  |
| SDBs                 |       | This folder is the default location for custom Sky Databases.   |
| Source Extraction    |       | This folder holds the Source Extraction configuration files.  |
| Star Chart GIFs      |       | This folder is the default location for saving exported Sky Charts in GIF format.   |
| SVG                  |       | This folder is the default location for saving scalable vector graphics (.svg) files that can be applied to Chart Elements.   |
| Tours                |       | This folder is the default location for saving custom tours that are generated by the <b>Create Tour</b> command (page 90).   |
| TPoint               |       | <p>This folder is the default location for saving TPoint data. These files end with the extension <i>.tptx</i>.</p> <p>Click the <b>TPoint Add On User Guide</b> command from the <b>Help</b> menu for details about using TPoint improve the telescope's pointing.</p> |

## About This Documentation

We'll discuss customizing *TheSkyX* for your geographic location in a moment...

The purpose of the User Guide is to familiarize you with the basic organization and structure of our program, and to introduce those of you who are new to the subject of astronomy to some of its most important terms and concepts. We also hope the Guide will stimulate you to become more interested in astronomy and space science, and excited to start learning about the extraordinary universe we live in.

We urge you join the Software Bisque support community at [www.bisque.com/support](http://www.bisque.com/support). If you have questions, our support staff and other knowledgeable astronomers will try to help.

## Having a Look Around

The star chart display is the heart and soul of *TheSkyX*. We call it the *Sky Chart*, to distinguish it from the real thing. To the left of the Sky Chart you'll find a series of stacked windows with vertical tabs to access the most commonly used commands and options. You can show or hide stacked windows from the **Display** menu.

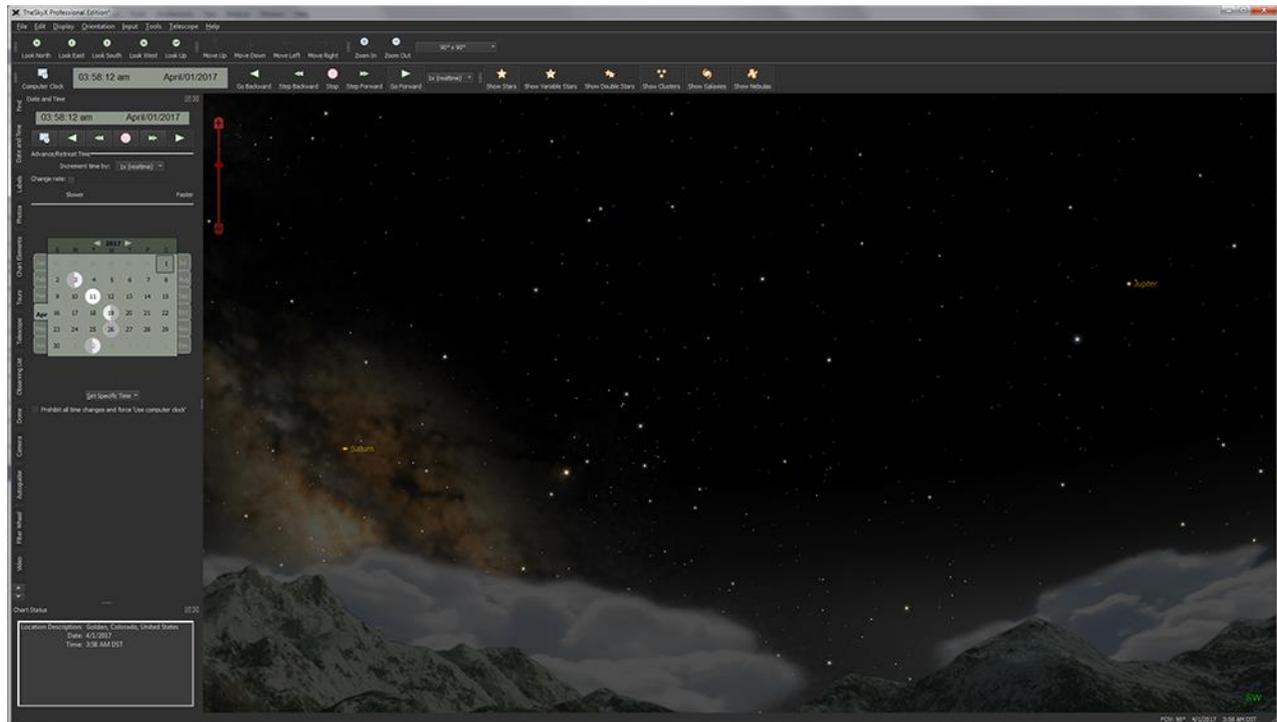


Figure 9: *TheSkyX*'s default screen showing the Sky Chart, with stacked tool windows on the left and toolbars on the top.



Figure 10: The Orientation, Move and Date and Time toolbars (click and drag the checkered “gripper” on the left side of each toolbar to move it).

When *TheSkyX* is first launched, it attempts to automatically set your location using the web; the date and time are read from your computer’s clock.

You’ll also notice that if you are using *TheSkyX* during daytime, the sky it displays is blue (just like the actual sky). In a moment, we’ll describe how to change that to a night view even during the day.

To help you get started and more easily identify commands, the toolbar buttons are configured with large icons and text description.

The software authors understand that showing both a graphic and text consumes valuable real estate on notebooks, smaller computer screens, or when operating *TheSkyX* from a remote computer. To reduce the size of the toolbar buttons, click the **Preferences** command from the Tools menu (**TheSkyX** menu on the Mac), then click the Toolbars icon. In the **Appearance** pop-up, select **Icon Only**; in the **Size** pop-up, select **Small** and then click **Close**. See “*Customizing Toolbars*” on page 202 for more information.

Right now, let’s make sure that the program is set to display the Sky Chart from your location.

## Entering Your Location

Home is where you hang your hat, and where most of you probably view the sky. The first time *TheSkyX* is launched, your computer’s IP address is used to place your location on Earth, typically within a few miles, which is close enough for most astronomy work.

If you know the precise longitude of your location, you can enter it, or choose the name of the city you live in, or the one closest to you, from the list in the **Location** window.

1. Highlight the **Input** item in the main menu.
2. Select the first command, **Location**.

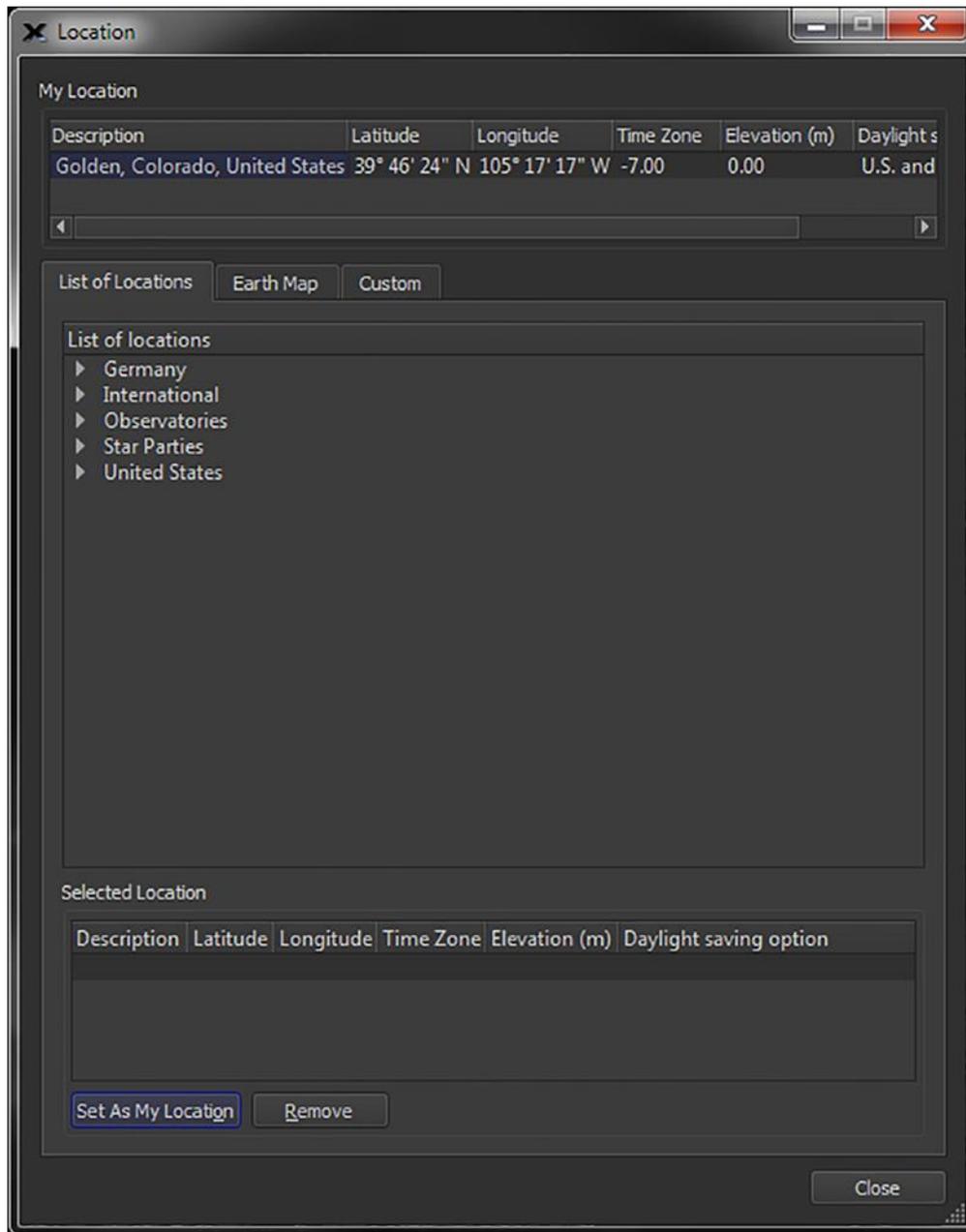


Figure 11: Location window, List of Locations tab.

A window appears displaying options for setting your location. From the **List of Locations** tab, if you live in the U.S., *double-click* on United States. A list of the major cities within your country appears. You can choose your city, or the one closest to where you live, by double-clicking on it.

### **The Location on Earth used by TheSkyX (My Location)**

The **My Location** table shows your location on Earth as defined by its longitude, latitude, time zone, elevation and Daylight-Saving Option.

### **Location Description (Description)**

The location **Description** is for reference purposes only. Double-click the description to change it.

### **Time Zone Offset (Time Zone)**

The time zone of a location on Earth is defined as the difference between Coordinated Universal Time (UTC) and local time, in hours. For most locations, this equals your longitude divided by 15 degrees. In some regions, the value used for time zone can differ by plus or minus one hour.

If you are unsure of your time zone, try searching the web for the time zone of a nearby city. For example, a Google search for “time zone Golden Colorado” shows the following information:



Figure 12: Results of a Google search for Golden, Colorado’s time zone.

If you live in Golden, Colorado, USA, enter *minus* seven (–7) hours for the time zone.



The value for time zone is *independent of Daylight Saving Time*, so the number entered above **should not be changed** when Daylight Saving Time is in effect.

The **Daylight-Saving Option (DSO)**, described below, determines whether *TheSkyX*’s time will be changed when Daylight Savings Time starts and ends for a given region.

### **Daylight Saving Option (DSO)**

*TheSkyX* can be configured to automatically “spring forward” when Daylight Saving Time begins, then “fall back” when it ends. Select the **Daylight-Saving Option** that applies for your region.

See “Appendix C: Daylight Saving Time” on page 649 to see the starting and ending dates for each option. The **Not Observed** option means that Daylight Saving Time is not observed for the location, so *TheSkyX*’s time does not change during the year, for example, if you live in Tucson, Arizona, USA.

### **Location Database (List of Locations)**

*TheSkyX* includes a large database of pre-defined locations that can be used to get you “close enough” to your home location.

When a location is highlighted in the list, the **Selected Location** table shows the details for this location.

Select a location from the list, then click the **Set as My Location** button, or double-click on the location name to use it as your location.

Click the **Remove** button to remove the selected location.

Your location settings are saved when you click the **Close** button, and will be used the next time *TheSkyX* is started.

### **Custom Location**

Alternatively, you can enter your latitude and longitude or U.S. zip code from the **Custom** tab.

Before entering your time zone, please carefully read “Time Zone Offset (Time Zone)” on page 35 and “Daylight Saving Option (DSO)” on page 35 for details about how *TheSkyX* uses these two settings.

A very common error is to manually change the **Time Zone** value by one hour when Daylight Saving Time is observed. *TheSkyX* does this automatically. If your local time is off by one hour, make sure the **Time Zone** is correct for your location, using the time zone definition above.

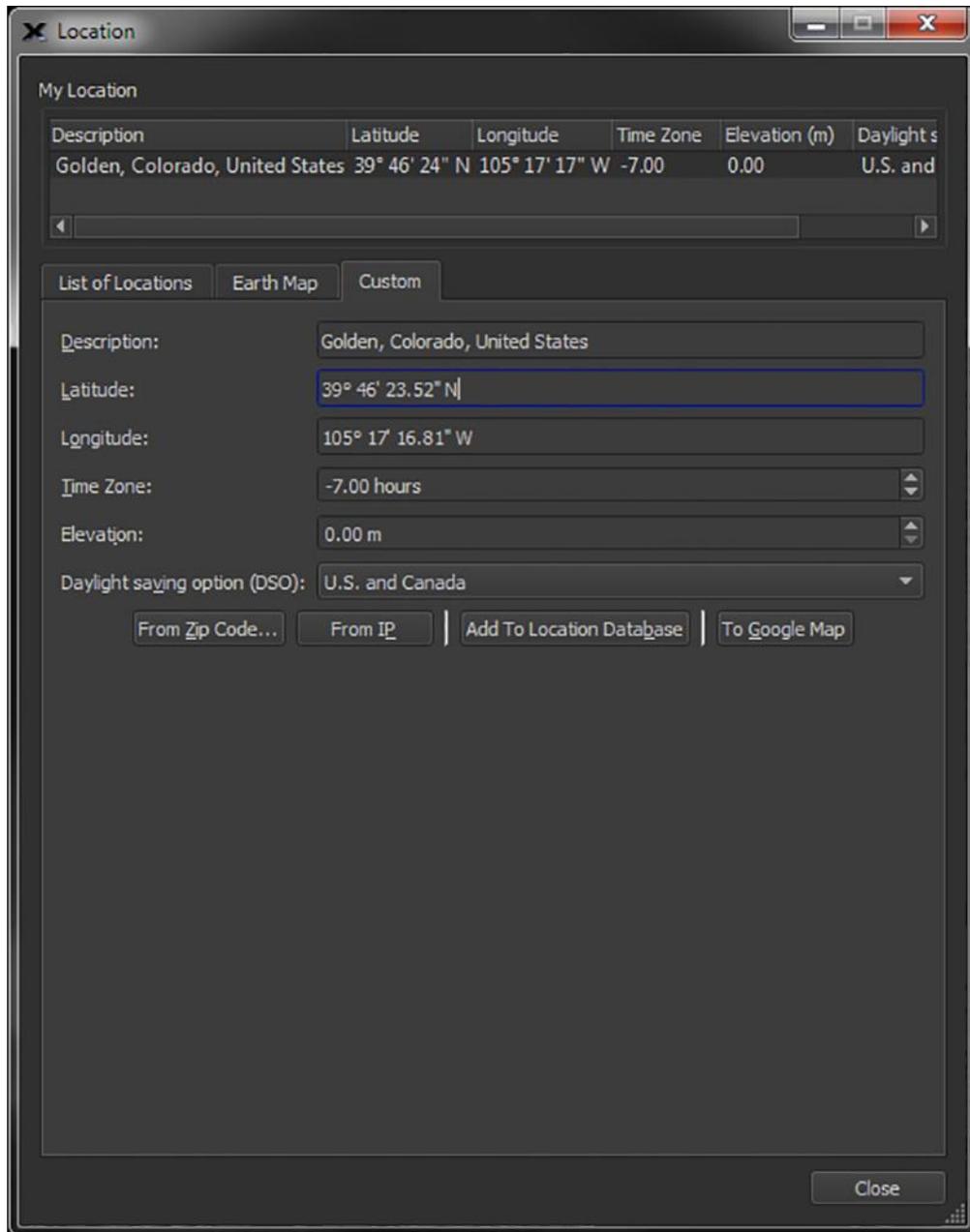


Figure 13: The Custom location tab (Location command, Input menu).

**Location from Zip Code (From Zip Code button)**

U.S. residents can enter a zip code to retrieve their approximate location from the web. If your computer is protected by a firewall, you may need to configure the firewall settings to allow *TheSkyX* to retrieve this information from the web.

**Location from Computer's Internet Protocol (From IP button)**

If your computer is connected to the Internet, you can obtain reasonably accurate location data using your computer's IP address. If your computer is protected by a firewall, you may need to configure the firewall settings to allow *TheSkyX* to retrieve this information from the web.

### **Adding Custom Locations to TheSkyX's Location List (Add to Location Database button)**

After manually entering your location details, click this button to permanently save them in TheSkyX's Locations List.

### **Using Google™ Maps (To Google Map button)**

Compare your coordinates to a Google map to make sure they're accurate. Or, use the Google map to refine your location. Clicking the **To Google Map** button launches a browser and shows this location on a Google Map.

To refine the coordinates, adjust the map accordingly, right-click (⌘+left-click on the Mac) on the map, or click the Satellite button to show the satellite photo of your observatory, for example, then click the Directions To command to show the precise latitude and longitude, in decimal format, of this point in the Driving Directions.

Highlight the latitude (the first coordinate that is shown), then select the Copy command from the Edit menu. From TheSkyX, right-click (⌘+left-click on the Mac) and select the Paste command. Repeat this procedure for longitude.

When you're done, click the **To Google Map** button again to make sure the values you entered are correct. The coordinates of pointer on the map that appears should match your observing site.



Double-check your location before proceeding! Longitude, latitude and, most commonly, time zone errors result in sky charts that do not match what you see in the nighttime (or daytime) sky, and the telescope may not point accurately.

To verify your location is correct, click the **To Google Map** button to show a map for the specified longitude and latitude coordinates. This will show a map directly above the location.



Location changes are prohibited while TheSkyX is connected to a telescope.

## **Earth Map**

Yet another way to find home is to use the **Location** window's **Earth Map** tab.

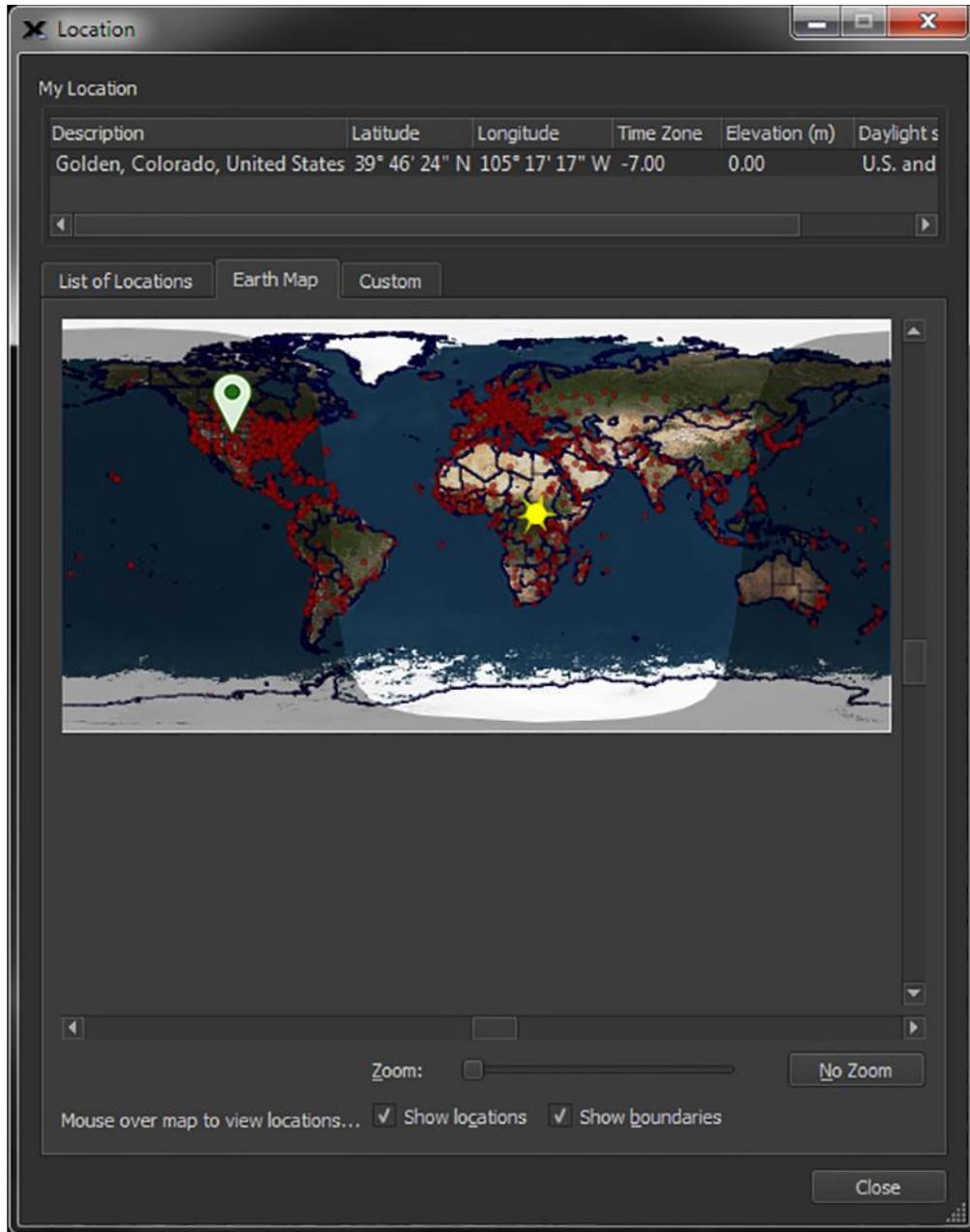


Figure 14: The Earth Map tab (Input > Location window).

The default view shows a map of the entire Earth with a red stick pin at the current location. Use the **Zoom** slider to change the magnification, and the scroll bars, or left drag on the map, to center the desired region. Turn on the **Show Locations** checkbox to overlay *TheSkyX's List of Locations* on the map, indicated by a small red dot. The location descriptions will also appear at higher magnifications. The **Show Boundaries** option shows you the approximate country and U.S. state boundaries. Double-click on the map to choose the location beneath the mouse cursor.

## The Basics

What follows is an introductory section, which describes the basic functions of *TheSkyX*, and will help you to quickly get started exploring the marvels of the sky. Included in this section are instructions for zoom, scroll, and pan controls, as well as display options, returning to home position, and moving/adjusting the toolbars and “dock-able” windows.

### **Zoom Control**

There are several ways to zoom in and out in the Sky Chart. You can use the **zoom in/zoom out** buttons on the toolbar, the **zoom box**, or by using **Orientation** menu controls.

#### **Zoom Buttons**

To zoom in on objects in the Sky Chart, simply click the **zoom in** button in the toolbar. This will reduce your field of view, and increase the angular size of the scene (called the *field of view* or *field width*).

To zoom out, simply click the toolbar’s **zoom out** button. This will increase the Sky Chart’s field of view, giving you a wider field of view.

#### **Zoom Menu Controls**

Alternatively, you can zoom in or out using menu commands. Under the **Orientation** menu, you will find controls to zoom in and out.

#### **Sky Chart Zoom Tool**

On the left side of the Sky Chart window, you will find a red **zoom tool**. This tool makes it easy to zoom in and out with a simple click and drag. Just click the zoom tool’s slider bar, and by dragging it up or down, you will zoom either in (up) or out (down). Or, click the **+/-** symbols to zoom out or in.

To show or hide the zoom tool, click the **Zoom Tool** command from the **Tools** menu.



Figure 15: The Zoom Tool on the Sky Chart.

### **Zooming with Scroll Wheel Mouse**

If you are using a mouse with a scroll wheel feature, you can zoom in or out by simply rolling the wheel forward for zoom in, and backward for zooming out. This feature is great for quick, convenient zooming.

### **Zoom Box**

Using the zoom box is another easy way to zoom in on objects in *TheSkyX*. Choose a portion of the Sky Chart into which you would like to zoom. Hold down the **SHIFT key** (the cursor changes to the pointing finger) while clicking in one corner of the chosen portion, and drag the mouse to the opposite corner. Release the mouse button, and the box's caption says, "**Click inside to zoom, outside to cancel.**"

Notice that the box's diagonal dimensions appear above it in degrees, minutes and seconds of arc. Click anywhere inside the box to *zoom in*, filling the Sky Chart's field of view with the dimensions of the *zoom box*.

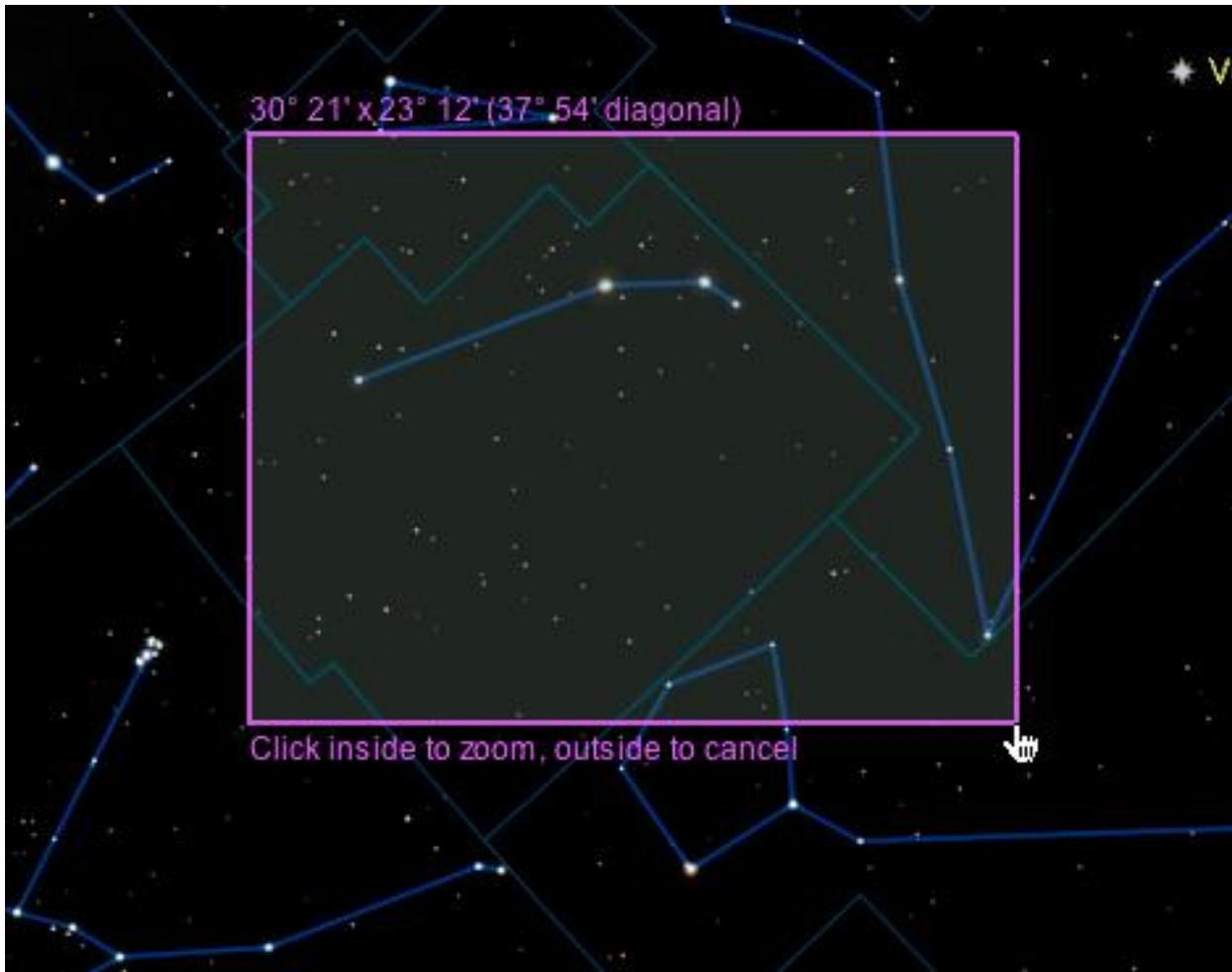


Figure 16: A zoom box on the Sky Chart (SHIFT+drag).

### ***Returning to Naked-Eye View***

Regardless of how you zoom, you can always return to the naked-eye field of view by either zooming out manually, or by selecting ***Orientation > Zoom To > Naked Eye 100°***.

## ***Scrolling and Panning Control***

Scrolling or panning the Sky Chart's "camera" will allow you to look at the universe in any desired direction, giving you that perfect view.

### ***Toolbar Controls***

The toolbar features four easy to use buttons for camera scrolling and panning. By locating and clicking any of the ***four blue arrow buttons (Move Up, Move Down, Move Left, Move Right)***, you can move to camera to look up, down, left, or right. Also, to look specifically in the four cardinal directions or at the zenith (straight up), locate and click the "***look***" buttons (***Look North***, for example). Clicking any of these buttons will orient the Sky Chart in the corresponding direction.

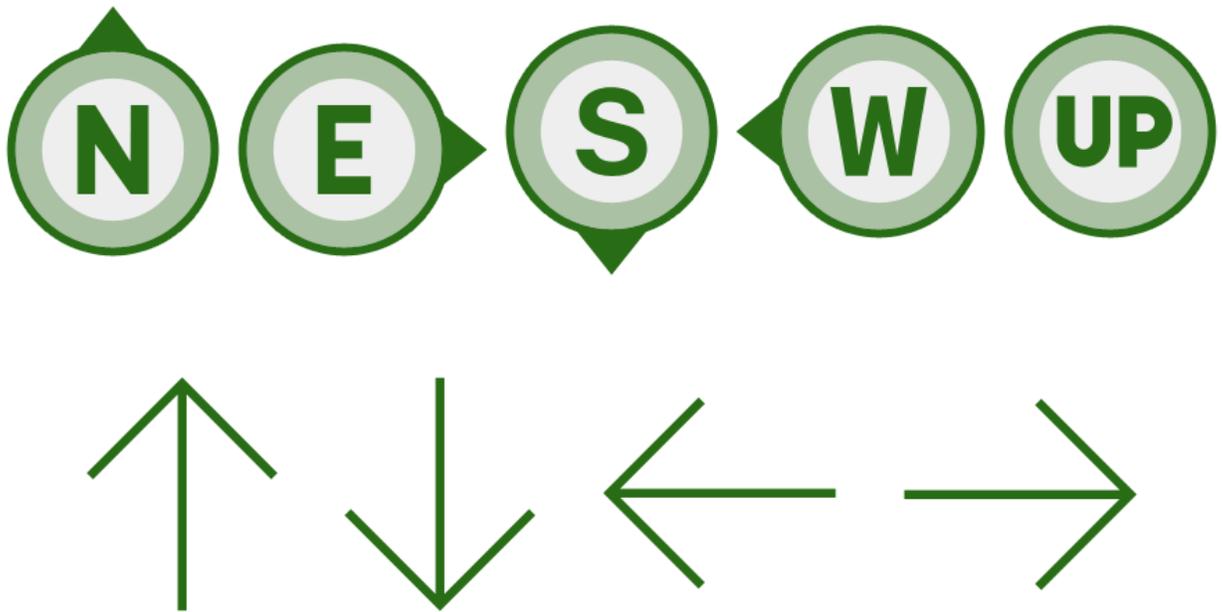


Figure 17: The cardinal directions, up, and panning buttons.

### ***Clicking and Dragging***

Alternatively, you can adjust the field of view by ***left-clicking*** your mouse anywhere in the Sky Chart and dragging the view.

## ***Chart Navigation***

The navigate command lets you explore the digital sky through a celestial sphere map (showing the constellations and their boundaries), by entering specific coordinates, or by selecting a specific position angle.

### **Using the Navigate Command**

To access the Navigate command, select ***Orientation > Navigate***. Three tabs at the top of the window indicate the navigator choices: ***Celestial Sphere, Sky Chart Center, and Rotation***.

### Celestial Sphere Tab

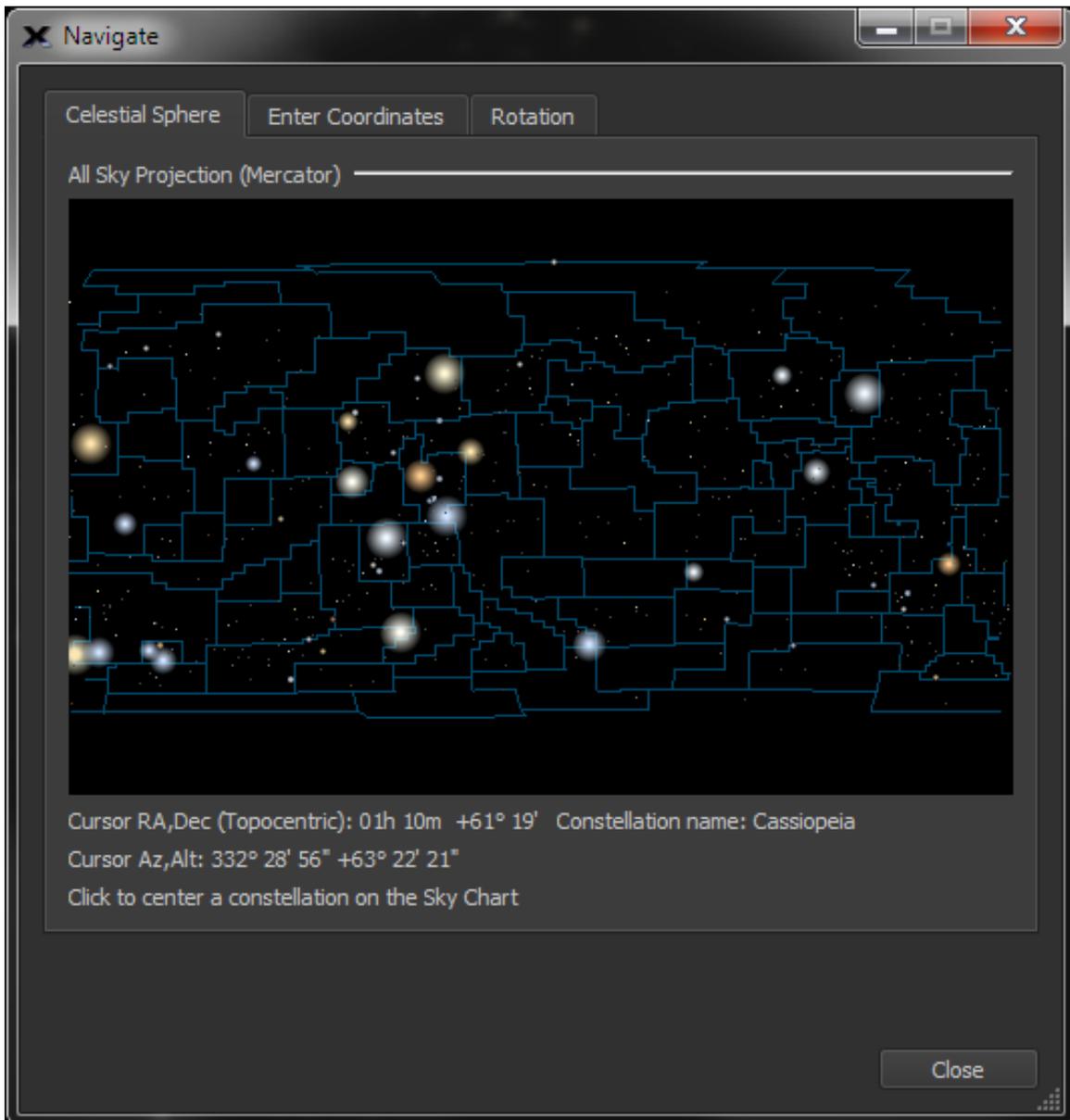


Figure 18: The Celestial Sphere tab on the Navigate window.

The Celestial Sphere tool shows a view of the entire sky with constellation boundaries. The RA/Dec of the mouse pointer, and constellation name are updated in the status text. Click the mouse on the graphic to center the Sky Chart on this constellation.

If the chart looks too small at first, simply click and drag the window's lower right corner to resize it. After you close the window or quit the application, *TheSkyX* will remember the window size and position each time you open it.

By default, *TheSkyX* attempts to pin the local horizon near the bottom of the screen. If the “clicked on” position happens to be below the horizon, the Sky Chart moves to the closest visible point. Turn on the ***Allow Sky Chart to be Scrolled Below the Horizon*** option on the Horizon tab on the ***Display > Horizon & Atmosphere Options*** window to allow regions below the local horizon to be accessible.

To move a region of the sky to the center of the window, click and drag the map. Because it represents a sphere, the map is a continuous loop.

You can remove the horizon picture from the Sky Chart altogether by deselecting the ***Show Horizon*** checkbox. Click ***Close*** on the ***Navigate*** window to return to the Sky Chart. You will notice that you can now scroll below the horizon either manually or with the ***Celestial Sphere*** navigator.

When finished with the Navigate window, click ***Close*** to return to the Sky Chart.

### Enter Coordinates Tab

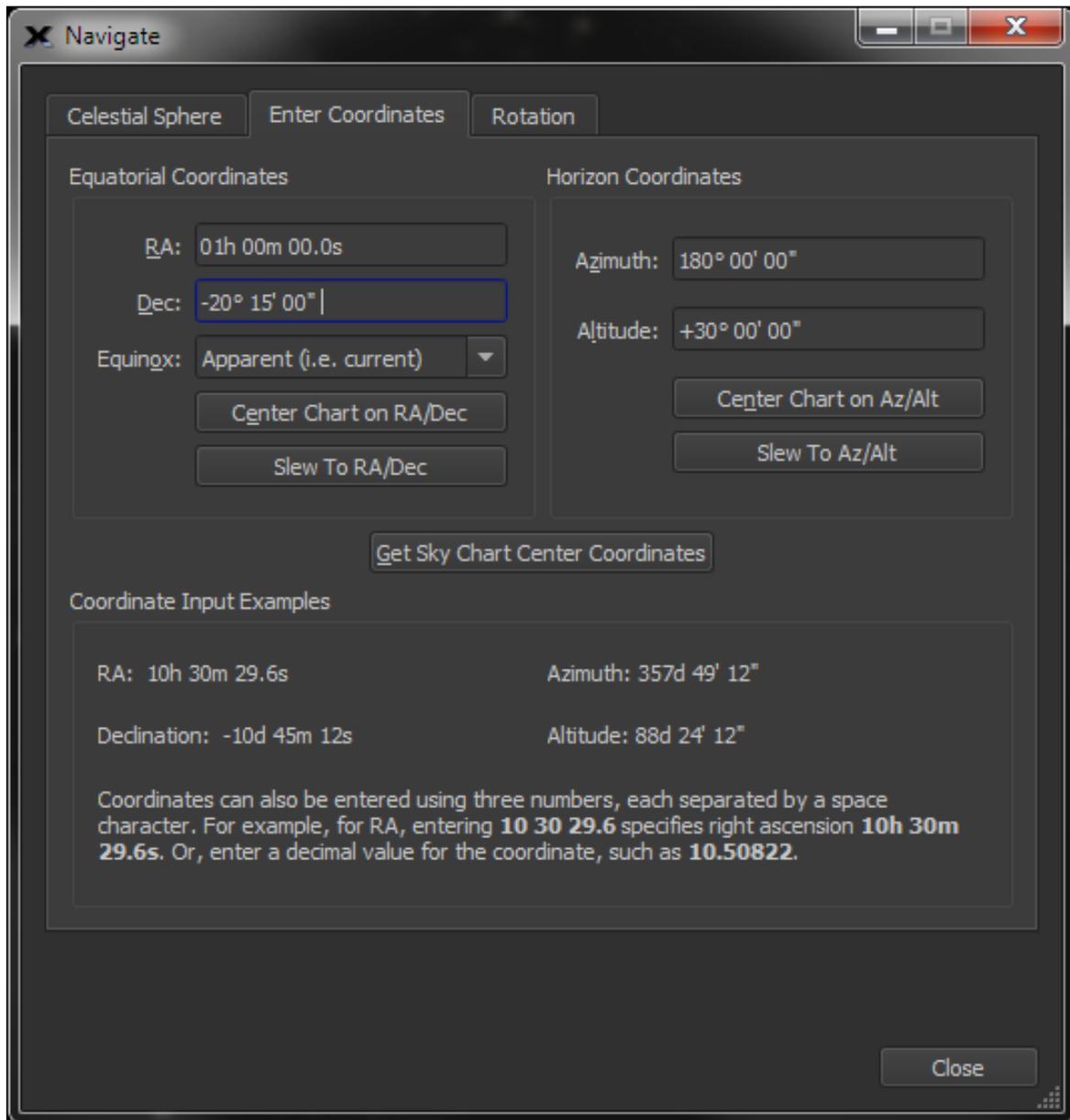


Figure 19: The Enter Coordinates tab on the Navigate window.

Select the **Enter Coordinates** tab to enter specific coordinates in either equatorial (RA/Dec) or horizon coordinate (Az/Alt) systems.

To enter coordinates, click on the desired field and directly enter the values into it. For convenience, you can simply enter three numbers separated by spaces. For example, enter **10, 30, 29** into the **RA** field to specify right ascension of 10h 30m 29s.

Because equatorial coordinate systems are based upon the orientation of Earth's axis, their accuracy diminishes over time due to, among other factors, precession. For that reason, many

publications reference equatorial coordinates at a specific point in time known as an *equinox*. If you are using RA/Dec coordinates, it is important to choose the correct equinox (either **2000.0** or **1950.0**). The 1950.0 equinox setting can be useful, as many older publications list equatorial coordinates per the 1950.0 equinox.

Click **Center on RA/Dec** (for equatorial coordinates) or **Center on Az/Alt** (for horizon coordinates) to center the Sky Chart on the selected coordinates.

When connected to a telescope, click **Slew To RA/Dec** to slew the telescope to these equatorial coordinates, or click **Slew to Az/Alt** to slew the telescope to these horizon coordinates.

Click the **Get Sky Chart Center Coordinates** button to display the current coordinates of the Sky Chart's center in the above coordinate fields.

For your reference, example input for each of the coordinate systems appears in the **Coordinate Input Examples** near the bottom of the window.

Click **Close** to return to the Sky Chart.

See "Slewing to a Specific Coordinate" on page 381 for details about slewing a telescope using the Navigate commands.

### Rotation Tab

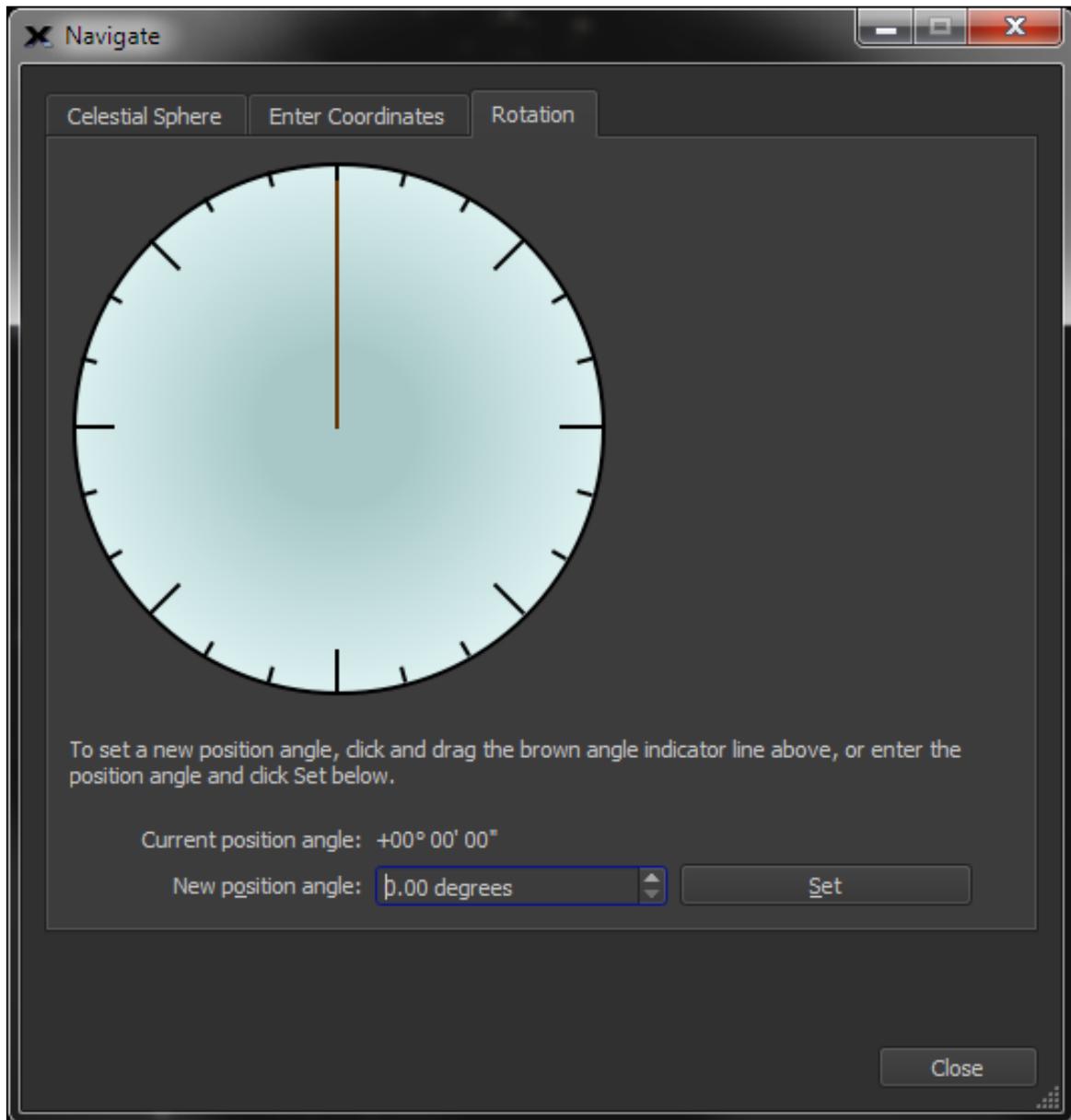


Figure 20: The Rotation tab on the Navigate window.

The Sky Chart can be rotated to any angle, called the *position angle*, and it helps to match the Sky Chart to the actual sky and to paper charts you may use while observing or planning an observation session.

Click the **Rotation** tab to view and adjust the Sky Chart's position angle. You will immediately see a graduated circle with a **brown indicator** showing the Sky Chart's current position angle. Click and drag this indicator to adjust the position angle to whatever you wish in real-time.

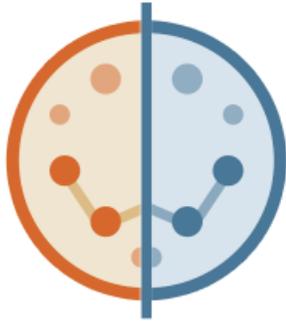
Near the bottom of the window, you will see the Sky Chart's **Current Position Angle**. You can also enter a **New Position Angle** into the field at the bottom of the window (to hundredths of a degree of accuracy). Use the up and down arrows here for an easy way to adjust the position angle in whole-degree increments. For example, if you enter 42.78°, clicking the up arrow once will increase the value to 43.78°.

Once you have entered a position angle, click **Set** to update the Sky Chart.

Click **Close** to return to the Sky Chart.

The horizon is hidden automatically when you adjust the position angle. Changing the position angle is equivalent to changing the direction of “down” in relation to the horizon, so the horizon as a reference becomes irrelevant. **TheSkyX** removes it to avoid confusion.

### **Mirror Image**



Refractors and catadioptric telescopes used with star diagonals produce mirror images of the sky because they have an odd number of image reflections. Selecting **Display > Show Mirror Image** flips the Sky Chart to “reflect” the view through a refractor or catadioptric telescope with star diagonal.



- The mirror image icon appears in the upper left corner of the Sky Chart when **Show Mirror Image** is turned on.
- When your optical system produces mirrored photos, and one of these photos is used to perform a successful Image Link (page 312), **Show Mirror Image** is turned on automatically.

### **Right Clicking the Sky Chart**

Commonly used commands can be accessed by right-clicking the mouse on the Sky Chart.

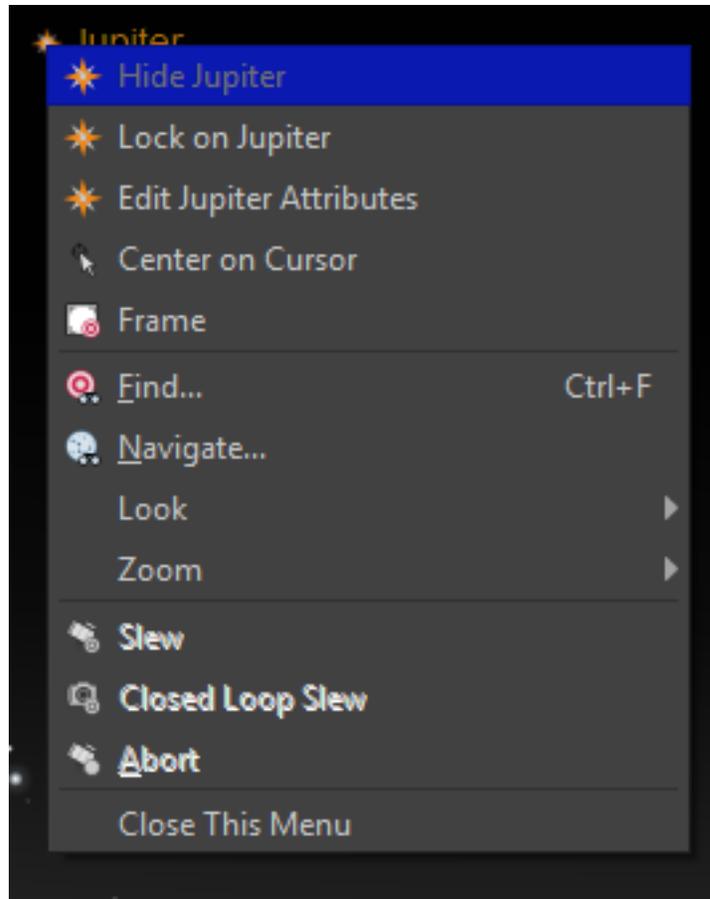


Figure 21: Right-click on the Sky Chart to access the pop-up menu above.

### ***Hide <Object Type>***

Right-clicking the Sky Chart when the mouse cursor is placed on a star or other object shows a pop-up menu where the first command is to ***Hide <Object Type Here>***; clicking this command turns off objects of this type. In Figure 21, for example, the mouse cursor was placed over a star, so the command reads ***Hide Star***.

### ***Lock On <Solar System Object>***

Right-clicking on a solar system object shows the ***Lock On*** command (page 69) that pins the object to the center of the Sky Chart.

### ***Edit <Object Type>***

Choosing the second command in the right-click pop-up menu shows the ***Edit Preferences*** window that allows the attributes for this element to be changed. See “Editing Chart Element Attributes” on page 236 for more information.

### ***Center on Cursor***

Click this command to center the Sky Chart on the right-click mouse position.

### **Frame**

Click this command to center the object on the Sky Chart and adjust the chart's field of view to approximately match the object's angular size.

### **Find**

Click this command to show the **Find** window (page 70).

### **Navigate**

Click this command to command to show the **Navigate** window (page 43).

### **Look Pop-Up Menu**

The commands in the **Look** pop-up menu orient the Sky Chart to look north, south, east, west or directly overhead (page 150).

### **Zoom Pop-Up Menu**

The commands in the **Zoom** pop-up menu can be used to change the Sky Chart's field of view to any one of several preset values (page 40).

### **Slew**

Click this command to slew the telescope to the celestial coordinates of the right-click mouse position on the Sky Chart (page 381).

### **Abort**

Click this command to halt the telescope's motion during a slew.

### **Close This Menu**

Click this command to hide the Sky Chart's right-click pop-up menu.

## **Display Chart Elements**

In addition to the huge database of celestial objects in *TheSkyX*, several other useful elements, such as coordinate system lines, constellation boundaries, and other reference lines, are all available to you. Each can be toggled on or off with ease.

### **Chart Element Buttons**

On the toolbar, you will find a few buttons assigned to control chart elements (Constellation Figures, the Ecliptic, etc.). To toggle a given chart element on or off, simply click the appropriate button. For instance, if you want to turn on the constellation figures, locate and click the **Show Constellation Figures** button on the toolbar: the constellation figures appear in the Sky Chart. Also, note that the button is now a darker gray than the rest of the toolbar. This change indicates that the constellation figures are turned on. To hide them, click the button again. The button color will lighten, and the constellation figures will fade from view. There are several other chart element buttons on the toolbar. Try them all to get a feel for how they work.

### Chart Elements Window

A complete list of chart elements is available by selecting **Chart Elements** from the **sidebar** of the **stacked tool windows**, which is located on the left side of the screen when you first open *TheSkyX*.

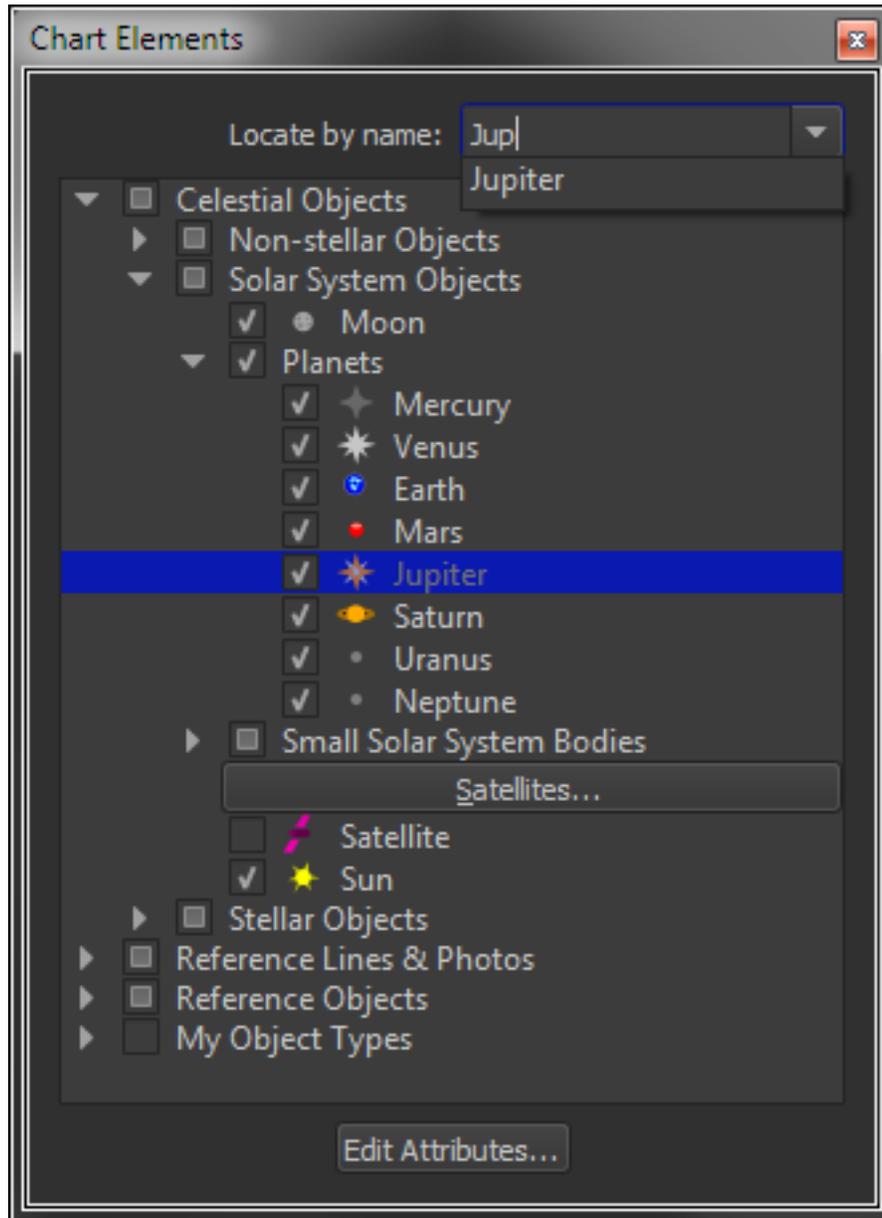


Figure 22: The Chart Elements window (Display menu).

If **Chart Elements** does not appear in your stacked tool window, or if you removed it, you can always access it again by selecting **Chart Elements** from the **Display** menu.

### **Locating a Chart Element by Name (Locate by Name)**

If you know the name of the Chart Element you're after, there's a quick way to find it in the list. For example, suppose you want to turn on the line that represents the galactic equator. Typing the letter "g" into the **Locate by Name** text input shows a list of all the elements that begin with this letter in the pop-up menu. Selecting **Galactic Equator** expands the Reference Lines and Photos node to reveal this option. Press the TAB key to place the "focus" on this checkbox.

From here, you can turn the checkbox on or off, or, click the **Edit Attributes** button to configure this element's upper and lower magnitude limits, angular size limits and other display properties, such as the font size, line styles, fill colors and symbol. See "Customizing Chart Elements" on page 236 for more information.

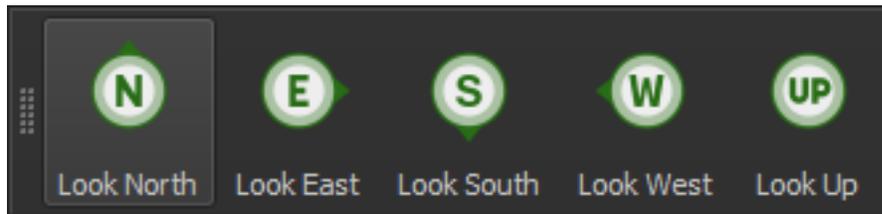
## **Customizable Interface**

One of the great features of *TheSkyX* is its customizable interface. All toolbars and "dock able" windows are movable and adjustable, giving you great flexibility in using *TheSkyX* to best suit your needs.

### **Positioning Toolbars**

When you first open *TheSkyX*, you will notice rows of toolbars on the top of the screen, a stacked tool window on the left, and the Sky Chart on the right.

When looking at the toolbars, notice that at the far left of each, you will see a textured area (or "gripper bar").



**Figure 23:** The textured region on the left side of toolbar windows can be used to position the toolbar.

Clicking and dragging on this area will allow you to move that toolbar to almost any new desired location on the screen. As you drag the toolbar, you will notice that portions of the screen move to allow you to drop the toolbar into position. If you drop a toolbar in one of these positions, it will "snap" into place. (You may also drop the toolbar over the Sky Chart in any location, without snapping.) Feel free to experiment with this feature to get a feel for how the toolbars can be moved, as you can always move the toolbar back to its default position later. Be sure to look over each toolbar, and you will see that they are divided into sections, each of which can be moved. Note that the textured section denotes the beginning of a new toolbar section.

### **Moving Dockable Windows**

To the lower left of the screen, you will find a set of tool windows that are stacked together. A **sidebar** allows you to choose which window you want to see. All the windows stacked together on the left side of the screen can be moved and/or made into a new stack. Notice that when you select a stacked window on the sidebar, its name also appears at the top of the window along with a **window resize button** and a **close window button**. By clicking the **window resize button**, you release that window from the stack. Now you are free to move the window to any location that you like by clicking and dragging it.

Alternately, you can dock the window on the left or right side of the window by dragging it and releasing it in any area that readjusts as the window is drug over. For instance, try clicking **Labels** in the stacked tool window. Now click the **window resize button** in the top right of that window. The window will now undock from the stack. Click and drag the window to the far-right side of the screen. You will notice that the Sky Chart will move slightly to the left, and a dark gray area will appear, indicating that you may “dock” this window here. Release the mouse button, and you have docked the window. If you would like to move another window, simply repeat the previous steps.

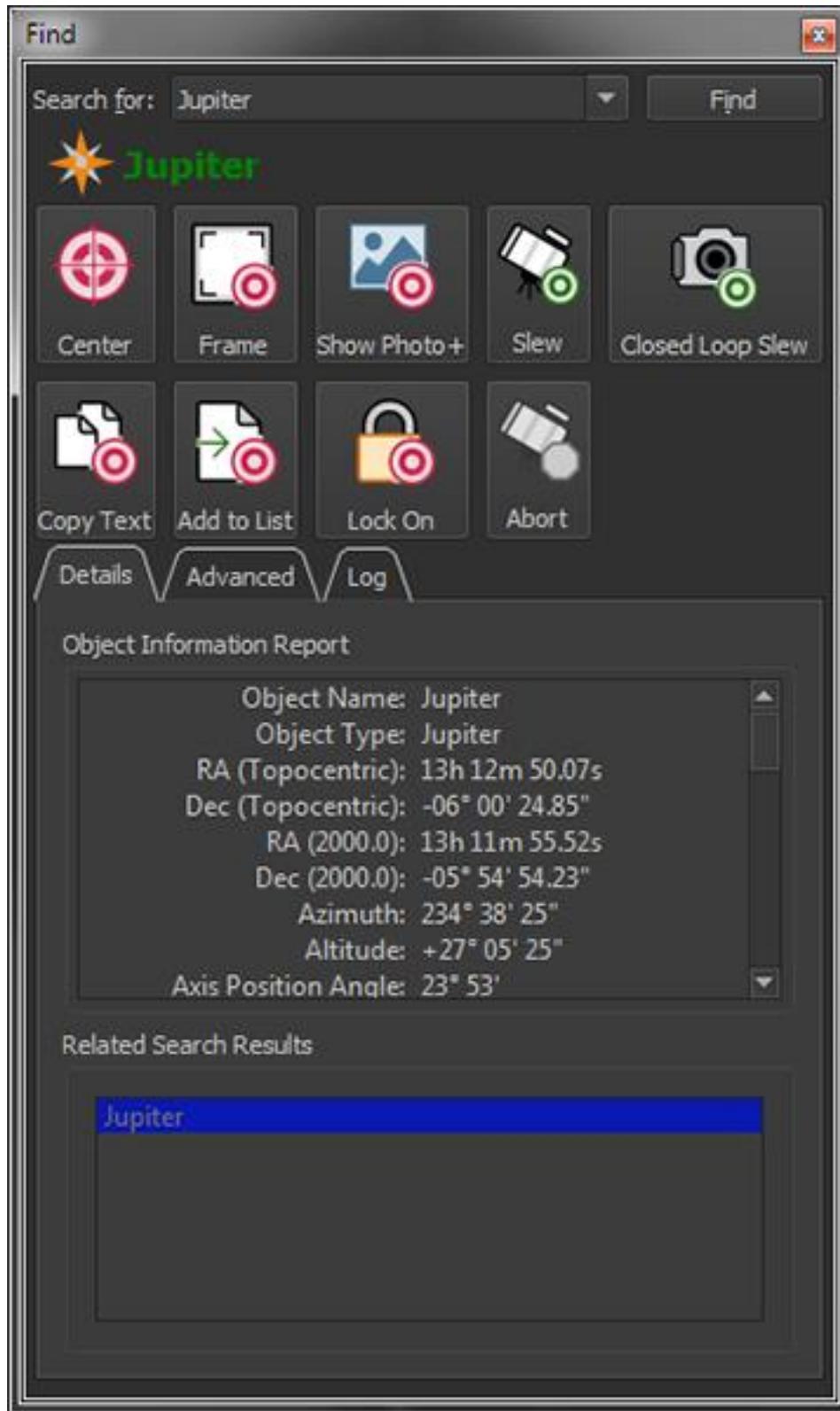


Figure 24: The stacked tool windows, include the Tours, Find, Date and Time, Photos, Labels and Telescope, Observing List and other hardware-specific windows.

### **Stacking and “Dockable” Windows**

Windows can be stacked by dropping a window on top of docked windows. When the docked window turns a dark gray, drop the window you are moving to stack them.

### **Closing and Reopening a Docked Window**

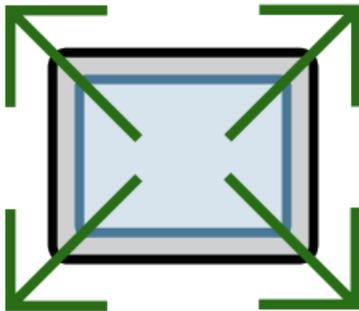
If you wish to remove a window from view completely, simply select it from the stacked tool window sidebar, and click the **close window** button.

If you want to view a window again, simply select it from the **Display** menu.

The following windows can be stacked on the left or right side of the main window, or, by dragging the window’s title (caption), positioned anywhere on your computer’s monitor.

- Chart Elements
- Chart Status
- Date and Time
- Find
- Labels
- Observing List
- Photos
- Telescope
- Tours
- Telescope-specific command windows

### **Full Screen**



The Sky Chart can fill the entire screen. To enter Full Screen Mode, click the **Full Screen command** from the **Display** menu.



Press the Escape (ESC) key on the computer’s keyboard to exit **Full Screen Mode**.

## **Heading Home**

The universe is a big place, and when you are ready to go home, it is nice to know that *TheSkyX* can get you there in only two clicks (that's one clicks faster than it takes with a pair of famous red shoes). When you are ready to return to your default space and time, simply click **Look South**, followed by **Computer Clock**, both in the toolbar. This action will adjust the Sky Chart's view to the south, and at the current time designated by your computer's internal clock. Welcome back!

### **Restoring Default Sky Chart Settings**

Or, select the **New** command from the **File** menu whenever you want to restore *TheSkyX*'s chart settings to their default values.

This will show the daytime sky (**Show Daylight** command, **Display** menu), set the date and time to the computer's clock and (turn on the **Computer Clock** button on the **Date and Time** window, **Input** menu), shows the default objects labels, object types, reference lines, object magnitude and size limits; just like when *TheSkyX* was first launched.

## **Saving & Retrieving Your Sky Chart**

Your Sky Chart settings can be saved and opened at any time by creating special *TheSkyX* files with the extension `.skyx`.

### **Saving Your Sky Chart**

You can save your current Sky Chart, along with all its settings, at any time by selecting the **Save** command from the **File** menu. This saves the Sky Chart (as a `.skyx` settings file), which is a handy way to save data you wish to quickly recall later, such as when you journey to your favorite hilltop.

Choosing the **Save As** command from the **File** menu allows you to save the settings without overwriting the current settings file.

### **Opening an Existing File**

To open an existing Sky Chart, select the **Open** command from the **File** menu. You will then be able to search your hard disk for existing `.skyx` files.

## **Help Options**

As you continue to use *TheSkyX* and read through this User Guide, keep in mind that we have included the complete User Guides for both *TheSkyX* and the *TPoint Add On*, as well as an XML-based help, and all are accessible from *TheSkyX*'s **Help** menu. Even the most seasoned observer sometimes needs a little help, and with all the features packed into *TheSkyX*, it is handy to always have a reference guide at your fingertips.

### **Help Search**

You can easily search through *TheSkyX*'s many commands by entering search terms into the Help menu's search field. For more detailed help, continue reading for more help options.

### ***TheSkyX* Help - Assistant**

*TheSkyX* includes a powerful, html-based help guide called *Assistant*, which is designed to help you to get the most out of *TheSkyX*, no matter how you plan to use it. Whether you use *TheSkyX* to plan for meteor showers, or you want to use the most advanced telescope controls, *TheSkyX Assistant* is there for you, regardless of your user experience.

### ***TheSkyX* User Guide**

This user guide is available, in its entirety, can be viewed, or searched by selecting **Help > *TheSkyX* User Guide** to access it.

### ***TPoint* Add On User Guide**

*TPoint* software is an advanced telescope pointing analysis system that allows you to analyze and model the errors inherent to a telescope system to dramatically improve pointing performance. *TheSkyX* offers the optional *TPoint Add On* that integrates telescope modeling and pointing corrections, polar alignment assistance, automated pointing calibration (*Professional Edition only*) and *TPoint*-assisted tracking corrections via ProTrack™ on Paramount model mounts.

Both *TheSkyX Serious Astronomer Edition* and *TheSkyX Professional Edition* come with a trial version of the *TPoint Add On*, which can be activated the first time you use the add on, after which time, you must purchase a license separately. *TPoint* can be accessed from the **Tools** menu.

Like many aspects of an imaging system, there is a significant learning curve with *TPoint*. Fortunately, *TheSkyX* makes using *TPoint* smooth, and you should be able to complete a pointing calibration run on the first night and start analyzing your system right away. The *TPoint Add On* User Guide in PDF format can be viewed by clicking **Help > *TPoint Add On* User Guide**.

## Finding and Identifying Celestial Objects



*TheSkyX*'s astronomical databases can quickly locate any one of up to a *billion* objects, either by clicking on the object on the Sky Chart (called "identifying a target") or with the **Find** command from the **Edit** menu.

### Identifying Target Objects

The Sky Chart is linked to *TheSkyX*'s astronomical databases. Click the left mouse button on any celestial object to identify it, and display the **Object Information Report** on the **Find** window (the **Find** window will be displayed automatically if it is hidden). The **Object Information Report** provides a wealth of information about the object.

You can also search for objects by name or catalog number using with the **Find** command on the **Edit** menu (see "Finding Objects" on page 70 for more information).

A red bull's eye appears on the Sky Chart at the mouse click position (Figure 26) and identifies this object as the *target object*, or *target*. Tool bar buttons that act on, or apply to, the target include a red or green target graphic.

#### **Object Information Report Contents**

- the object's common name and/or its catalog designation
- the graphical symbol used to represent this object on the Sky Chart
- cross references to other catalogs (in the Name 2–Name 10 fields)
- the object's type (planet, variable star, irregular galaxy, and so on)
- the constellation in which the object lies
- the object's magnitude
- a star's Bayer (Greek-letter) brightness designation
- the plain English Dreyer description for the object
- the object's distance from Earth, in light years and AU (where available)
- catalog-specific information (such as min/max magnitude of variable stars, spectral class, parallax, proper motion, position error, distance from the Solar System)

- the object's topocentric equatorial (RA-Dec) coordinates, for both the date specified in the **Date and Time** window (page 139) and Equinox 2000.0
- the object's current horizon (Az-Alt) coordinates
- the object's rise time, transit time and set time for the site location and the object's angular dimensions
- the angular separation from the last object identified
- the object's position angle (the angle between the line connecting the object and the last-identified object, and the line connecting the last identified object and the North or South Celestial Pole)
- Other catalog and object-specific information

"Appendix J: Object Properties" on 667 includes a comprehensive list of objects properties.

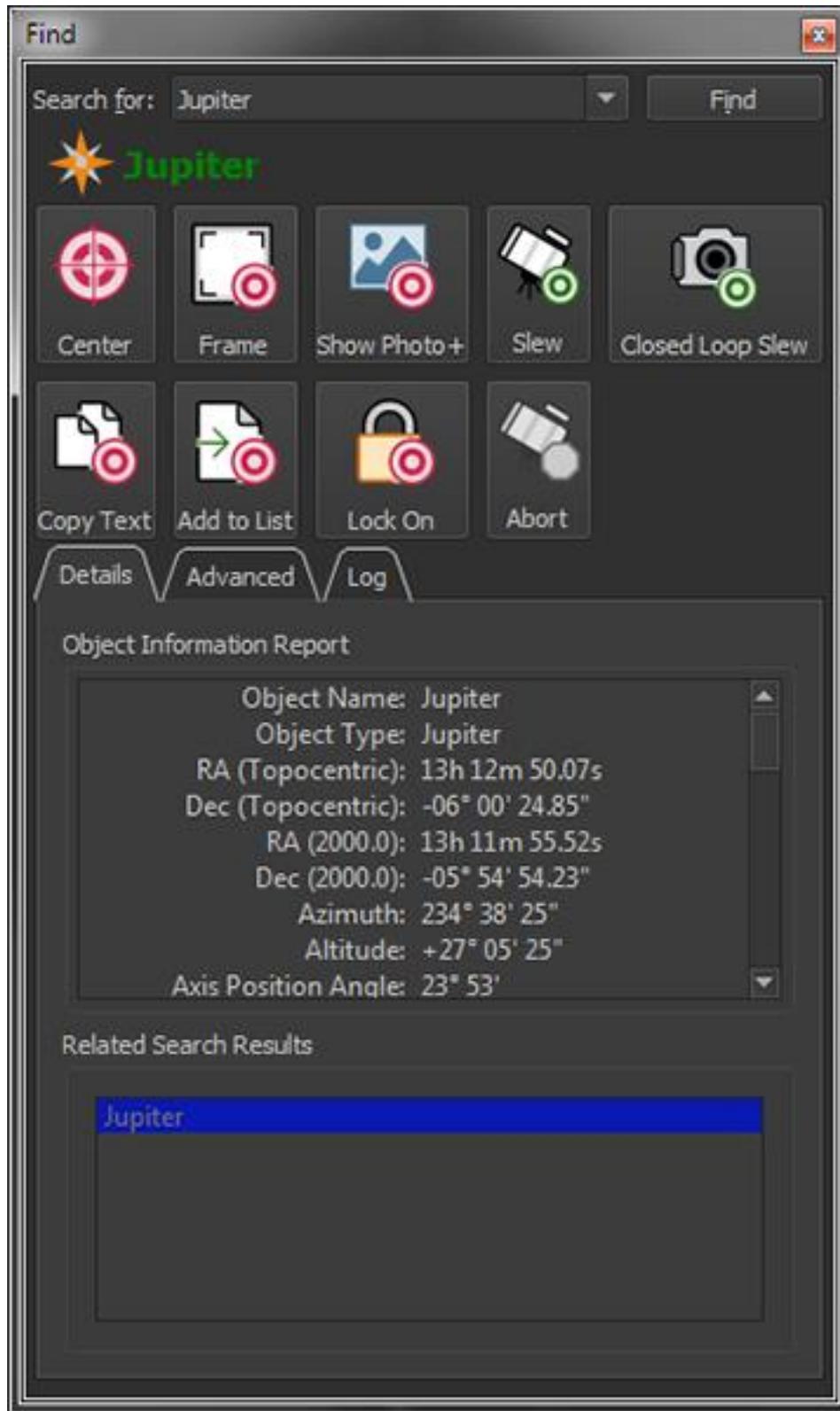


Figure 25: The Object Information Report appears on the Details pane of the Find window (Edit menu).

The *target* is highlighted with a red bull's eye on the Sky Chart (Figure 26). Press the *ESCAPE* key to hide the bull's eye.



Figure 26: The Sky Chart displays a bull's eye centered on the current target.

The object you clicked on (or located using the **Find** command), and up to ten “nearby” objects (or objects with names that closely match this object), are listed in the **Related Search Results** box. This eliminates any need to click exactly on the object, and makes it easy to study groups of objects without having to click on each one. If you click in an area without any nearby objects, the **Mouse Click Position** is the only entry.

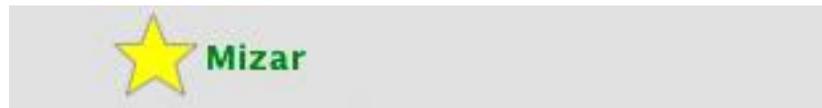


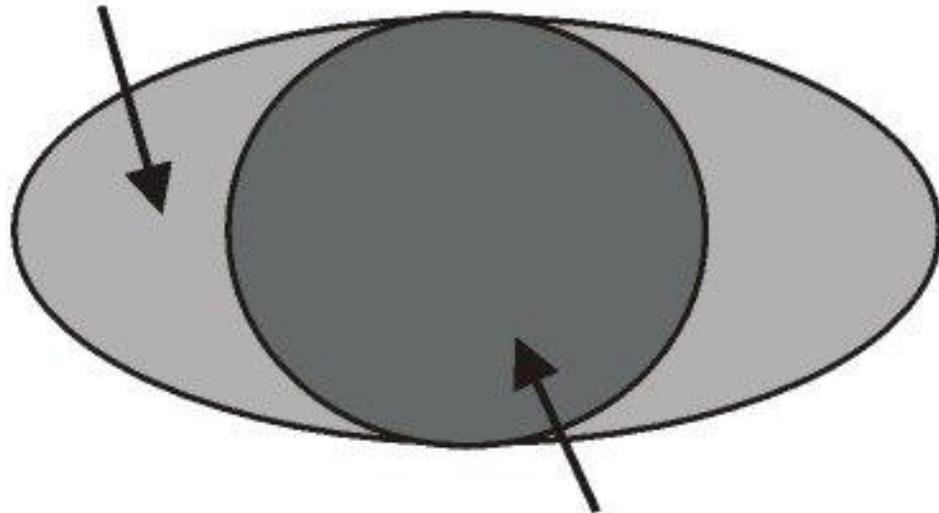
Figure 27: The text color indicates the object's visibility (green means the object is currently above horizon; black text means it is below horizon).

The object's symbol (a yellow star in Figure 25) is displayed next to the object's name. When the object's name is displayed with green-colored text, the object is presently above the horizon. Black-colored text means the object is currently below the horizon.

## Identifying Galaxies, Nebulas, and Open Clusters

At wide fields of view, galaxies, nebulas and open clusters are displayed as their standard symbols. At higher magnifications, the symbols are replaced with circles or ellipses that represent the shape and dimensions of the object. Within these extended objects, there is no marked point on which to click. If the object is displayed as a circle, you can click anywhere within the circle. For objects displayed as ellipses, click within the circular region defined by the ellipse's minor axis, as shown in the drawing below.

The ellipse defines the galaxy's extent.



Click within the circle to identify the galaxy.

Figure 28: Click inside the shaded circle to identify this extended object (galaxy).

The Andromeda galaxy (M31) is one example of an extended object. You need to click on a point towards the center of M31 – without too many nearby stars – to identify it. Click on the central region of stars to identify them.



Figure 29: The target object-specific buttons on the Find window.

### **Centering Objects on the Sky Chart (Center button)**

The **Center** button repositions the Sky Chart with the identified object at the center.

### **Framing Objects (Frame button)**

The **Frame** button repositions the Sky Chart with the identified object at the center and adjusts the field of view to show extended objects.

The default field of view for point sources (or cataloged objects that do not have size information) is 10 arcminutes. To use a different framed field width, change the Default **Frame Size when Object Size is Unknown** value on the **Non-Stellar Object Options** window from the Display menu.

**Show Photographs, HR Diagrams and Notes (Show Photo+ button)**

If the identified object has a photograph (not all objects have photographs), the **Show Photo+** button shows it in the **Photo Viewer** window (Figure 30).



Figure 30: Photo Viewer window showing a photo of Jupiter.

If the identified object is a star that has spectral class information, a Hertzsprung-Russell (HR) diagram is displayed instead. The yellow crosshairs show star's color relative to other stars.

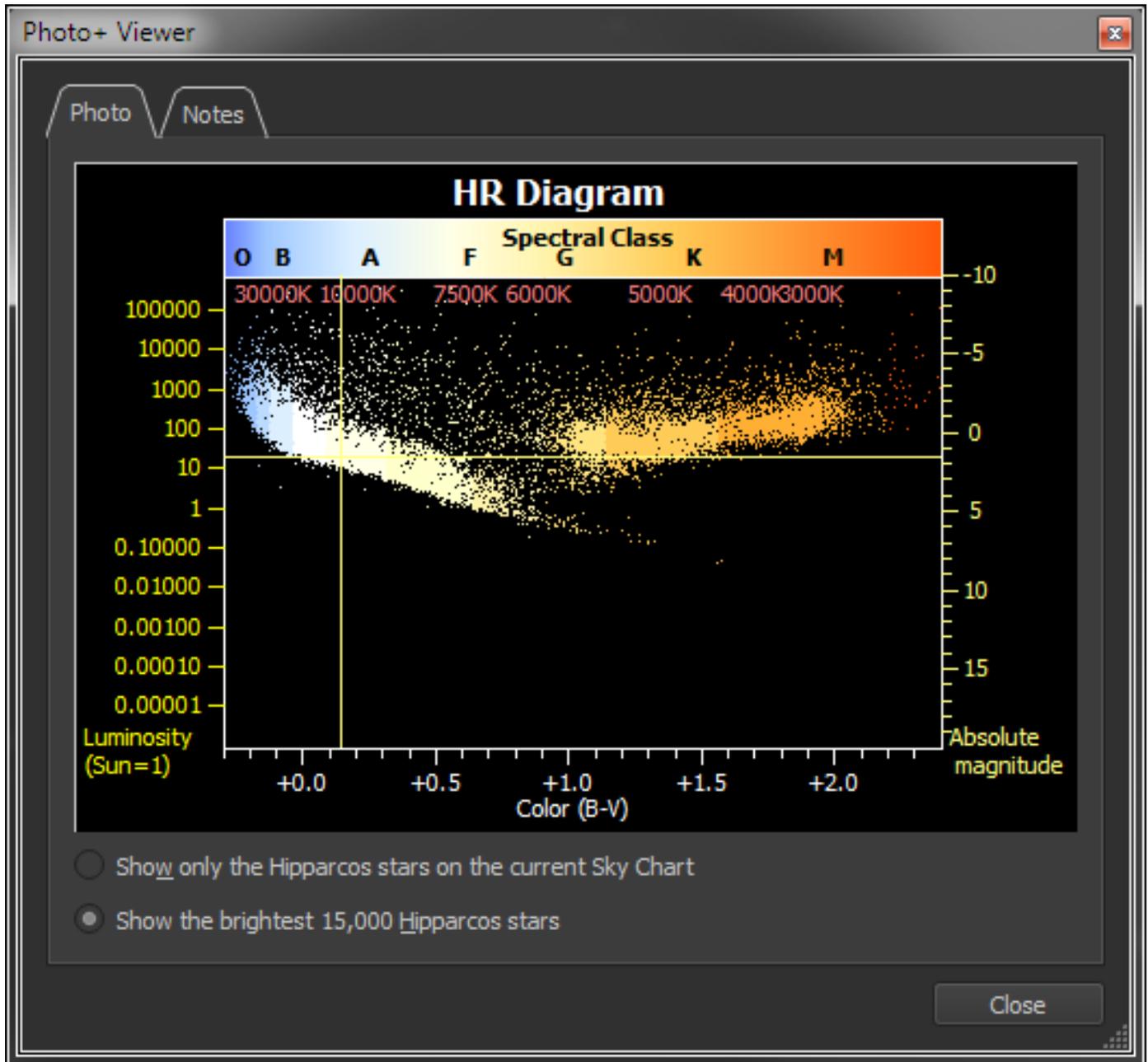


Figure 31: HR Diagram for a Hipparcos-Tycho star 68686.

**Show only the Hipparcos Stars on the Current Sky Chart**

Choose this option to graph only the Hipparcos stars that are on the current Sky Chart.

**Show the Brightest 15,000 Hipparcos Stars**

Choose this option to show the brightest stars from the Hipparcos catalog on the current Sky Chart.

**Observing and Other Notes about Objects (Notes tab)**

TheSkyX includes interesting and educational notes on the constellations, many Messier, IC and NGC objects as well as hundreds of stars.

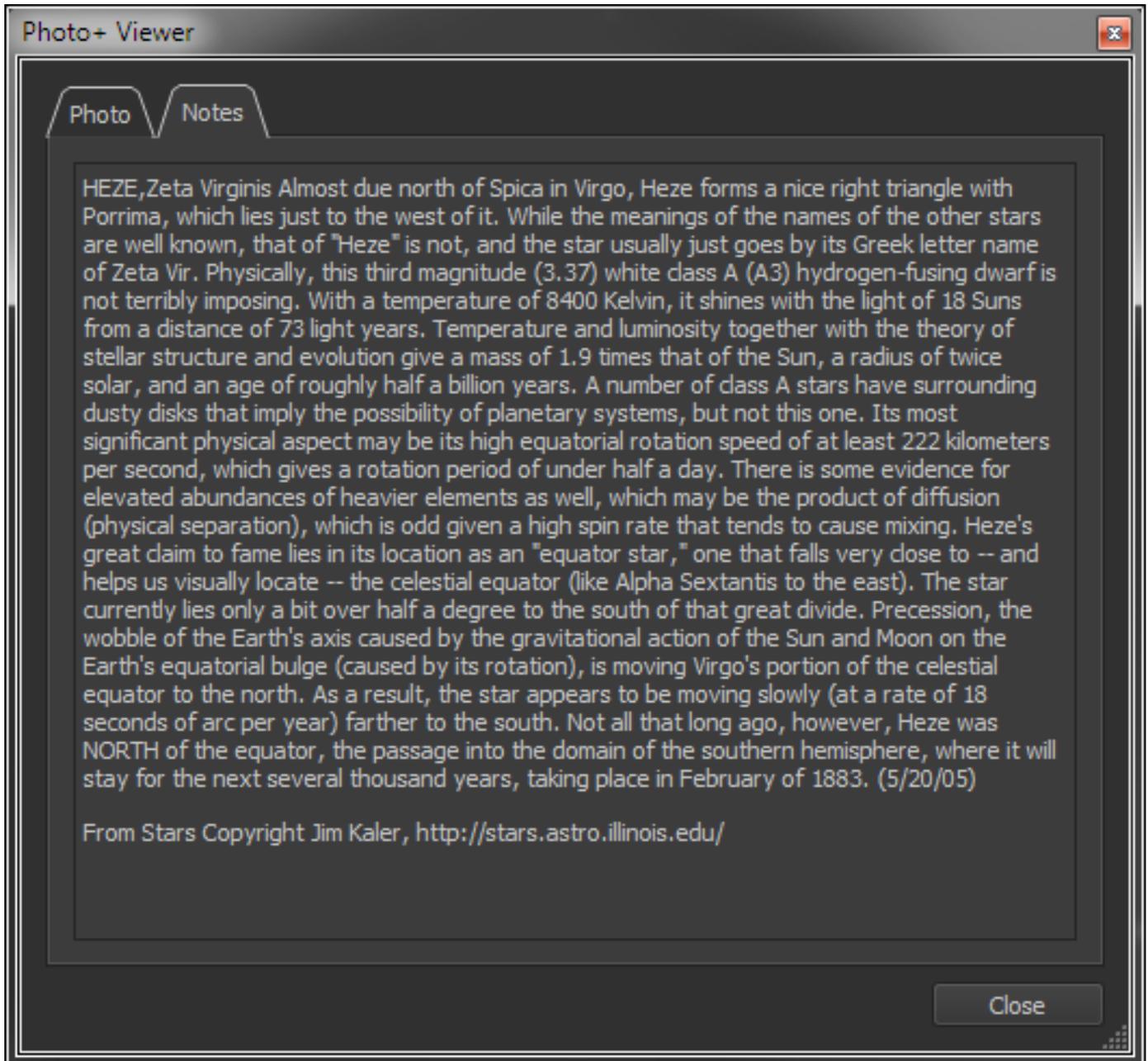


Figure 32: Notes for the star named Heze.

- Constellation notes based on the book *Star Tales* by Ian Ridpath
- Star notes from Jim Kaler (professor emeritus of astronomy, University of Illinois)
- Visual observing notes of selected objects by Steve Gottlieb
- Visual observing notes of selected objects by Tomm Lorenzin

These notes are copyrighted and distributed with permission.

***Slew the Telescope (Slew button)***

When a telescope connection is established, click the ***Slew*** button to command the telescope to slew to this object.

***Aborting Telescope Slews (Abort button)***

If you change your mind after clicking the ***Slew To*** button, click the ***Abort*** button to terminate the slew. This button is available only while the telescope is slewing.

***Copy Object Information Report to Clipboard (Copy Text button)***

To copy *all* the information in the Object Information Report to the Clipboard, click the ***Copy*** button. Or, right-click (⌘+click on the Mac) on the report and click the ***Copy Text*** command in the pop-up menu.

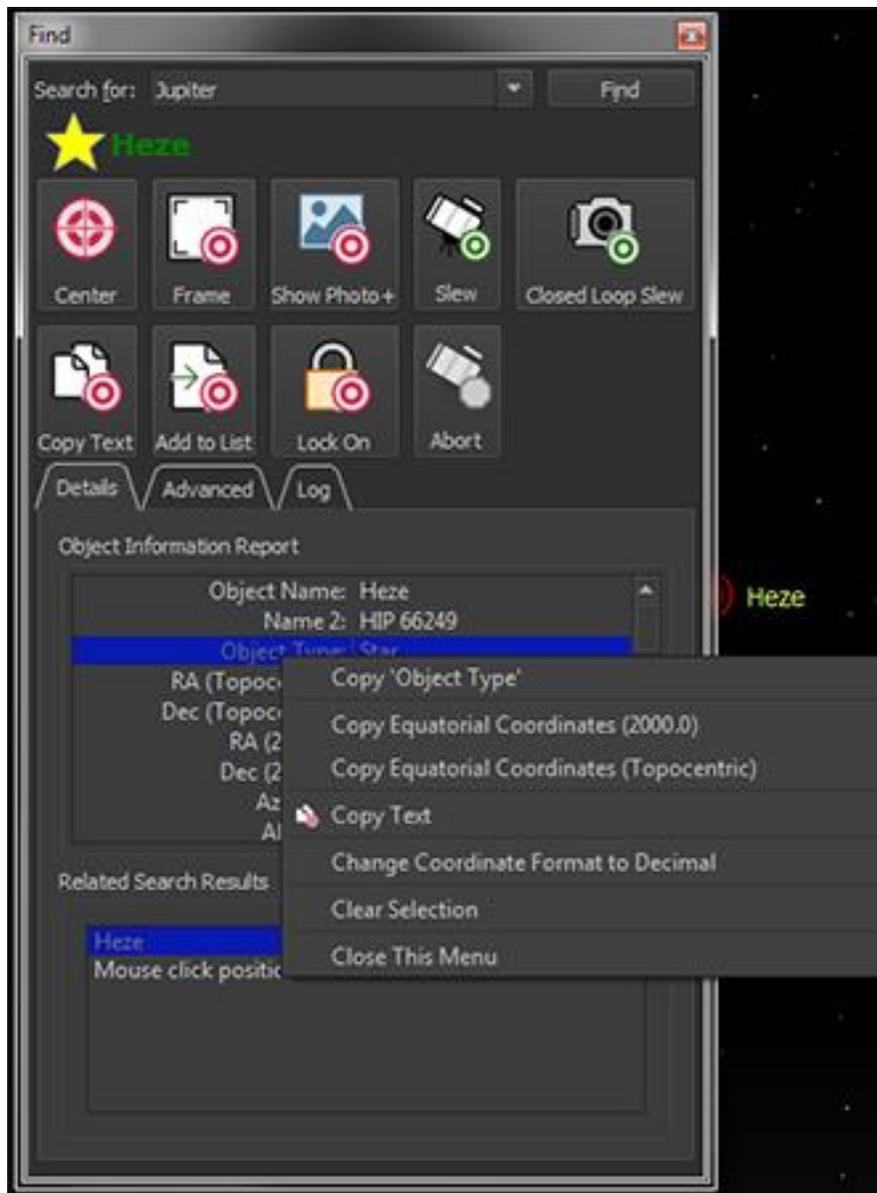


Figure 33: Right-clicking over the Object Information Report to show a context pop-up menu.

To copy the contents of a single field, move the mouse cursor over it, right-click the mouse (⌘+click on the Mac) and then click the **Copy '<Field Name>'**, where '<Field Name>' is the name of the information field beneath the mouse cursor.

Other pop-up menu commands allow copying just the equatorial coordinates (2000.0 or current), or toggling the number formatting between sexagesimal and decimal format.

### ***Adding Objects to an Observing List (Add to List button)***

TheSkyX can create an *observing list* of the objects. To add this object to the Observing List, click the **Add to List** button. See “*Observing Lists*” on page 288.

### **Locking on a Solar System Object (Lock On button)**

If the target object is a planet, moon or other solar system object, click the **Lock On** button to pin this object to the center of the Sky Chart. Locking on to a solar system object can reveal interesting phenomena. For example, the motion of Jupiter's moons can be observed by locking on Jupiter, then performing a time skip, and can be reveal when a Jovian moon's shadow is visible on Jupiter's surface (*shadow transit*, page 179) or when a moon passes behind the planet (*occultation*, page 179). The procedure described below can also be used to track the motion of other solar system objects.

### **To Observe the Motion of Jupiter's Moons**

1. Choose the **Find** command from the **Edit** menu.
2. Type **Jupiter.** in the **Search For** text box, then click the **Find** button. Note that placing a period immediately after any name in the **Search For** text box and then clicking the **Find** button automatically frames the object on the Sky Chart. If the period is omitted in the search for text, click the **Frame** button to frame the Jupiter now.
3. Click the **Lock On** button to pin Jupiter to the center of the Sky Chart.
4. Choose the **Celestial Sphere** command from the **Orientation** menu to orient the Sky Chart so that the celestial pole is toward the top of the window and Jupiter's pole always points up on the screen.
5. From the **Date & Time** window, choose a time skip increment of **1000x** (or other time skip increment), then click the **Go Forward** button to watch the motion of Jupiter's moons over time.

Figure 34 shows a “triple shadow transit” that occurred on June 3, 2014.

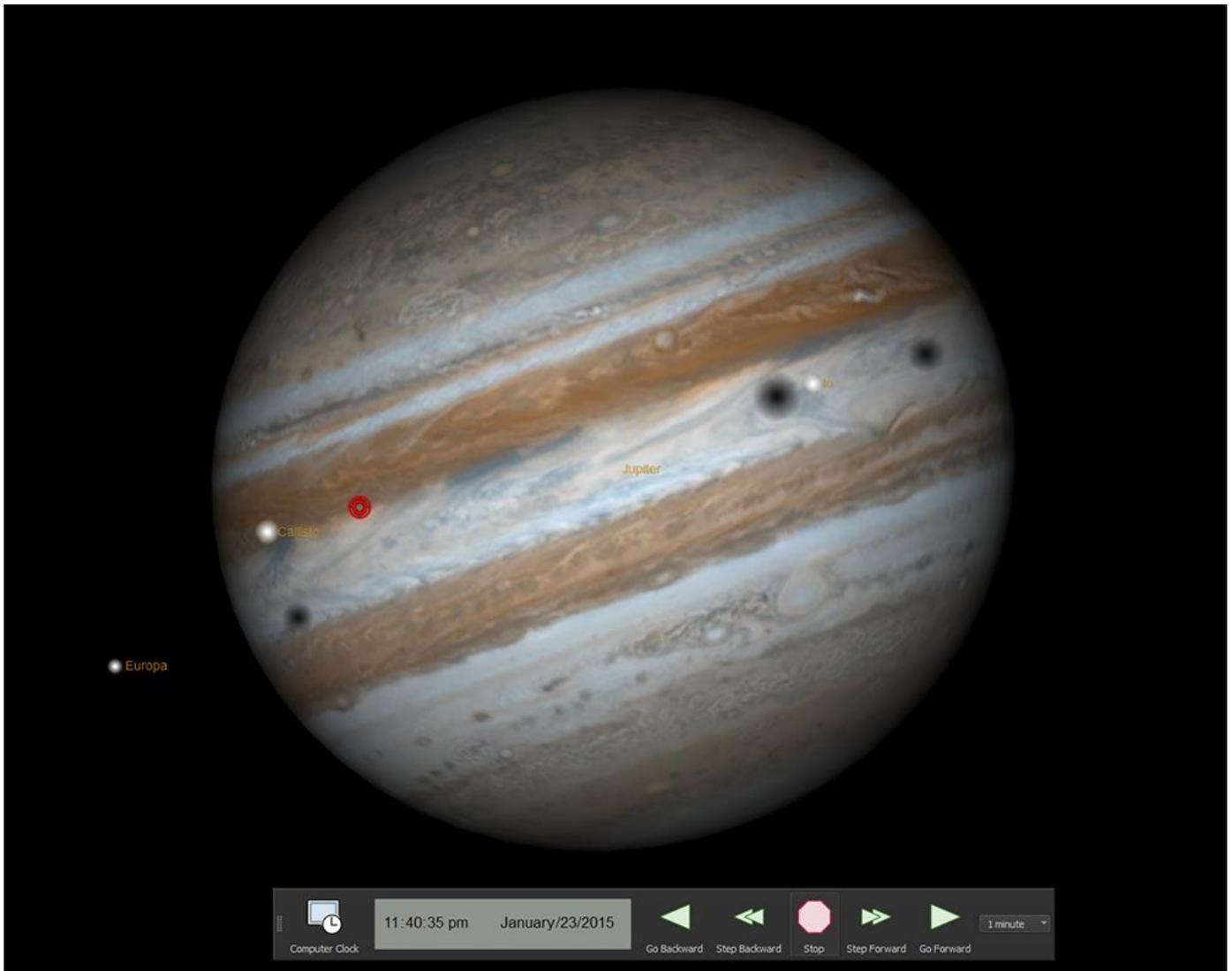


Figure 34: Sky Chart showing a triple Jovian moon shadow transit.

As a reminder, the text **Locked on <Solar System Object>** appears in the lower right corner of the Sky Chart. Left-click and drag the screen to break the lock.

Objects outside the solar system cannot be locked on.

As a reminder, the text **Locked on <Solar System Object>** appears in the lower right corner of the Sky Chart. Left-click and drag the screen to break the lock.

Objects outside the solar system cannot be locked on.

## Finding Objects

You don't have to locate an object in the Sky Chart to get information about it. The **Find** command in the **Edit** menu can locate every object in *TheSkyX's* databases.

You can also access it by pressing ⌘F, or by clicking the Find button in the Edit toolbar. Selecting the Find command displays the Find window, which provides several ways to locate any object.

### ***Finding by Name***

One way to find an object is to enter its *name* (Aldebaran, Bear Paw) in the **Search For** text input. You can enter the names of comets, minor planets, and auxiliary objects that appear in any active Sky Database.

For example, to find the Orion Nebula, type `Orion Nebula` and click the **Find** button. The Object Information report shows details about the Orion Nebula. If the Orion Nebula is within the current field of view, it's marked with a bull's eye.

You can also search for a star by manually entering its Bayer (Greek-letter) magnitude designation, followed by the constellation's three-letter abbreviation. For example, to find the third-brightest star in Orion, type `Gamma Ori`. Clicking the **Find** button locates that star, Bellatrix.

Great Nebula in Orion  
Gamma Ori

### ***If you are not sure of the correct spelling...***

Star names are Greek, Arabic, or Latin. You don't have to know the correct spelling. The Find command shows you matching names.

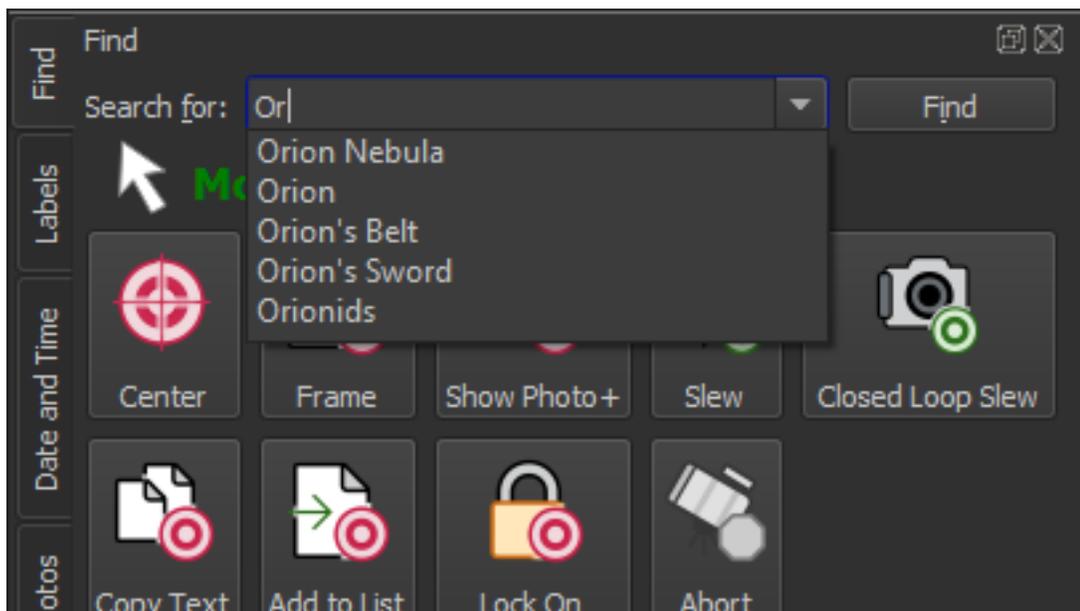


Figure 35: A list of matching names appears as you type.

For example, if you enter ‘Or’ the Search For text input shows objects that start with these letters.

### ***The Milky Way and the Magellan Clouds***

The Milky Way (our galaxy) is displayed as a photograph or draw as a polygon that can cover a significant portion of the Sky Chart. Keeping track of its boundaries in all cases would consume too many resources. It was therefore decided not to identify the Milky Way when you click inside it. At narrow fields of view, the Milky Way’s boundaries are not usually visible, and the polygon forms a solid background color. This is potentially confusing (“Is that the Milky Way or a nebula?”), so the Milky Way is not displayed at fields of view below 20°.

The Magellanic Clouds (the two smaller galaxies “attending” our galaxy) are large, complex objects. The Small Magellanic Cloud is shown as a filled ellipse and is easy to spot in the Sky Chart – it’s located at a right ascension of about 1h, not far from the south celestial pole. Type the text ‘Small Magellanic Cloud’ in the **Search For** text input and then click the **Find** button to locate it.

By default, the Large Magellanic Cloud is not shown as a specific object. To display the region in which it’s located, search for Large Magellanic Cloud. To have *TheSkyX* draw a polygon that represents this region, select the Large Magellanic Cloud Sky Database in the **Database Manager** window from the **Input** menu.

### ***Entering Catalog Numbers with the Mouse***

Because it can be difficult to type keyboard keys in the dark, *TheSkyX* includes a method for entering catalog numbers with the mouse.

On the **Advanced Find** tab, click the numbers (and the decimal point) on the right to enter numerical keys. Clicking Space enters a space. Clicking **Back** deletes the last (rightmost) character in the edit box, regardless of the current location of the text cursor.

## ***Advanced Searches***

### ***Finding by Object Type***

Objects are categorized by type in the **Find by Name or Catalog Number** list on the **Advanced** tab of the **Find** window.

A simple way to find any object is to first determine its type (is the object a star, galaxy, cluster or other?). Next, determine what catalog you want to search and then select the name of the object from the catalog list. The table below lists each category in the Find tree list.

| Object Type          | Catalog/Cross Reference       | Description   |
|----------------------|-------------------------------|---|
| Asterisms            |                               | Lists the names of many common asterisms.   |
| Constellations       |                               | Lists the names of the 88 constellations.   |
| Non-stellar Objects  |                               | Lists databases of non-stellar objects.   |
|                      | Caldwell                      | Caldwell Catalog objects.   |
|                      | Common Names                  | Names of common non-stellar objects.  |
|                      | Herschel                      | Herschel 400 catalog.   |
|                      | IC                            | Index Catalog.  |
|                      | Lorenzin                      | Tomm Lorenzin Catalog.  |
|                      | Messier                       | Messier Catalog.  |
|                      | NGC                           | New General Catalogue.  |
|                      | PGC                           | Principal Catalog of Galaxies.  |
|                      | PGC cross reference           | Cross references to the Principal Catalog of Galaxies.  |
| Sky Databases (SDBs) | Optional (non-core) databases | These optional Sky Databases (SDBs) can be turned on from the <b>Database Manager</b> command in the <b>Input</b> menu. |
|                      | Solar System                  | Objects within our solar system.  |
|                      | Meteor Shower Radiants        | Locations of meteor showers.  |
|                      | Moon                          | Earth's Moon.   |

| Object Type     | Catalog/Cross Reference   | Description   |
|-----------------|---------------------------|---|
|                 | Planets (alphabetical)    | Earth<br>Jupiter<br>Mars<br>Mercury<br>Neptune<br>Saturn<br>Uranus<br>Venus   |
|                 | Satellites                | Man-made satellites that have been imported from the Satellites window on the Input menu.   |
|                 | Small Solar System Bodies | Objects that are classified as Small Solar System Bodies by the IAU.  |
|                 |                           | Asteroids (Large Database): Names of asteroids that have been imported from the Large Database tab on the Small Solar System Bodies windows (Input menu). |
|                 |                           | Asteroids (Small Database): Names of asteroids that have been imported from the Small Database tab on the Small Solar System Bodies windows (Input menu). |
|                 |                           | Comets: Names of comets selected in the Comet tab on the Small Solar System Objects window (Input menu).  |
|                 | Dwarf Planets             | Pluto   |
|                 | Sun                       | The Sun.  |
| Stellar Objects |                           | Lists databases of stars.   |
|                 | Bayer                     | Bayer catalog designations.   |
|                 | Common name               | Common star names.  |
|                 | DM                        | Bonner Durchmusterung number.   |
|                 | Flamsteed                 | Flamsteed designations.   |
|                 | GCVS                      | General Catalog of Variable Stars.  |

| Object Type | Catalog/Cross Reference | Description                            |
|-------------|-------------------------|--|
|             | GSC                     | Guide Star Catalog.                    |
|             | HD                      | Henry Draper Number.                   |
|             | NSV                     | Catalog of Variable Stars.             |
|             | SAO                     | Smithsonian Astrophysical Observatory. |
|             | Struve                  | Struve Catalog stars.                  |
|             | WDS                     | Washington Double Star catalog.        |

### **SAC Cross References**

The Saguario Astronomy Club Database contains cross references to the astronomical catalogs in the table below.

| Catalog Name   | SAC Cross Reference |
|--|---------------------|
| Third Cambridge Catalog of Radio Wave Sources        | 3C                  |
| George Abell (planetary nebulae and galaxy clusters) | Abell               |
| Aitken Double Star catalog                           | ADS                 |
| Arp-Madore (globular clusters)                       | AM                  |
| (open clusters)                                      | Antalova            |
| Apriamasvili (planetary nebulae)                     | Ap                  |
| Halton Arp (interacting galaxies)                    | Arp                 |
| Barkhatova (open clusters)                           | Bark                |
| Barnard (dark nebulae)                               | B                   |
| (open clusters)                                      | Basel               |
| Bonner Durchmusterung (stars)                        | BD                  |
| Berkeley (open clusters)                             | Berk                |
| Bernes (dark nebulae)                                | Be                  |
| Biurakan (open clusters)                             | Biur                |
| (open clusters)                                      | Blanco              |

| Catalog Name                                     | SAC Cross Reference |
|--|---------------------|
| (open clusters)                                  | Bochum              |
| Cederblad (bright nebulae)                       | Ced                 |
| Catalog of Galaxies and Clusters of Galaxies     | CGCG                |
| Collinder (open clusters)                        | Cr                  |
| (open clusters)                                  | Czernik             |
| David Dunlap Observatory (dwarf galaxies)        | DDO                 |
| Dolidze (open clusters)                          | Do                  |
| Dolidze-Dzimselejsvili (open clusters)           | DoDz                |
| Dunlap (Southern objects of all types)           | Dun                 |
| European Southern Observatory (Southern objects) | ESO                 |
| Feinstein (open clusters)                        | Fein                |
| (open clusters)                                  | Frolov              |
| (bright nebulae)                                 | Gum                 |
| William Herschel (globular clusters)             | H                   |
| (open clusters)                                  | Haffner             |
| (open clusters)                                  | Harvard             |
| Havermeyer and Moffat (open clusters)            | Hav-Moffat          |
| Henize (planetary nebulae)                       | He                  |
| (open clusters)                                  | Hogg                |
| Holmberg (galaxies)                              | Ho                  |
| Haute Provence (globular clusters)               | HP                  |

| Catalog Name   | SAC Cross Reference |
|--|---------------------|
| Humason (planetary nebulae)  | Hu                  |
| 1st and 2nd Index Catalogs to the NGC (All types of objects except dark nebulae) | IC                  |
| Iskudarian (open clusters)   | Isk                 |
| Jonckheere (planetary nebulae)   | J                   |
| Kohoutek (planetary nebulae)   | K                   |
| Father Lucian Kemble (asterisms)   | Kemble              |
| (open clusters)  | King                |
| Krasnogorskaja (planetary nebulae)   | Kr                  |
| Lacaille (globular clusters)   | Lac                 |
| (open clusters)  | Loden               |
| Lynds (bright nebula)  | LBN                 |
| Lynds (dark nebulae)   | LDN                 |
| Northern Proper Motion, 1st part, Galaxies                                       | NPM1G               |
| (open clusters)  | Lynga               |
| Messier (all types of objects except dark nebula)                                | M                   |
| Morphological Catalog of Galaxies  | MCG                 |
| Merrill (planetary nebulae)  | Me                  |
| Markarian (open clusters and galaxies)   | Mrk                 |
| Melotte (open clusters)  | Mel                 |
| Minkowski (planetary nebulae)  | M1 thru M4          |

| Catalog Name   | SAC Cross Reference |
|--|---------------------|
| New galaxies in the Revised Shapley-Ames Catalog   | New                 |
| New General Catalogue of Nebulae & Clusters of Stars. (All types of objects except dark nebulae) | NGC                 |
| Palomar (globular clusters)  | Pal                 |
| Peimbert and Costero (planetary nebulae)   | PC                  |
| (open clusters)  | Pismis              |
| Perek & Kohoutek (planetary nebulae)   | PK                  |
| Rodgers, Campbell, & Whiteoak (bright nebulae)   | RCW                 |
| (open clusters)  | Roslund             |
| Ruprecht (open clusters)   | Ru                  |
| Sandqvist (dark nebulae)   | Sa                  |
| (open clusters)  | Sher                |
| Sharpless (bright nebulae)   | Sh                  |
| Sandqvist & Lindroos (dark nebulae)  | SL                  |
| Shapley & Lindsay (clusters in LMC)  | SL                  |
| Stephenson (open clusters)   | Steph               |
| (open clusters)  | Stock               |
| Terzan (globular clusters)   | Ter                 |
| (open clusters)  | Tombaugh            |
| Tonantzintla (globular clusters)   | Ton                 |
| Trumpler (open clusters)   | Tr                  |
| Catalog of selected Non-UGC galaxies   | UA                  |

| Catalog Name                                  | SAC Cross Reference |
|---|---------------------|
| Uppsala General Catalog (galaxies)            | UGC                 |
| United Kingdom Schmidt (globular clusters)    | UKS                 |
| (open clusters)                               | Upgren              |
| Vorontsov-Velyaminov (interacting galaxies)   | VV                  |
| van den Bergh (open clusters, bright nebulae) | vdB                 |
| van den Bergh & Herbst (bright nebulae)       | vdBH                |
| van den Bergh-Hagen (open clusters)           | vdB-Ha              |
| Vyssotsky (planetary nebulae)                 | Vy                  |
| (open clusters)                               | Waterloo            |
| Double Star (Messier 40)                      | Winnecke            |
| Zwicky (galaxies)                             | ZWG                 |

To locate objects in the SAC, in the **Search For** text input on the **Find** window, enter **SAC <Cross Reference> <Catalog Number>** and then click the **Find** button. For example, entering the text **SAC Cr 33** locates this open cluster in the Collinder catalog.

### **Finding by Catalog Designation**

Another way to find an object is to enter its *catalog designation*. Leading zeroes are not required; the search routine automatically adds them. Typing *just* the catalog abbreviation (with no number) lists the first 10 items in the catalog.

The Tycho catalog's designers indexed it with the corresponding GSC numbers. We have therefore not included it as a searchable catalog.

### **Searching Catalogs by Cross Reference**

Objects can be located using catalog designations that are cross referenced to the source catalog. The table below lists the available cross-reference catalogs and their prefixes, along with the number of galaxies in the catalog (Count) and an example of the correct format to use when search for an object in this catalog.

See Catalog Cross References in Appendix A: Databases and Cross References on page 632 for a list of these catalogs.

### More Find Examples

The following tables show a variety of useful search queries for the **Locate By Name** text box.

| Star Name    | Type of Query                              |
|--------------|--|
| Polaris      | Common star name                           |
| SAO 308      | Smithsonian Astrophysical Observatory star |
| GSC 4628:237 | Guide Star Catalog number                  |
| HIP 11767    | Hipparcos identifier                       |
| PPM 431      | Positions and Proper Motions (PPM) number  |
| HD 8890      | Henry Draper number                        |
| B+88 8       | Bonner Durchmusterung catalog              |
| C-34 12784   | Cordoba Durchmusterung catalog             |
| P-42 7856    | Cape Durchmusterung catalog                |

| Flamsteed/Bayer (use constellation abbreviation) | Result                |
|--|-----------------------|
| ALPHA UMI  | (Alpha Ursae Minoris) |
| 25 PSI 1 ORI                                     | 25 Psi 1 Orionis      |

| Non-stellar Objects       | Result                             |
|---------------------------|------------------------------------|
| Great Nebula in Andromeda | Common non-stellar object name     |
| M31                       | M31 Messier Object                 |
| NGC 224                   | NGC 224 in the New General Catalog |
| IC 434                    | IC 434 in the Index Catalog        |
| PGC 18508                 | Principal Galaxies Catalog         |
| GCVS GK ORI               | General Catalog of Variable Stars  |
| NSV                       | New Suspected Variable Catalog     |
| PLN 194+2.1               | Planetary Nebula                   |

| Solar System Objects | Result  |
|----------------------|---|
| Saturn               | Finds Saturn  |
| Wild 4               | Finds the comet named "Wild 4"  |
| Ceres                | Finds small database asteroid named "1 Ceres"   |
| MPL 835 OLIVIA       | "MPL" prefix finds that asteroid (or <i>minor planet</i> ) named "835 Olivia" from the large asteroid database. |

| Uranometria Star Charts | Result |
|-------------------------|--------|
|-------------------------|--------|

|         |   |
|---------|---|
| URA 36  | Centers on Uranometria star chart number 36   |
| URA 36+ | Centers on Uranometria star chart number 36 and sets Uranometria-like chart attributes. |

| Satellites/Spacecraft | Result  |
|-----------------------|---|
| SAT COSMOS 100        | Searches for the satellite named "Cosmos 100" |

| Miscellaneous Objects   | Result  |
|---|---|
| Zenith  | Moves to 90 degrees altitude  |
| AAVSO A   | Sets field width to AAVSO type A (accepts a-g)  |
| RA decimal hours, Dec decimal degrees                               | <p>Enter any RA, Dec coordinate pair, separated by a comma and in decimal format and click the <b>Find</b> button to locate this position on the Sky Chart and display information about it in the <b>Object Information</b> window.</p> <p>For example, enter <b>12.3, 13.4</b> to locate this coordinate on the Sky Chart.</p>  |
| RA hours RA minutes RA seconds, Dec degrees Dec minutes Dec seconds | <p>Enter any RA, Dec (2000.0) coordinate pair, separated by a comma, in <i>sexagesimal format</i>, and click the <b>Find</b> button to locate this position on the Sky Chart display information about it in the <b>Object Information</b> window.</p> <p>For example, enter <b>10h 26m 36.2s, 40d 20m 22.8s</b> to locate this coordinate on the Sky Chart. See Finding by Equatorial Coordinate below for more information.</p> |
| Z2.5  | Zooms to a 2.5-degree field of view   |
| Z2.5m   | Zooms to a 2.5-minute field of view   |
| Z200s   | Zooms to 200 arcsecond field of view  |
| SCALE 2.5   | Adjusts the sky chart so that the scale is 2.5 arcseconds/pixel   |

### **Finding by Equatorial Coordinate**

The Sky Chart can be centered on a RA, Dec coordinate (2000.0) using either decimal or sexagesimal format.

#### **Decimal format**

Enter any RA, Dec coordinate pair, separated by a comma and in decimal format and click the **Find** button to locate this position on the Sky Chart and display information about it in the **Object Information** window.

For example, enter **12.38893, 13.43345** and then click the **Find** button to locate this coordinate on the Sky Chart.

#### **Sexagesimal format**

Enter any RA, Dec coordinate pair, separated by a comma, in *sexagesimal format*:

UUh VVm WWs, XXd YYm ZZs

Each component is described in the table below.

| <b>Designation</b> | <b>Description</b>  |
|--------------------|---|
| UU                 | A number between 0-23 specifying the <i>hours</i> of RA.  |
| h                  | The lower-case letter “h” specifying the preceding number is RA hours.                          |
| VV                 | A number between 0-59 specifying the <i>minutes</i> of RA.                                      |
| m                  | The lower-case letter “m” specifying the preceding number is RA minutes.                        |
| WW                 | A number between 0-59.99999 specifying the <i>seconds</i> of RA.                                |
| s                  | The lower-case letter “s” specifying the preceding number is RA seconds,                        |
| ,                  | A comma character (“,”) separates the RA coordinate from the Dec coordinate.                    |
| XX                 | A number between 0-89 specifying the <i>degrees</i> of declination.                             |
| d                  | The lower-case letter “d” specifying the preceding number represents degrees of declination.    |
| YY                 | A number between 0-59 specifying the <i>minutes</i> of declination.                             |
| m                  | The lower-case letter “m” specifying the preceding number represents arcminutes of declination. |

|    |   |
|----|---|
| ZZ | A number between 0-59.99 specifying the <i>seconds</i> of declination.                                |
| s  | The second lower-case letter “s” specifies the preceding number represents arcseconds of declination. |

Sexagesimal format example:

10h 12m 32.22s, -80d 12m 44.3s

### Logging Observations

Click the **Log** tab on the **Find** window to view the observing log and notes for this object.

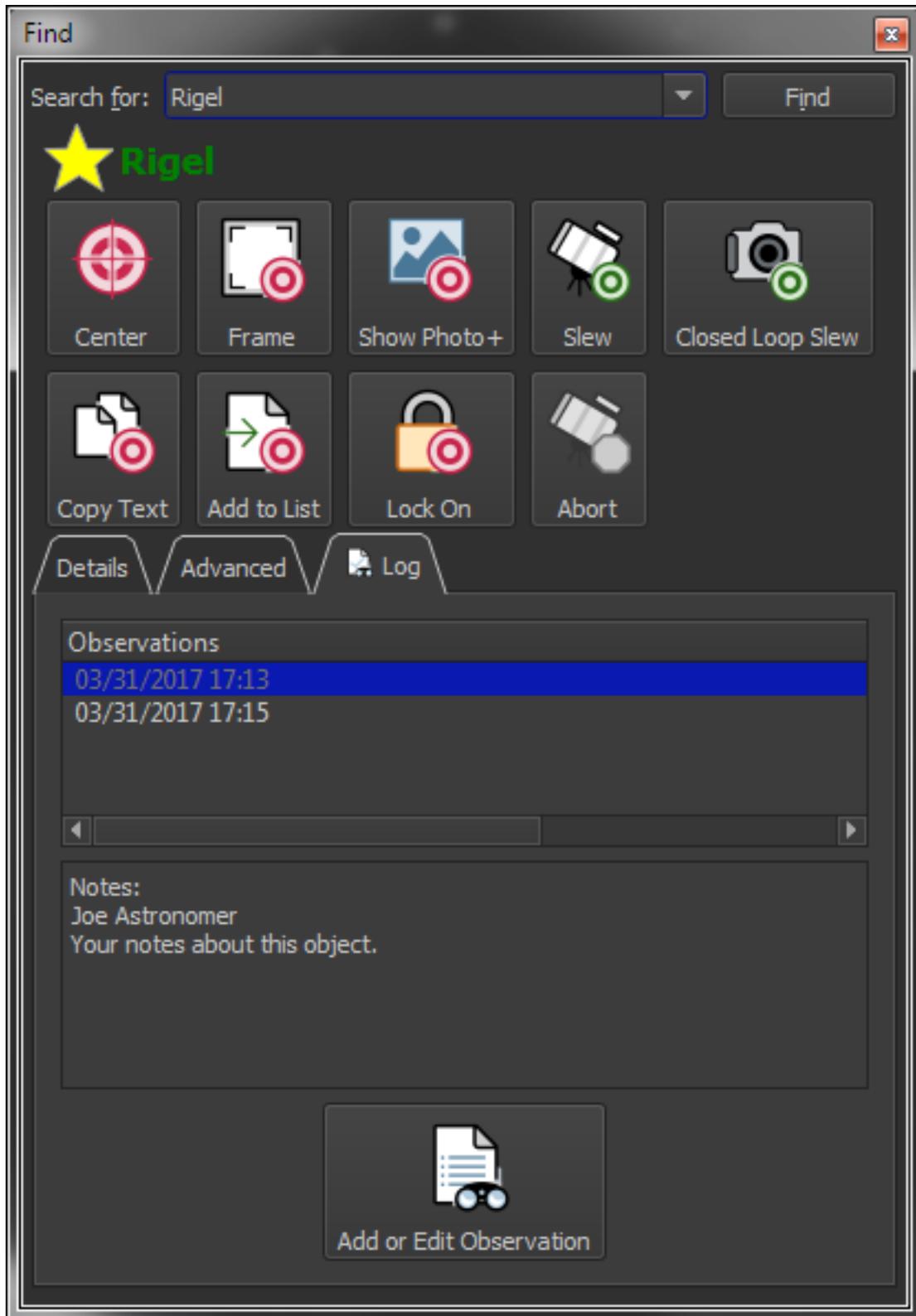


Figure 36: The Log tab on the Find window showing an observation notes for a star.



Click the **Add or Edit Observations** button to show the **Observer Log** window that allows you to add notes, a seeing scale, rating and other information for the current object, and view a table of your observations.



Note: The object observed graphic (above) appears on the **Log** tab for objects that have a recorded observation.

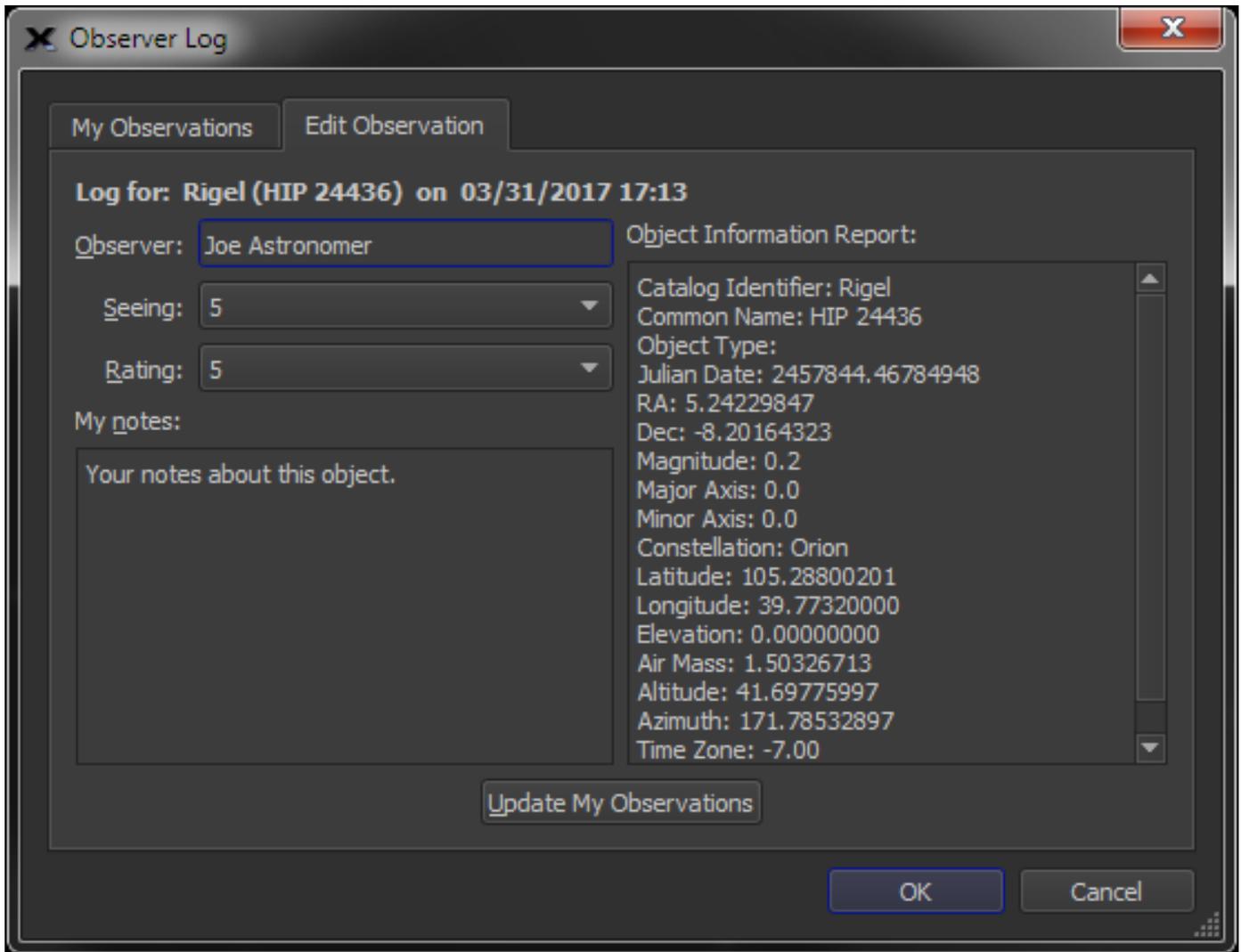


Figure 37: Observer Log window.

Observations are stored in XML format in the **Observer Log** folder located in the Application Support folder (page 26). See “Add Observing Notes (Add to Observer Log)” on page 296 for more information about Observer Logs.

## Labeling Objects



Figure 38: Common star, Bayer and Flamsteed designation labels near the Pleiades Nebula (M45).

The first time *TheSkyX* runs, the common names for the planets are shown. To show the names of other objects, select the **Labels** command from the **Display** menu to turn on the **Labels** window or click the **Labels** tab to make it visible.

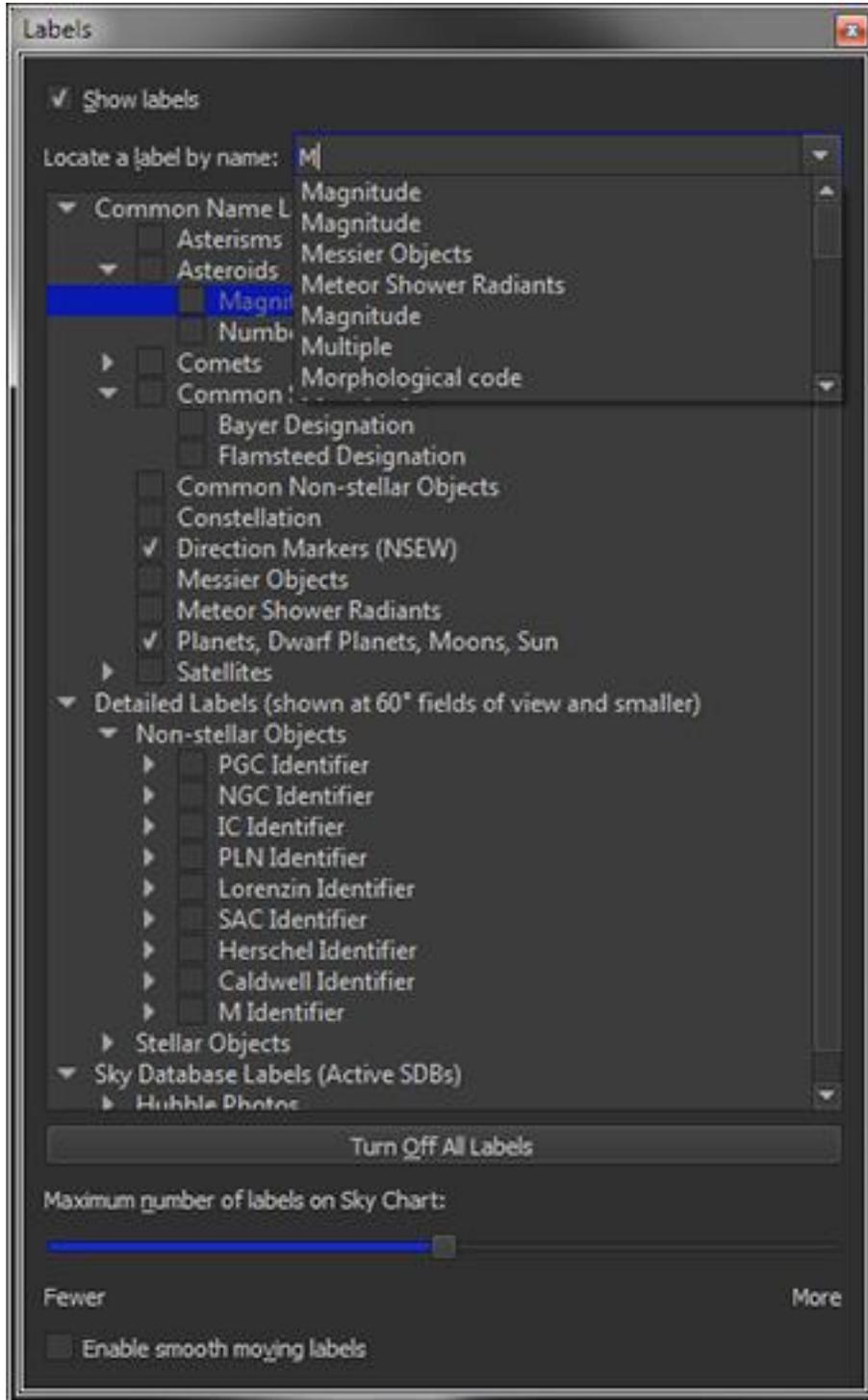


Figure 39: The Labels window (Display menu > Labels command).

The Labels window allows you to show or hide the names of the following common objects.

- Asterisms
- Asteroids (Name, Magnitude and Number)
- Comets
- Common Star Names
- Bayer Designation
- Flamsteed Designation
- Common Non-stellar Object Names
- Constellations
- Cardinal Directions
- Messier Objects
- Meteor Shower Radiants
- Planets, Dwarf Planets, Moons and the Sun
- Spacecraft or Artificial Satellites (Name, Range and Latitude/Longitude Position)
- Detailed and customizable catalog specific labels

Turn on the checkbox next to the desired common label to show it. Turn off the checkbox to hide the label.

## Detailed Labels



The astronomical catalogs used by *TheSkyX* also contain catalog-specific information that might be useful to show on the sky chart. **Detailed Labels** can also be shown for star and non-stellar catalogs and custom Sky Databases (SDBs).

For example, if you're working with double stars, you can show a detailed label that contains the magnitude and angular separation between star systems in Washington Catalog of Double stars by expanding **WDS** in **Stellar Objects** section under **Detailed Labels**.

Or, if you're researching galaxies in the New General Catalogue (NGC), you might want to show a detailed label that includes blue magnitude and equatorial coordinates (**Detailed Labels > Non-stellar Objects > NGC Identifier** group).



Detailed labels are shown on the Sky Chart at 60° fields of view and smaller.

### ***Showing Labels (Show Labels)***

This checkbox shows or hides the check marked labels.

### ***Finding a Specific Label (Locate a Label by Name)***

Use this text input to quickly locate (and turn on or off) a common name or detailed label in the labels tree. For example, to turn on Messier labels, type “m”; the labels that begin with this letter appear in the pop-up menu. Select **Messier Objects** to expand the labels list and show the **Messier Objects** checkbox. Pressing the TAB key highlights the checkbox

### ***Turning Labels Off (Turn Off All Labels)***

Press this button to turn off the **Show Labels** checkbox and turn off every checkbox in the labels list.

### ***Label Density (Maximum Number of Labels on Sky Chart)***

Adjust this slider to change the number of labels that will appear on the Sky Chart at one time.

### ***Label Size (Label Scale Factor)***

The default size of all chart element labels can be scaled from 80 percent to 200 percent. This option is especially useful for making fonts larger on high-resolution or “High DPI” displays.

### ***Anti-aliased Labels (Enable Smooth Moving Labels)***

When this checkbox is turned on, the font used to display labels is “anti-aliased” so that the motion of the label, particularly during time skip animations, is smooth. When this option is turned off, you might notice an otherwise slight “jerky motion” of fonts during animations.

## **Tours**



Before we investigate the various menu and “button” commands arranged across the top of the screen, let’s explore some of the tours that have been created to demonstrate some common yet fascinating things you can see in the sky.

Notice the series of tabs running vertically on the right side of the main. Select the tab labeled **Tours**. If this window is not visible, click the **Tours** command from the **Display** menu to show it. A list of available tours is displayed:

- Analemma
- Angular size of Mars
- Coordinates – Equatorial
- Coordinates – Horizon
- Mercury evening visibility
- Mercury morning visibility
- Moon cycle – size and phase
- Motion of Barnard’s Star
- 24-Hour Motion of Saturn’s Moons
- Rotation and Phase of Mercury 2008
- Rotation and Phase of Venus 2008
- Saturn from Earth Over 10 Years
- Venus and Mercury Paths
- What Was That? (Iridium Flare Example)
- Winter Constellations

Go ahead and take one of the tours. Highlight one that sounds interesting, then click the **Start** button. Or, click the **Run All** button to watch them consecutively.

## Creating Tours

### PROFESSIONAL

*TheSkyX Professional Edition* provides a powerful interface that can be used create *tours* that simulate astronomical events, highlight interesting objects, or demonstrate astronomical concepts.

A tour is based on a timeline that can be as long or as short as you want. Any number of *waypoints* can be added to the timeline at which you can “show something” (for example, turn on the constellation lines) or “do something” (for example, perform a 100-year time skip simulation) by executing a *macro command*. One, or any number macro commands can be executed at each waypoint, providing a virtually unlimited set of tools to create educational demonstrations. Tours can be saved later in QuickTime movie format.

To get started, let’s look at one of the supplied tours.

1. Highlight the **Winter Constellations** tour on the **Tours** window. Click the **Tours** command from the **Display** menu to show this window if necessary. This displays the **Tour Information** tab.

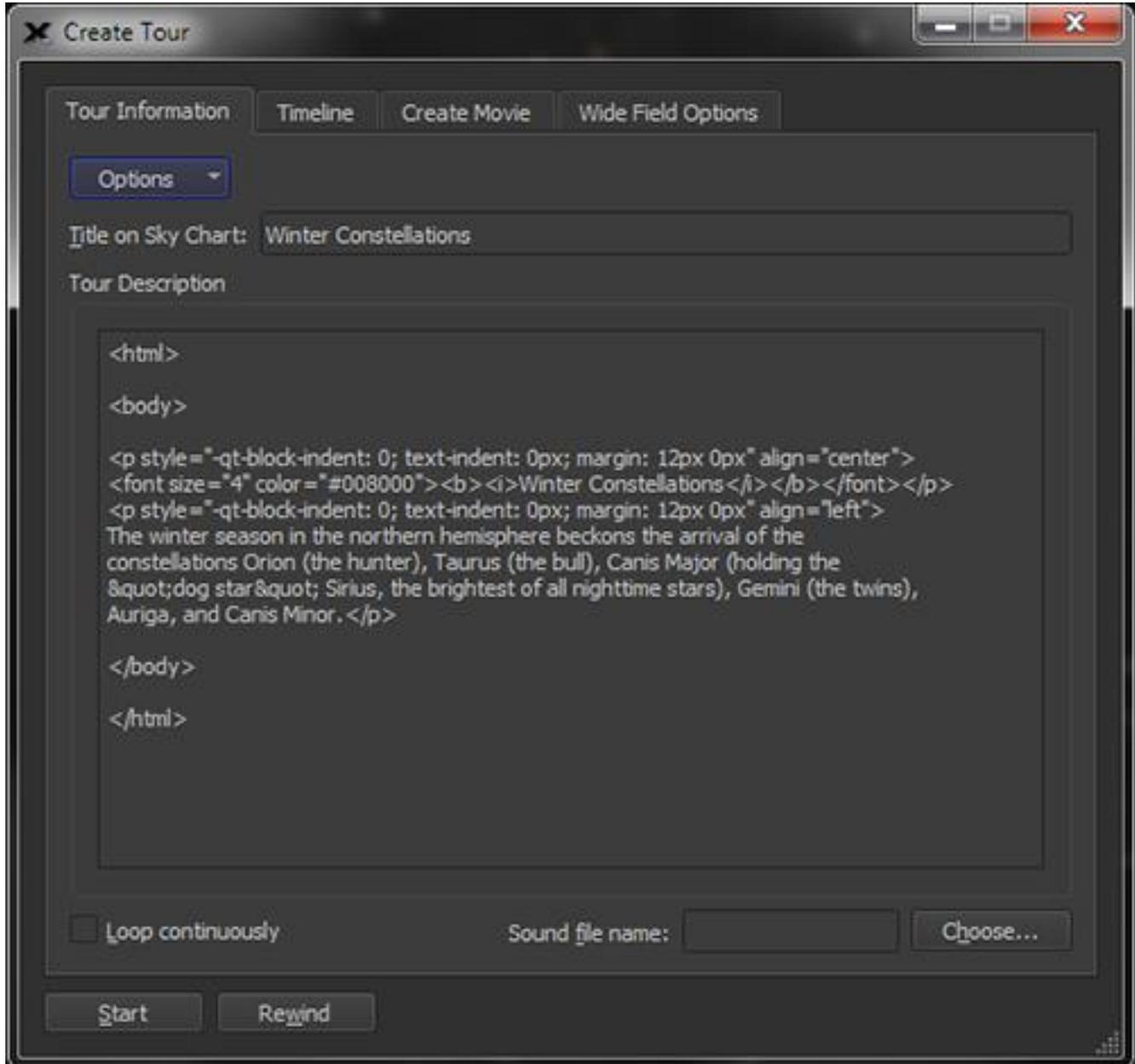


Figure 40: The Tour Information tab on the Create Tour window.

2. Enter the title of the tour in the **Title on Sky Chart** text input. This text will appear at the top of the Sky Chart while the tour is running.
3. Enter a **Tour Description** as plain text or HTML. This description appears on the **Tours** window when the tour name is highlighted.

4. To play a sound at the beginning of the tour, click the **Choose** button and select the file. Turn on the **Loop Continuously** checkbox to play the tour repeatedly.
5. Drag the tour time pointer to 0 seconds or click the **Rewind** button to go to the beginning of the tour. The **Macro Commands at Waypoint** text input now shows the four macros that will be run when the tour begins. See “Appendix D: Macro Commands” on page 653 for a complete list of available macro commands.
6. Drag the time pointer under each red arrow to reveal the macro commands for that waypoint.
7. Click the **Rewind** button, then the **Start** button to watch the entire tour.

## **Options Pop-up Menu**

### ***New Tour***

Select this command to reset the tour parameters to default settings.

### ***Open Tour***

Select this command to choose a tour file name to open.

### ***Save Tour/Save Tour As***

Saves the current tour to the Tours folder in the “Application Support Files” folder (page 26). Save As lets you use enter a different name for the tour file.

### ***Copy Tour***

Copies the tour to the Clipboard as text.

### ***Paste Tour***

Pastes a tour-formatted text file from the Clipboard.

The next step is to define the timing of the tour on the **Timeline** tab.

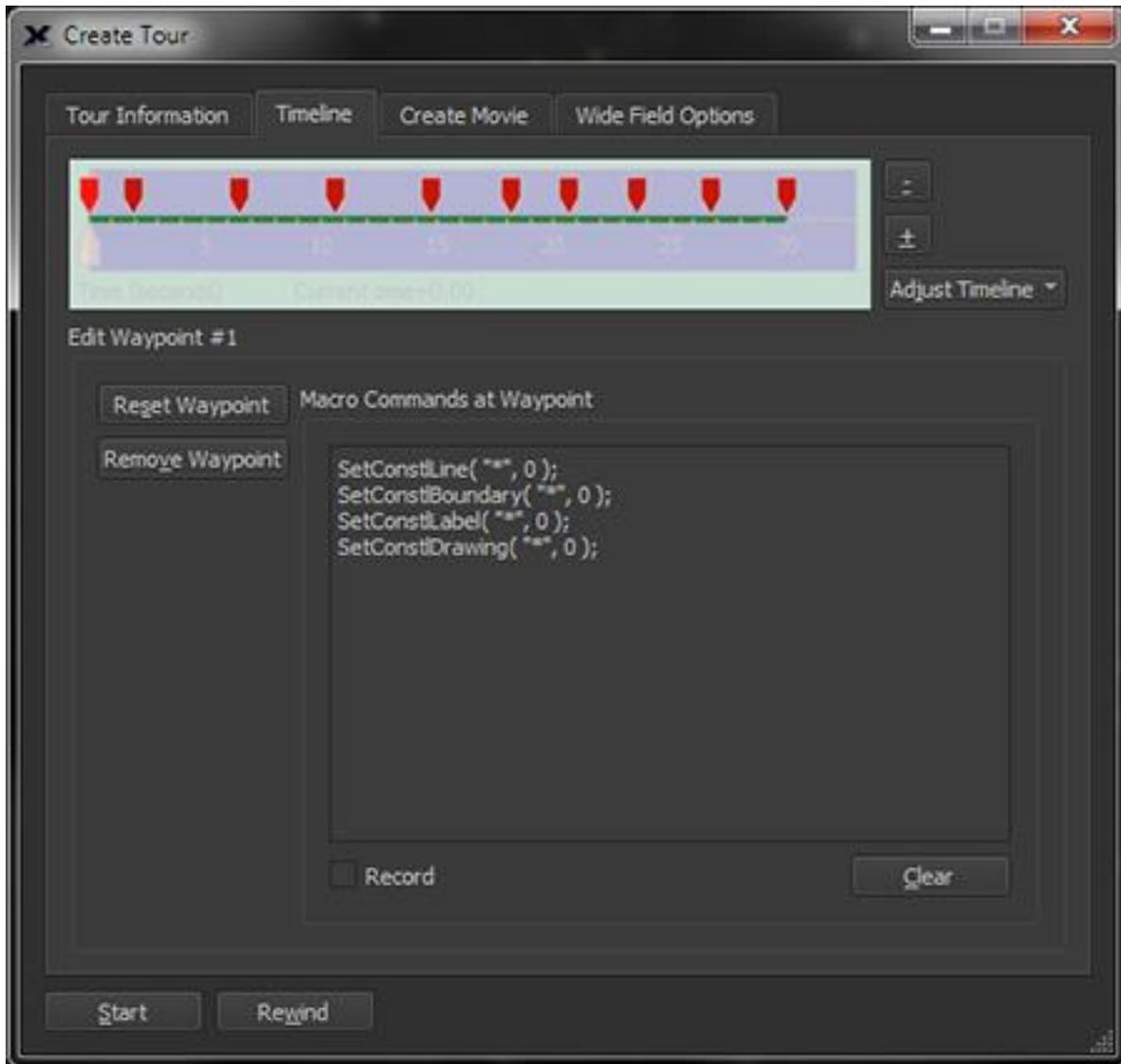


Figure 41: The Timeline tab.

The green line on the timeline graphic shows the length of the tour, in seconds. A red arrow on the top of the timeline represents the position of a waypoint. Dragging the gray, upward pointing *tour time pointer* (positioned at 0 seconds in Figure 41) lets you advance to a specific time in the tour.

The *Winter Constellations* tour is 30 seconds long. Click the + button to expand the timeline, or the – button to shorten it. This tour also includes ten different waypoints (indicated by a red pointer on the top of the timeline). Each waypoint represents a point of transition in the tour.

Defining a new waypoint is easy, just drag the tour time pointer to the desired time and then click the **Add Waypoint** button. When the tour time pointer is positioned beneath a waypoint, the button text **Reset Waypoint** appears instead.

| Macro                       | Explanation  |
|-----------------------------|--|
| SetConstLine( "*", 0 );     | <p>Show or hide constellation lines.</p> <p>Argument 1 is either constellation's abbreviation in quotation marks ("Ori"), or an asterisk in quotes "*" to indicate all constellation lines.</p> <p>Argument 2 defines how to show the constellation lines. A 1 means to turn on the constellation(s), a 0 turns them off.</p>                                  |
| SetConstBoundary( "*", 0 ); | <p>Show or hide constellation boundary lines.</p> <p>Argument 1 is either constellation's abbreviation in quotation marks ("Ori"), or an asterisk in quotes "*" to indicate all constellation boundary lines.</p> <p>Argument 2 defines how to show the constellation lines. A 1 means to turn on the constellation boundary lines on, a 0 turns them off.</p> |
| SetConstLabel( "*", 0 );    | <p>Show or hide constellation labels.</p> <p>Argument 1 is either constellation's abbreviation in quotation marks ("Ori"), or an asterisk in quotes "*" to indicate all constellation lines.</p> <p>Argument 2 defines how to show the constellation labels. A 1 means to turn on the constellation label(s) on, a 0 turns them off.</p>                       |
| SetConstDrawing( "*", 0 );  | <p>Show or hide constellation drawings.</p> <p>Argument 1 is either constellation's abbreviation in quotation marks ("Ori"), or an asterisk in quotes "*" to indicate all constellation lines.</p> <p>Argument 2 defines how to show the constellation labels. A 1 means to turn on the constellation drawing(s) on, a 0 turns them off.</p>                   |

### **Adjust Timeline Pop-up Menu**

Use the commands in the **Adjust Timeline** pop-up menu to add or remove time from the tour.

- **Scale Time to Pointer** adjusts the length of the tour based on the current position of the time slider.
- **Remove Before Pointer** resets the start of the tour to the current position of the time slider and removes all waypoints before this position.

- **Remove After Pointer** resets the end of the tour to the current position of the time slider and removes all waypoints after this position.
- **Mirror** creates a mirror image of the timeline and waypoints.

### **Clear Button**

Click this button to remove all text from the **Macro Commands at Waypoint** text input.

### **Record**

When the **Record** checkbox is turned on, the macro commands necessary to perform an action are displayed as you perform them. For example, clicking **Display > Horizon & Atmosphere Options** and turning off the **Show Horizon** checkbox shows:

```
setVisible("Horizon", 0);
```

Note that you can access any of *TheSkyX's* celestial object types in macro arguments by name. For example, instead of "Horizon" as argument 1, you can turn the *meridian line* on or off by using the text "Meridian" as the first argument instead. See "Customizing Chart Elements" on page 236 and the Chart Elements window for the complete list of permitted object type names.

### **New Tour**

Click this button to start a new tour.

### **Start/Pause/Resume**

The text on this button changes depending on current position of the tour time pointer. When the pointer is at 0 seconds and the tour is not playing, click **Start** to begin playing the tour. When the tour is playing, click **Pause** to stop it. Click **Resume** to play the tour from the current position of the tour time pointer.

### **Rewind**

Resets the tour time pointer to the beginning of the tour.

## **Create Movies**

Once your tour is complete, you can create a QuickTime™ movie from the **Create Movie** tab. Windows users will have to install QuickTime (available free from Apple's web site) to use this feature.

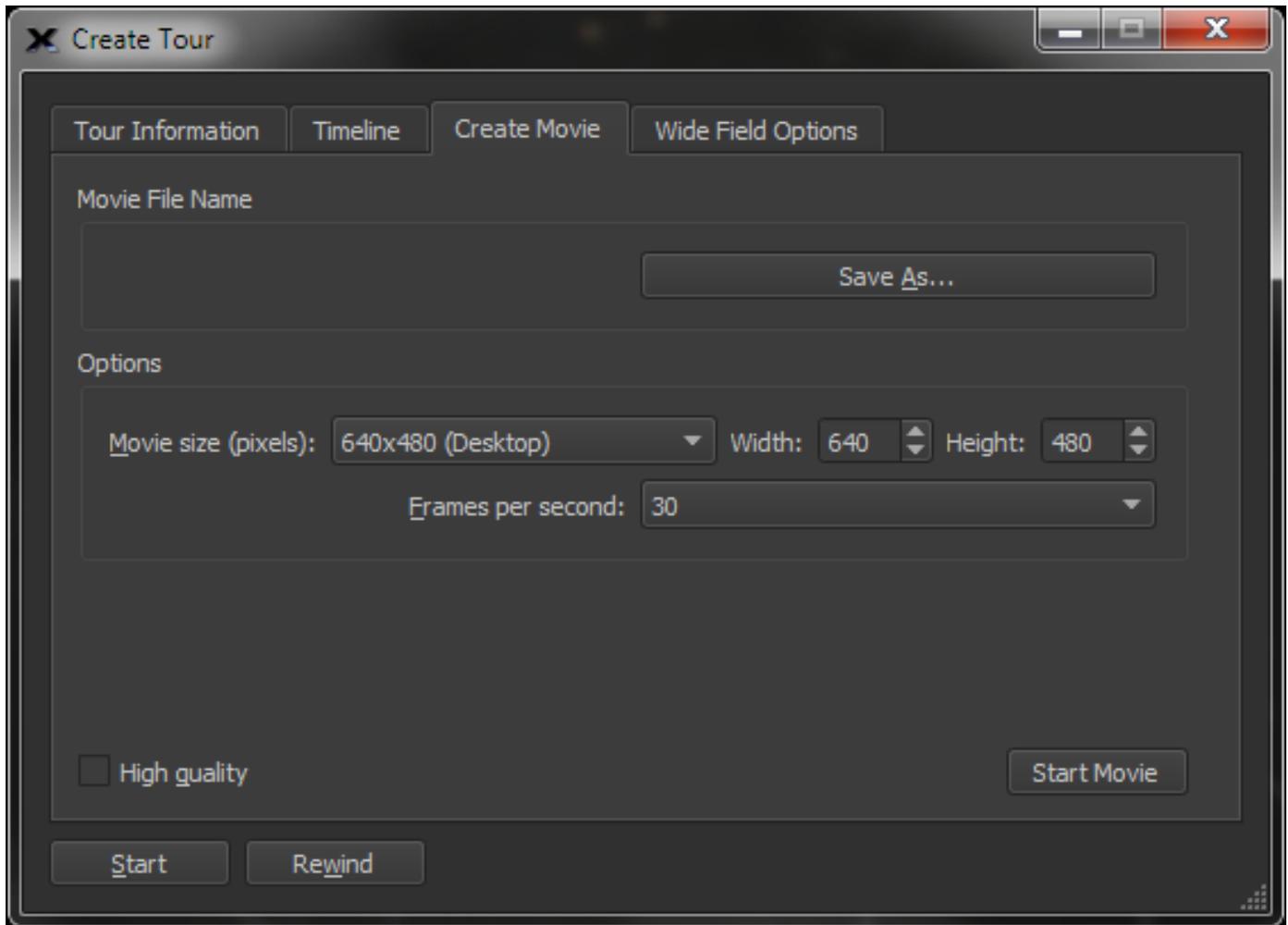


Figure 42: The Create Movie tab on the Create Tour window.

### **Movie File Name**

Displays the file name of the movie that will be created. Click the **Save As** button to specify a different file name.

### **Save As Button**

Click this button to enter the name of the movie.

### **Options**

The resolution and frame rate of the movie is configurable to your audience.

### **Movie Size (Pixels)**

Select the resolution of movie from the **Movie Size** list.

- 320x240 (iPod Classic)
- 640x480 (Desktop)
- **480x272 (PSP)** Sony PlayStation Portable™ format

- 480x320 (iPhone/iPod Touch)
- 800x600

### ***Frames per Second***

Select the number of frames, or frequency to capture the Sky Chart when creating the movie. The higher the frames per second, the better the quality at the expense of a larger movie file.

### ***High Quality***

Turn this radio button on to configure high quality QuickTime movie settings.

### ***Create Movie***

Click this button to create the movie. The length of time it takes create the movie depends on the length of the tour, the resolution and frame rate settings, as well as the speed of your computer.

## **Photos of the Deep Sky**

Since the middle of the 19<sup>th</sup> century astronomers have been taking pictures of the sky. In recent years, digital imaging sensors have replaced film to capture even more remarkable views of the Moon and planets, as well as star clusters, nebulas, and galaxies. Relatively modest amateur telescopes, equipped with digital cameras, can capture images that rival the best photographs taken by professional observatories just a couple of decades ago.

*TheSkyX* has a veritable art gallery's worth of fantastic space images you can look at any time. Browsing these images will give you a taste of the extraordinarily diverse number of objects that populate the night sky.

### ***Viewing Astronomical Photos***

In the stacked windows, you'll see a tab called ***Photos***. Select it. (Select the ***Photos*** command from the ***Display*** menu to show this window if necessary.)

In the window that opens, you'll see two items, ***Photo Groups***, and ***NGC/IC Digitized Sky Survey Photos***. NGC/IC stands for New General Catalogue/Index Catalog. These are two of the most popular catalogs astronomers use to keep track of the huge number of celestial objects they've been studying over the centuries.

As you scroll through the list of objects, a small picture of each will be displayed below the list. Click the ***Show in Photo Viewer*** option to view them in a separate window.

## Placing Photos

### PROFESSIONAL

TheSkyX Professional Edition's **Place Photo** command lets you create and manage individual or groups of photographs and provides tools to precisely position each photograph on the Sky Chart. In short, there's everything you need to show off your "in-place" photos.

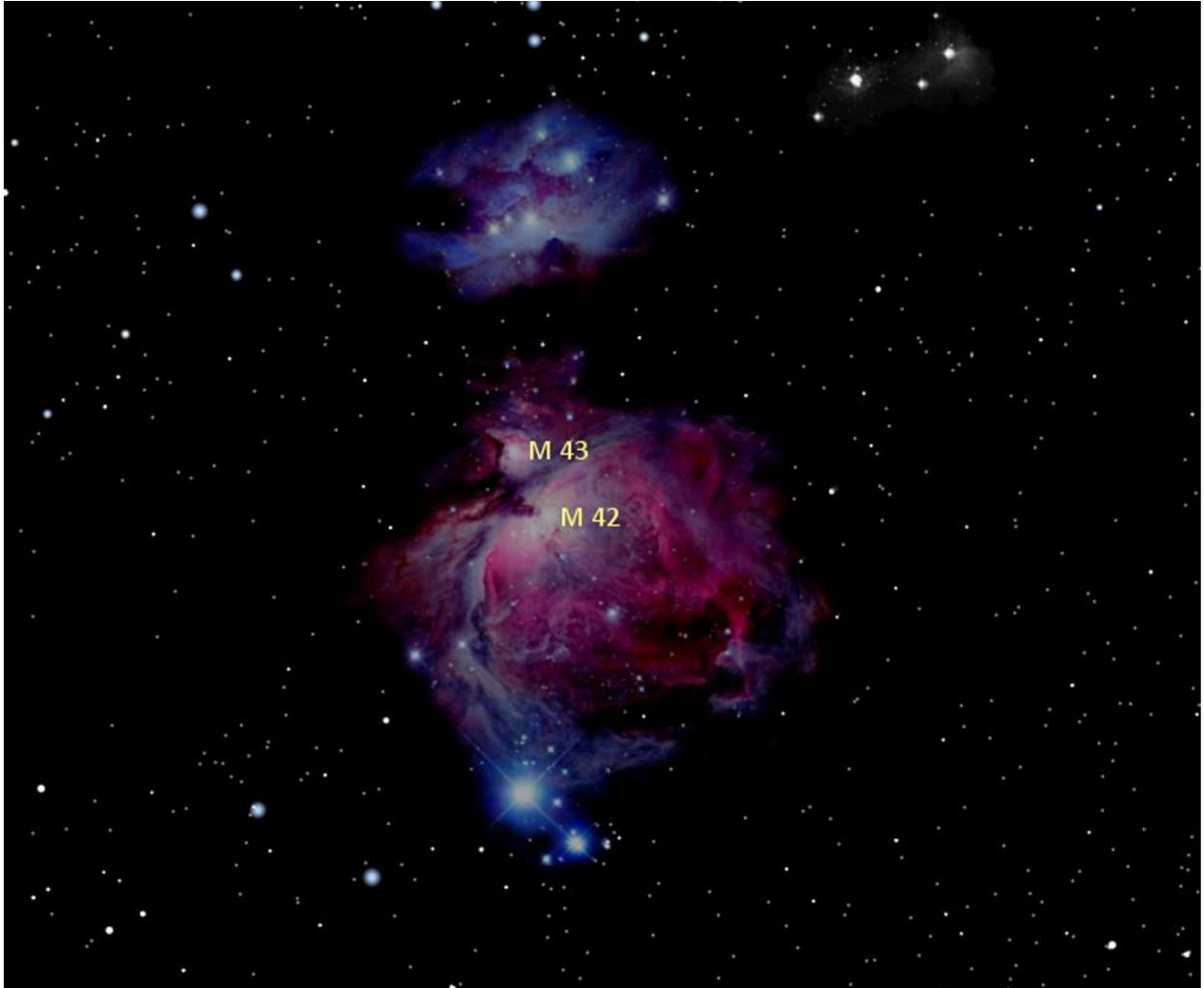


Figure 43: Sky Chart showing in-place photo of the Great Nebula in Orion (M42).

The Bevis constellation drawings are one example of one Photo Overlay Group that is included with *TheSkyX*. The **Deep Sky Overlays** is another.

## Creating a Photo Group

To create a photo group from your collection, start by copying all the photos to a single folder on your computer. Note that *TheSkyX* can show *GIF*, *JPG*, *TIFF* and *PNG* file formats. The *PNG* format works well since it can have a transparency layer and is compressed.

We'll use the **Messier Overlay** photos as a "collection" to demonstrate how to create a photo group. On the Mac, *TheSkyX's* resources are stored inside the *application bundle*, so these photos are not readily accessible or visible from Finder. If you are familiar with accessing files in an application bundle, you'll find the files in this example in the folder named:

*TheSkyX Professional Edition.app/Contents/Resources/Common/Photos/SDBs/Messier Overlays*

If you'd like to follow along, you can make a copy of these files in a folder on your desktop. On Windows, these files are located, by default, in the following folder:

```
C:\Program Files\Software Bisque\TheSkyX <Edition Name Here>\
Resources/Common/Photos/SDBs/Messier Overlays
```

Where *<Edition Name Here>* is either *TheSkyX Serious Astronomer Edition* or *TheSkyX Professional Edition*.

1. To avoid confusion, first turn off the existing Messier Overlays Photo Group by clicking the **Database Manager** command from the **Input** menu, and turning off the checkbox next to **Messier Overlays** in the **Photo Databases** node under **Sky Databases**, then click **Close**.
2. Select the **Place Photo** command from the **Input** menu to show the **Place Photo** window.

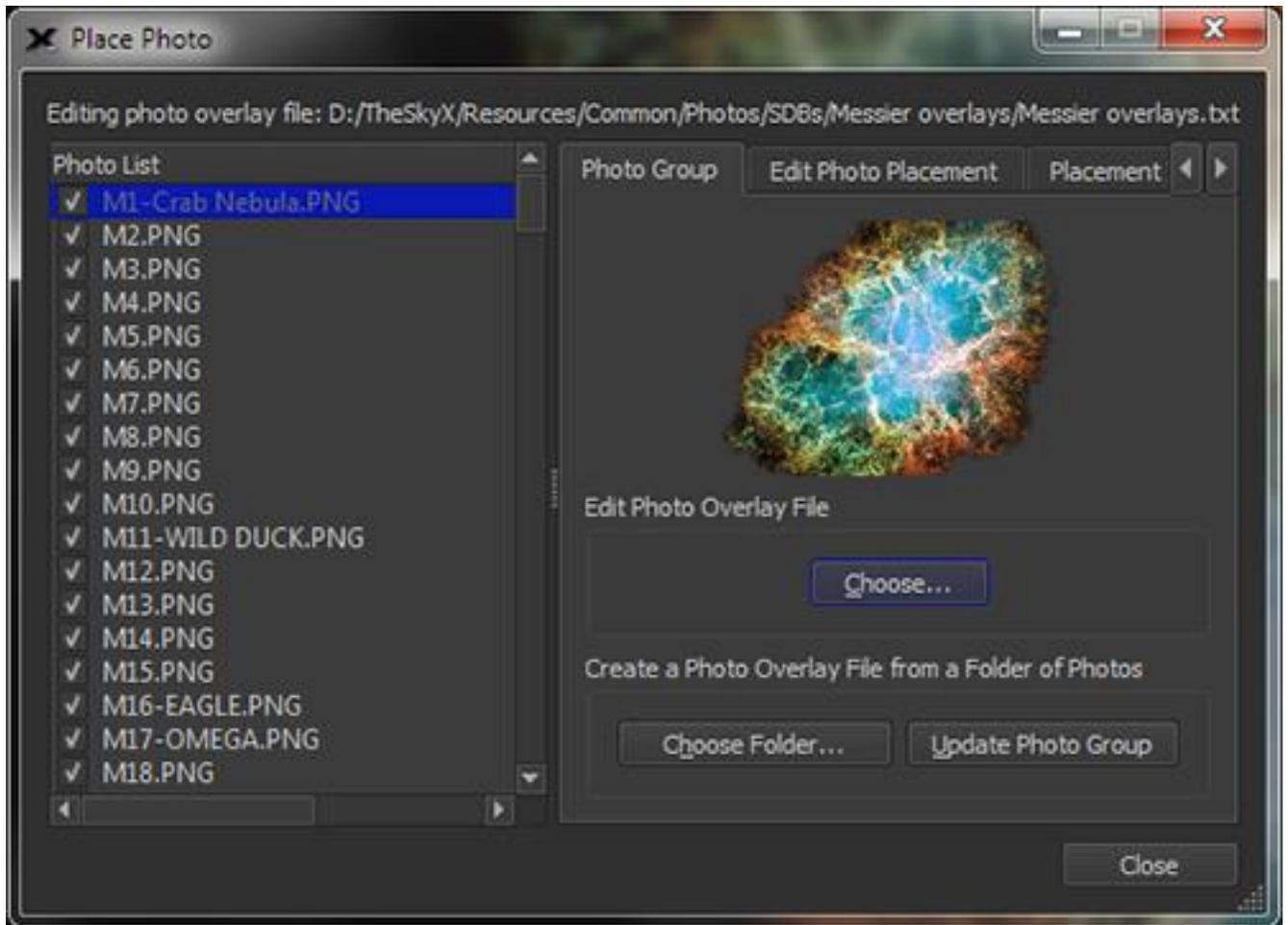


Figure 44: Photo Group tab on the Place Photo window (Input menu).

3. On the **Photo Group** tab, click the **Choose Folder** button and navigate to the folder that holds your collection of photos then click the **Choose** button.
4. Your photos appear in the **Photo List**. The name of the photo group text file, which stores the photo group information, is listed in the **Editing Photo Overlay File** text input box.
5. To overlay and place a single photo in the list on the Sky Chart, highlight its name. A preview of the photo appears on the Photo Group tab.
6. Click the **Place Photo** tab. The selected photo is centered on the Sky Chart. From here, you need to adjust the Sky Chart's center coordinates, field width and rotation to align the photo.

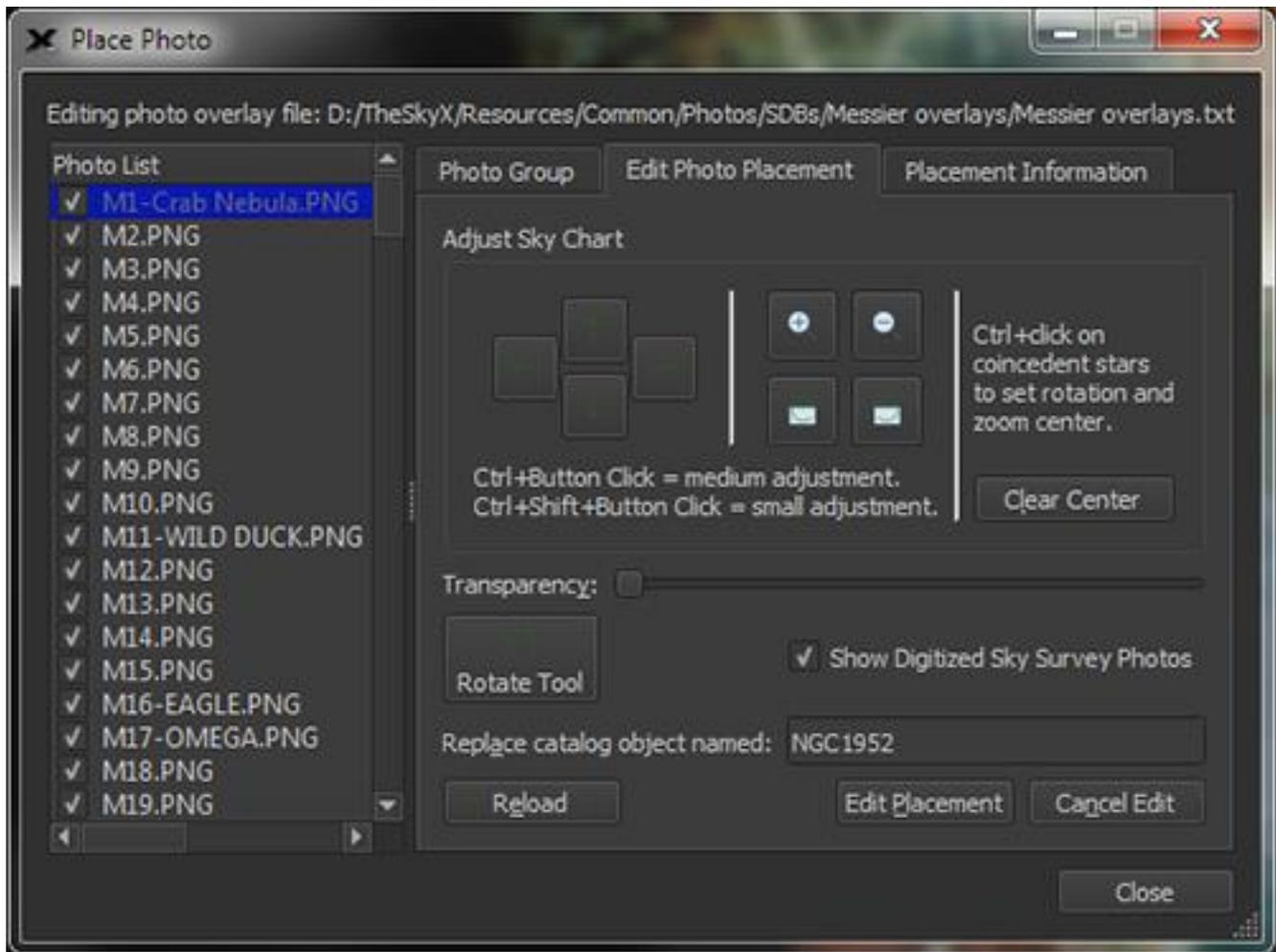


Figure 45: The Edit Photo Placement tab on the Place Photo window.

7. The **Edit Photo Placement** tab has tools to move left, right, up, down, zoom in, out and rotate the Sky Chart so that the photo can be aligned with the Sky Chart. Click the **Edit Photo Placement** button to begin this process. The **Show Digitized Sky Survey Photos** checkbox allows you to show these photos as another frame of reference to help align your photo. Once you are satisfied with the position of the photo, click the **Save Placement Changes** button to save it. Click the **Cancel Edit** button to abort the process and not save changes.
8. Repeat steps 5-7 for each photo in the **Photo List**.

### **Placement Information**

Click on the **Placement Information** tab to show the equinox 2000.0 **RA/Dec** coordinates of the photo, as well as the photo's **Scale**, in arcseconds/pixel and **Position Angle**, in degrees.

## Managing Photo Databases

Click the **Database Manager** command on the **Input** menu to show the **Database Manger** window. Next, expand the **Photo Databases** branch of the **Sky Databases** node in the **Databases** tree to show the available photo overlays.

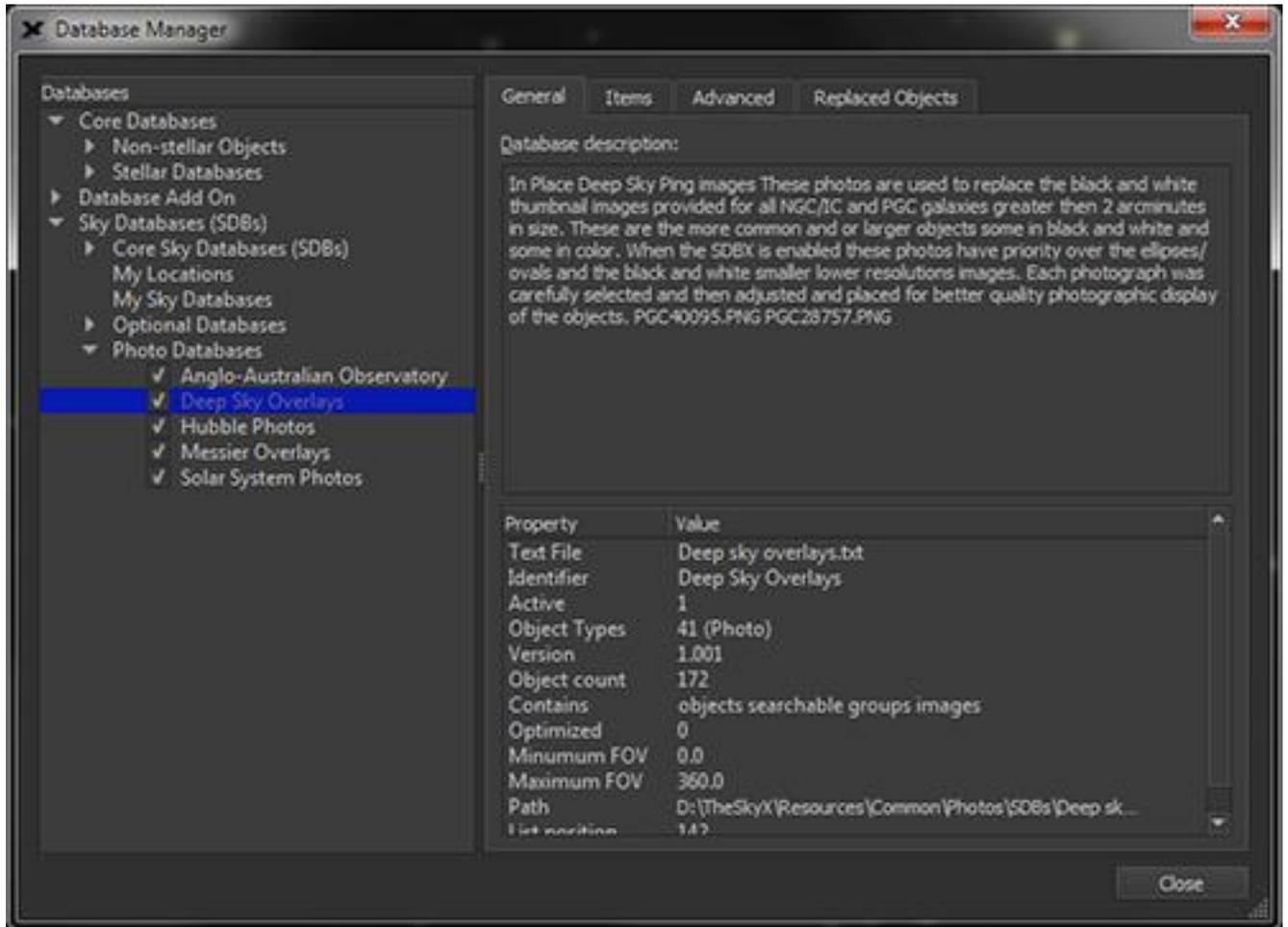
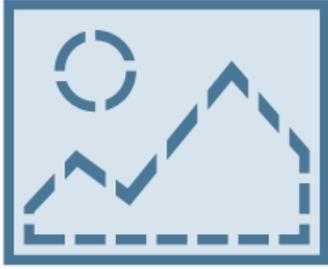


Figure 46: The list of the photo databases in the Database Manager’s Databases list.

## Viewing Photos from the Digitized Sky Survey

PROFESSIONAL



TheSkyX Professional Edition can overlay photos from the Digitized Sky Survey (DSS) on the Sky Chart (see Figure 138) or retrieve the equivalent FITS image for any position on the celestial sphere and for any field of view up to  $2^\circ \times 2^\circ$ . This “all-sky photographic reference” can be extremely useful when searching for new objects such as supernovas or asteroids.

#### **Overlaying Digitized Sky Survey Photos on the Sky Chart**

1. Adjust the Sky Chart to the desired position and field of view. For example, frame the spiral galaxy M81 by selecting the **Find** command from the **Edit** menu, entering **M81** in the **Search For** text input, and then clicking the **Frame** button. You should now see the color photo of M81 on the Sky Chart.
2. For convenience, select the **Celestial Sphere** command from the **Orientation** menu. This command fixes the equatorial center of the Sky Chart to the center of the window with the north celestial pole “up” on the screen.
3. Select the **Digitized Sky Survey** command from the **Tools** menu.

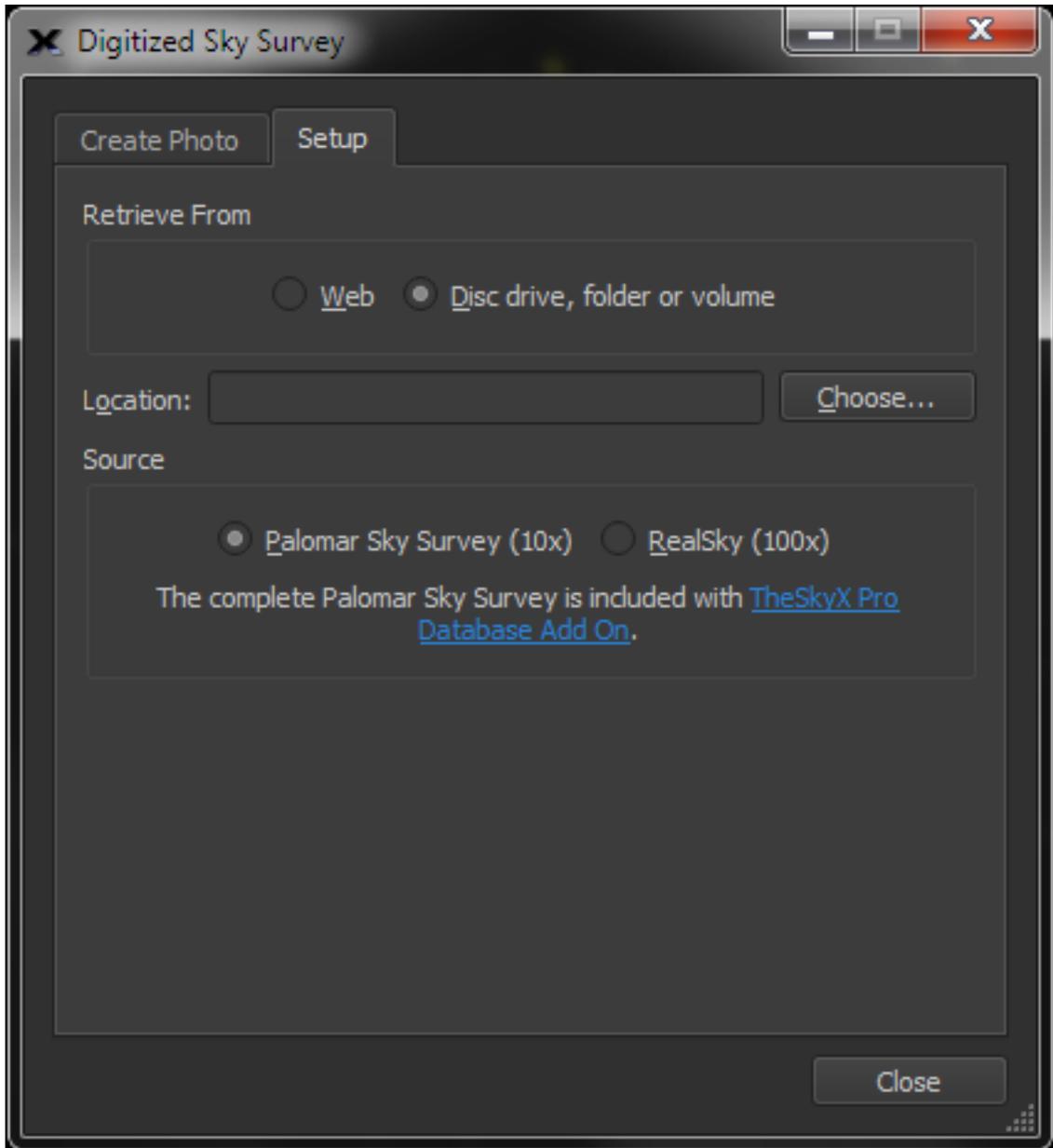


Figure 47: Setup tab of the Digitized Sky Survey window.

4. From the **Setup** tab, select the **Web** option (internet connection required). If you own the *TheSkyX Pro Database Add On* (page 637), select the **Disc Drive, Folder or Volume** option, click the **Choose** button to specify the location of the Digitized Sky Survey data, then select the **Palomar Sky Survey (10x)** option.
5. Click the **Create Photo** tab.
6. Click the **Fill Sky Chart** button. The photo is retrieved from the selected source.
7. Click the **Show Photo in Front of Chart Elements** option to show the photo on top of everything else on the Sky Chart.

### Creating a FITS File of a Digitized Sky Survey Photo

1. Follow steps 1-5 above.
2. Click the **Create** button. The FITS file is retrieved from the selected source and displayed in the **FITS Viewer** window.

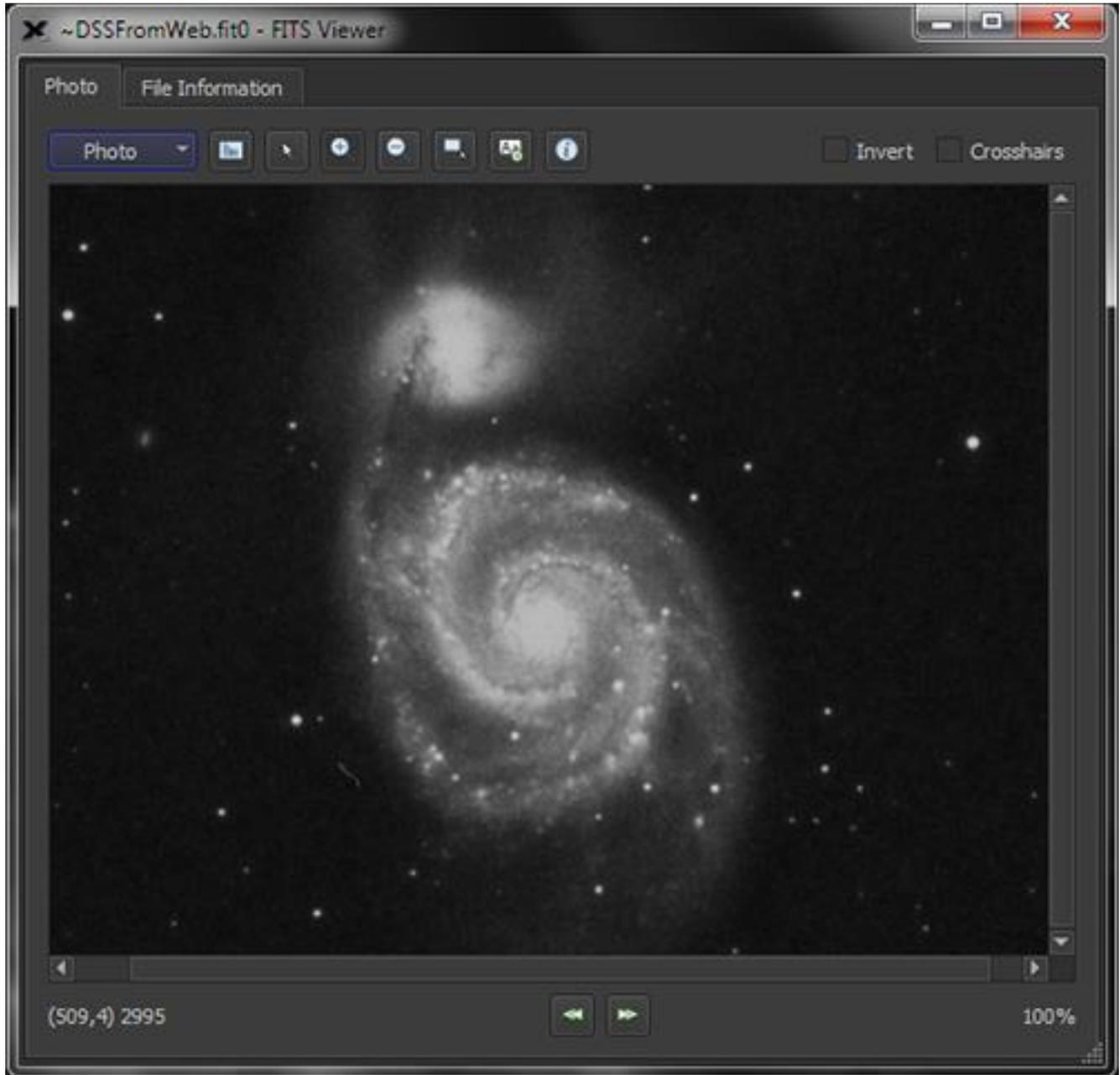


Figure 48: M52 in the FITS Viewer window.

### Viewing FITS Photos

PROFESSIONAL



TheSkyX Professional Edition uses the High-Energy Astrophysics Science Archive Research Center's (HEASARC) *CFITSIO* software library to manage FITS files. It is the "standard" library that handles the all complexities of different FITS file formats so that your FITS (provided it adheres to the FITS standard) will be opened and displayed correctly.

### **Opening a FITS Photo**

1. Click the **Open FITS** command from the **Tools** menu.
2. Navigate to the location of the FITS file, select it and then click **Open**.
3. The FITS photo is now displayed on the **FITS Viewer** window.

## **FITS Viewer Window**

The **FITS Viewer** window contains basic image manipulation commands and shows a table with the FITS header information.

### **Photo Pop-Up Menu**

The following commands are available from the **Photo** pop-up menu.

#### **Open**

Opens a FITS and displays it on the **FITS Viewer** window. Note that the FITS file must use the extension FIT or FTS to be recognized as a FITS on the Mac.

#### **Save**

Saves the FITS file using its current file name.

#### **Save As**

Saves the FITS file using the file name you specify.

#### **Print**

Prints the FITS file to the default printer.

### File Information

This command shows the **File Information** tab with the FITS header information. Search the web for the *Flexible Image Transport System specification* for details about FITS headers and keywords.

The screenshot shows a window titled "--DSSFromWeb.fit0 - FITS Viewer" with two tabs: "Photo" and "File Information". The "File Information" tab is active, displaying a table with three columns: "Keyword", "Value", and "Comment". The table contains 32 rows of FITS header data.

|    | Keyword  | Value                 | Comment                               |
|----|----------|-----------------------|---------------------------------------|
| 1  | SIMPLE   | T                     | FITS: Compliance                      |
| 2  | BITPIX   | 16                    | FITS: I*2 Data                        |
| 3  | NAXIS    | 2                     | FITS: 2-D Image Data                  |
| 4  | NAXIS1   | 588                   | FITS: X Dimension                     |
| 5  | NAXIS2   | 414                   | FITS: Y Dimension                     |
| 6  | EXTEND   | T                     | FITS: File can contain extensions     |
| 7  | DATE     | '2016-04-01'          | FITS: Creation Date                   |
| 8  | ORIGIN   | 'STScI/MAST'          | GSSS: STScI Digitized Sky Survey      |
| 9  | SURVEY   | 'POSSI-E'             | GSSS: Sky Survey                      |
| 10 | REGION   | 'XE173'               | GSSS: Region Name                     |
| 11 | PLATEID  | '07VR'                | GSSS: Plate ID                        |
| 12 | SCANNUM  | '00'                  | GSSS: Scan Number                     |
| 13 | DSCNDNUM | '00'                  | GSSS: Descendant Number               |
| 14 | TELESCID | 1                     | GSSS: Telescope ID                    |
| 15 | BANDPASS | 8                     | GSSS: Bandpass Code                   |
| 16 | COPYRGHT | 'STScI/AURA'          | GSSS: Copyright Holder                |
| 17 | SITELAT  | 33.356                | Observatory: Latitude                 |
| 18 | SITELONG | 116.863               | Observatory: Longitude                |
| 19 | TELESCOP | 'Palomar Schmidt'     | Observatory: Telescope                |
| 20 | INSTRUME | 'Photographic Plate'  | Detector: Photographic Plate          |
| 21 | EMULSION | '103aE'               | Detector: Emulsion                    |
| 22 | FILTER   | 'plexi'               | Detector: Filter                      |
| 23 | PLTSCALE | 67.20                 | Detector: Plate Scale arcsec per mm   |
| 24 | PLTSIZEX | 355.000               | Detector: Plate X Dimension mm        |
| 25 | PLTSIZEY | 355.000               | Detector: Plate Y Dimension mm        |
| 26 | PLATERA  | 205.348690000         | Observation: Field centre RA degrees  |
| 27 | PLATEDEC | 47.2421130000         | Observation: Field centre Dec degrees |
| 28 | PLTLABEL | 'E1593'               | Observation: Plate Label              |
| 29 | DATE-OBS | '1956-04-07T09:42:00' | Observation: Date Time                |
| 30 | EXPOSURE | 45.0                  | Observation: Exposure Minutes         |
| 31 | PLTGRADE | '1'                   | Observation: Plate Grade              |
| 32 | OBSHA    | -1.06667              | Observation: Hour Angle               |

Figure 49: The FITS header data on the File Information tab of the FITS Viewer window.

### **Zoom In/Zoom Out**

These commands can be used to change the scale of the displayed photo by zooming in or out.

### **Actual Pixels**

This command shows the photo with no scaling.

### **Clear**

Click this command to close the FITS image.

### **To Image Link**

Select this command to copy the displayed photo to the **Image Link** window. See “Image Link and Automated Astrometry” on page 312 for details.

### **Close**

Click this command to close the **FITS Viewer** window.

### **Fits Viewer Toolbar**

The toolbar buttons located at the top of the **FITS Viewer** window give access to commonly used commands to manipulate photos.



### **Histogram Control Button**

Click this button to show the histogram control at the bottom of the **FITS Viewer** window. The histogram control is used to adjust the photo’s contrast.



This feature takes advantage of multi-core processors, making real-time contrast adjustments possible, even on large photos.



Figure 50: The histogram control is displayed by clicking the Histogram button.

### ***The Histogram Control***

The histogram control can adjust the photo's contrast graphically or manually.

The upper portion of the histogram control shows a red triangle with a red vertical line, and green triangle with a green vertical line. Red represents the position on the histogram below which all data are displayed using the color black. Green represents the position on the histogram above

which all data is displayed using the color white. Values between the minimum and maximum positions are scaled using different shades of gray.

- Click and drag the green-blue triangles to adjust the white and black points.
- Click the mouse on the left side of the histogram to change the black point; right side clicks adjust the white point.

To manually adjust contrast, enter the minimum and maximum values in the text boxes below the histogram, then click **Apply**.

**Minimum**

Enter the value below which the photo's data is scaled to the color black.

**Maximum**

Enter the value above which the photo's data is scaled to the color white.

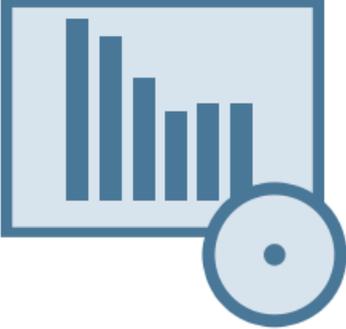
**Apply**

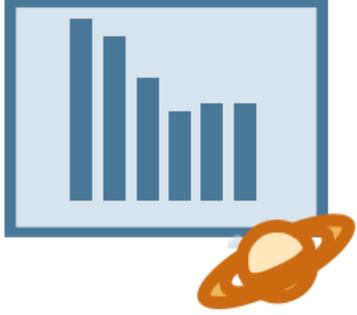
Adjust the photo's contrast based on the **Minimum** and **Maximum** values.

**Histogram Control Toolbar**

The six toolbar buttons near the bottom of the Histogram control can be used to adjust contrast. Each is described in the table below.

| Button  | Description   |
|---|---|
|  | Reset the histogram's minimum and maximum values to zero and the maximum data value for this photo, respectively. |

| Button  | Description  |
|---|--|
|    | Scale the histogram so that minimum and maximum contrast values approximately match or “bound” the photo’s data. |
|   | Scale the histogram for low contrast.  |
|  | Scale the histogram for medium contrast.   |
|  | Scale the histogram for high contrast.   |

| Button  | Description   |
|---|---|
|  The icon for the Histogram Control button. It features a blue-bordered square containing a histogram with six vertical bars of varying heights. Below the square is a stylized orange planet with rings, resembling Saturn. | Scale the histogram to best show photos of planets. |

### **Method**

The **Method** pop-up menu on the lower left corner of the *Histogram Control* provides several different algorithms that can be used to set the photo's contrast.

### **SBIG**

Use SBIG's algorithm to scale the photo.

### **Bjorn**

This is a proprietary algorithm (named after the author) that can be very effective in setting appropriate contrast values for a variety of photos.

The Bjorn method's **Background** settings include:

- None
- Weak
- Medium
- Strong
- Very Strong

The "stronger" the background setting, the higher the black point on the histogram. A **Very Strong** background shows the least faint detail in the photo.

The Bjorn method **Highlights** options include:

- None
- Weak
- Medium
- Strong
- Very Strong
- Adaptive (for general purpose use)

- Planetary (best for planets)

The lower the highlight setting, the higher the white point value and the more “data” that is included when scaling the histogram. Lower highlights can reveal details in the brightest portions of the photo.

### **Linear**

This method scales the data in the histogram linearly.

### **Custom**

Use this option with the **Minimum** and **Maximum** inputs to scale the photo.

\*If the contrast algorithm used to scale a photo’s histogram results in an all-white or all-black photo, try using a different contrast method.

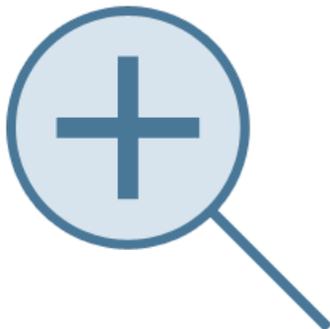
### **Arrow Button**



When the **Arrow** button is clicked, the X and Y position of the mouse cursor, and the brightness value of this picture element (pixel) is displayed in the lower left of the photo window.

Clicking and dragging changes the position of the zoomed photo.

### **Zoom In Button**



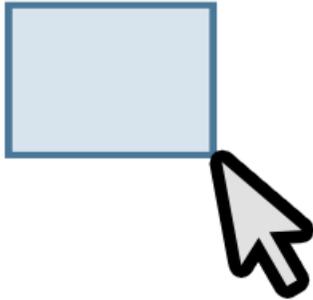
Click this button to zoom in and magnify the photo.

**Zoom Out Button**



Click this button to zoom out, making the photo appear smaller in the window.

**Subframe Button**



Click this button to enable the subframe tool that can be used to draw a rectangular region, or subframe on the photo.

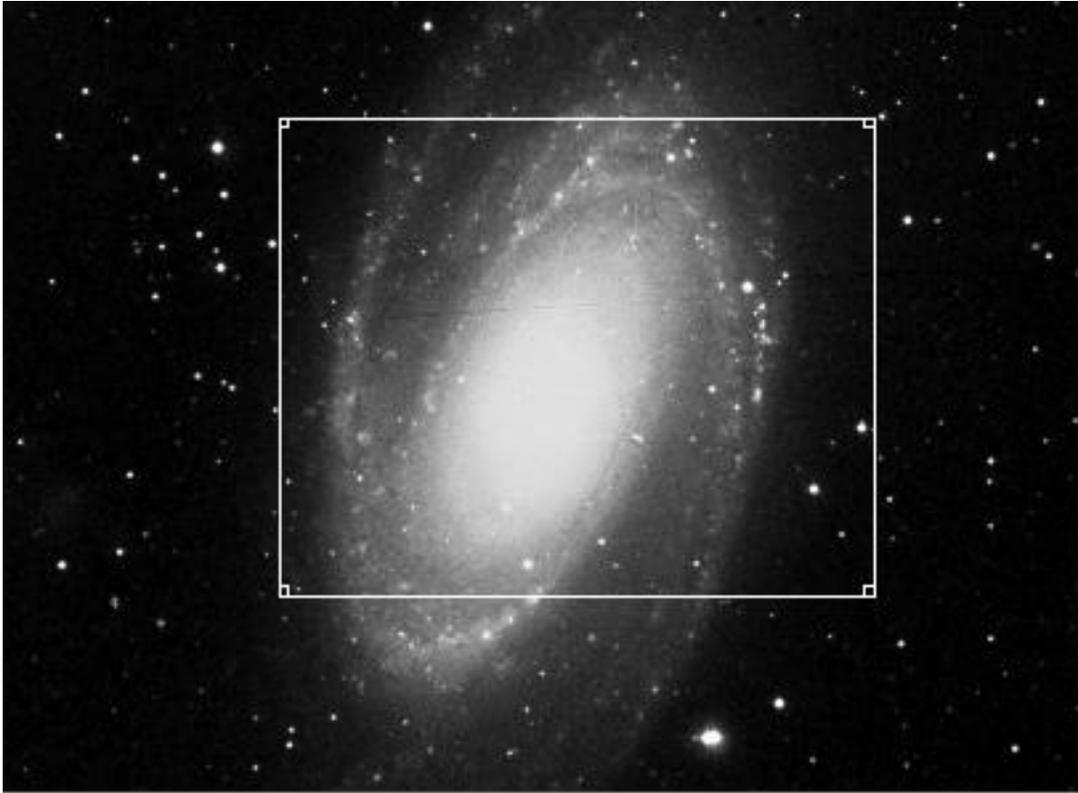
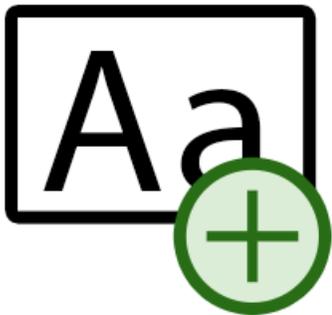


Figure 51: A subframe drawn on the photo of M81.

The control can be used to define the region around a guide star during autoguiding (page 476) or to define a region of interest (ROI) on a photo so that subsequent photos are acquired for this region, only.

### ***Text Tool***



Click this button to enable the text tool that can be used to add text to a photo. Click on the photo to place the text input box, then enter the desired text. The text box can be clicked and positioned anywhere on the photo.

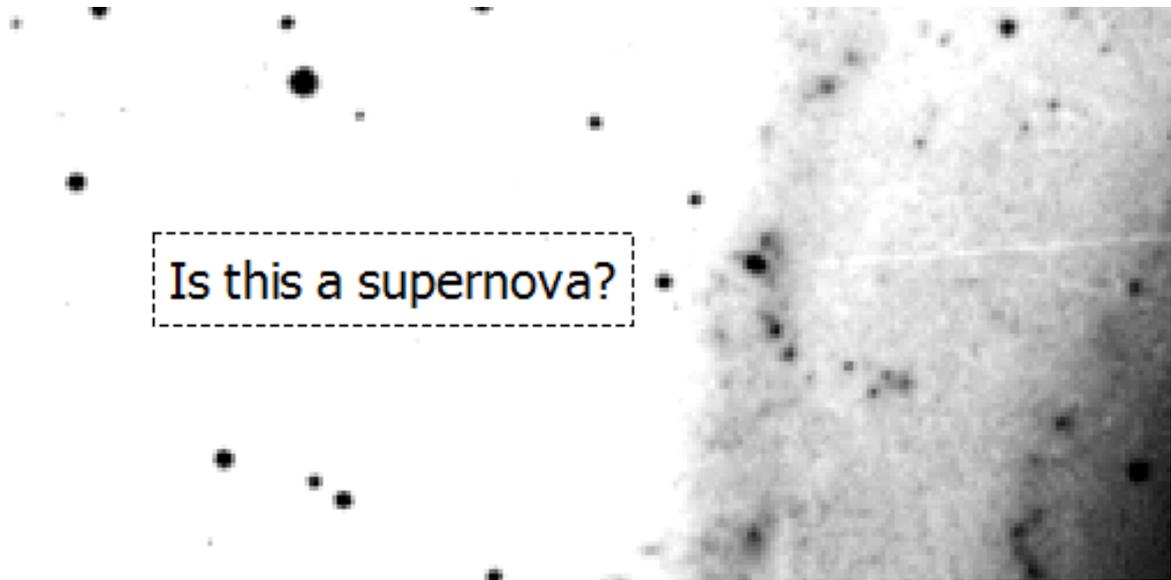


Figure 52: Custom text can be added to photos.

### ***Cursor Information***



Click this button to display the pixel position and right ascension and declination coordinates of the pixel directly under the mouse cursor, based on the photo's World Coordinate System (WCS) information.

- WCS data is added to the FITS header after a successful Image Link (page 312).
- If the photo does not contain WCS, only the pixel position is shown.

The equatorial coordinates of a centroid around the region under the mouse cursor is also displayed. Notice the slight difference between the ***Cursor*** coordinates and the ***Centroid Under Cursor*** in Figure 53.

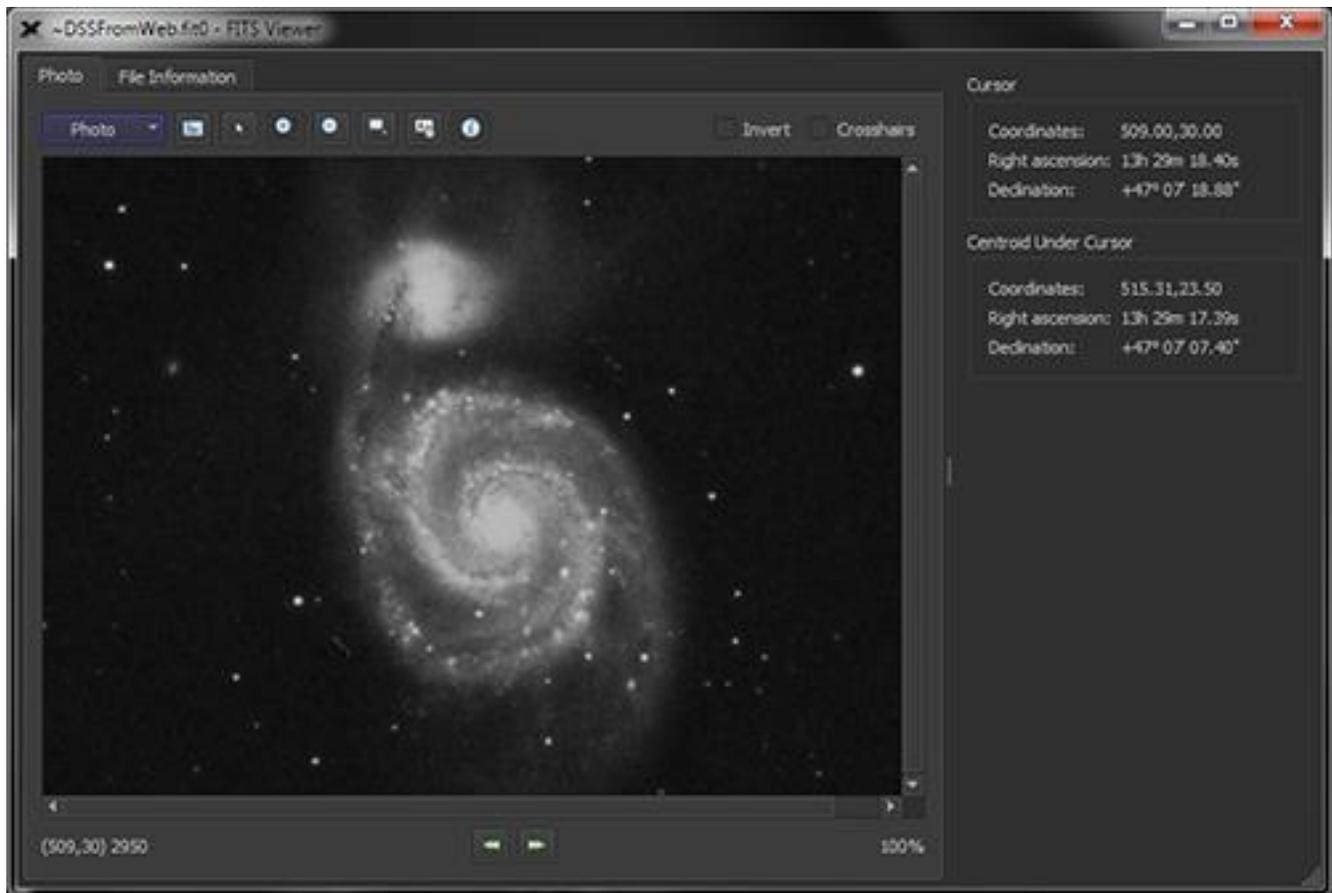


Figure 53: The Cursor Information button shows WCS coordinates for the cursor position.

### ***Crosshairs***

Turn on this checkbox to overlay a graphical crosshair on the photo.

## **Your Sky Tonight**

This section is intended to help you explore the night sky from your location on any date, at any time. You'll be able to answer the question: "When I head outside tonight at, say, 9 p.m., what am I going to be able to see?" You'll also learn how to plan for special events, like meteor showers and lunar eclipses.

For a given location, what you can see in the sky on any given night depends on the date and time. The stars that are visible at 9 p.m. on a December night are very different from the ones you would see at 9 p.m. in June, for example. And the Moon and planets follow their own unique celestial paths – their positions, and their brightness, vary from month to month and year to year.

## Observing Lists

TheSkyX includes a command that will display a select list of objects that will be visible in your night sky on the current date. You can set the parameters of this list to choose the kinds of objects you're most interested in seeing.

To generate a What's Up Observing List:

1. Go to the **Tools** menu.
2. Select the Manage Observing List command.
3. Click the **What's Up Setup** tab.
4. Select the **Viewing Time** for the list.
5. Select the **Optical Aid** that you will be using.
6. Click the **What's Up?** button.
7. Click the **Close** button.

Clicking the **What's Up?** button creates and shows the list of objects that are visible from your location in tonight's sky on the Observing List window. When you highlight an item, observing notes are displayed.

Some of these objects, and the data displayed with them, may be unfamiliar to you. We'll be describing most of the information in the **What's Up?** command in more detail on page 288.

## Field of View Indicators



A Field of View Indicator (FOVI) is a chart element that represents the field of view that is rendered by an eyepiece, CCD sensor, camera body and optical tube, or a Telrad™ finder, binoculars or other optical system.

As you zoom in or out in the Sky Chart, the FOVIs shrink or grow in proportion to the field of view. The utility to this feature is endless, particularly helpful during observing sessions and with

telescope control. Easy, quick identification of celestial objects can be made when you view the Sky Chart as if you were looking through the eyepiece, so there is no guesswork required.

## Choosing Your Telescopes, Eyepieces and Cameras

Select the **Field of View Indicators** command from the **Display** menu to open the **Field of View Indicators** window.

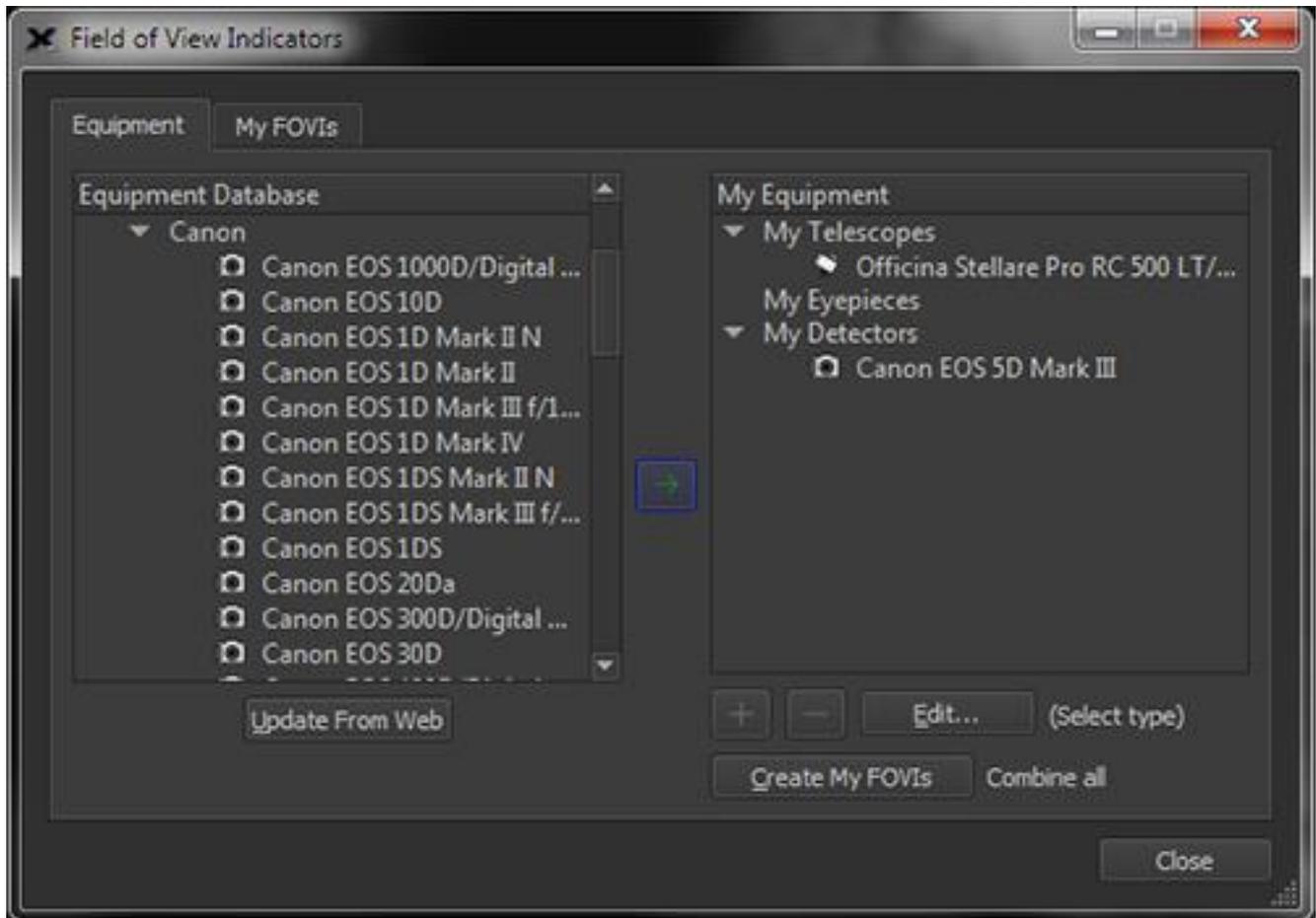


Figure 54: The Equipment tab of the Field of View Indicators window.

To the left, you will see the equipment database list, including selections for **Telescopes**, **Eyepieces**, and **Detectors**. To select a telescope, expand the **Telescopes** portion of the tree. You will see a large selection of telescope makers. Expanding a telescope maker's menu will produce a list of telescope models by that manufacturer. Choose your telescope from the list. Once you have selected your telescope, click the **green arrow** button found in the middle of the window. You will then see the telescope listed on the **My Equipment** list to the right of the window.

Now, choose your eyepiece and/or detector from the appropriate menu from the left side **Equipment Database**.

### Update Equipment Button

If your model camera, eyepiece, lens or telescope is not listed, click this button to download the most recent equipment databases available from the Software Bisque web site, then check the appropriate **Equipment Database** to see if your hardware has been added since you installed your software.

If your equipment still does not appear, post a question on the Software Bisque community forums with the exact make and model of your equipment, and we'll try to update our databases.

Once you have chosen your telescope, eyepieces, and detectors, click the **Create my FOVIs** button. You will then be taken to the **My FOVIs** tab, where each FOVI will appear in a list with a checkbox to turn each FOVI on or off.

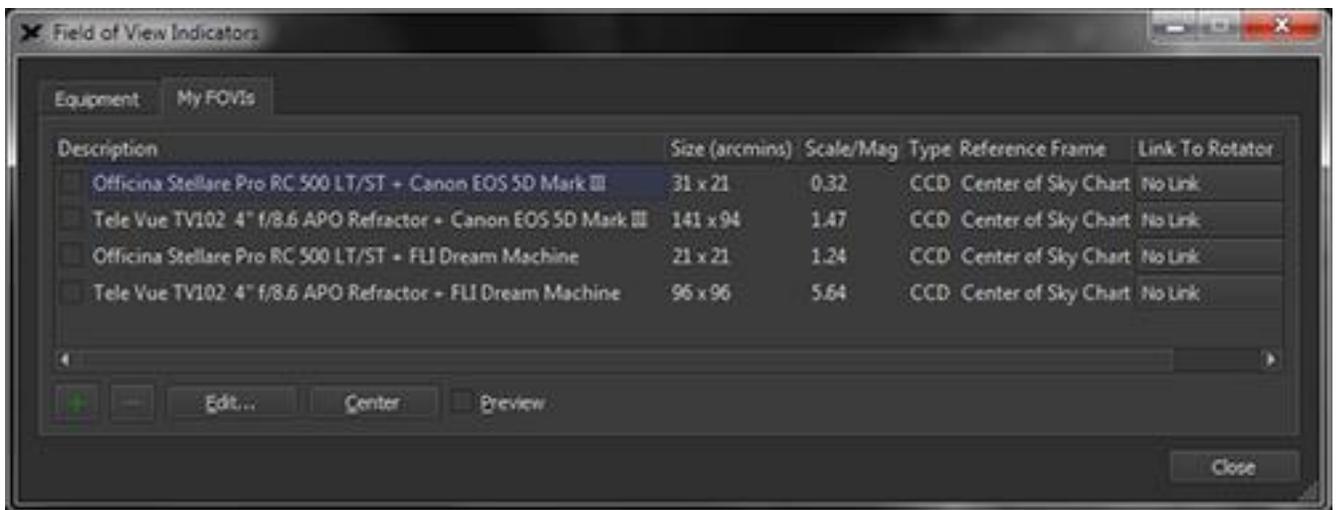


Figure 55: The My FOVIs tab.

Selecting a FOVI and clicking the **Edit** button will show the **Add/Edit Equipment** window where you can edit each element and aspect of the telescope and eyepiece or detector combination (page 124).

Clicking the **Quick Add** button also opens the **Add/Edit Equipment** window, in which you can add a FOVI with characteristics of your choosing. Just input the desired **Shape, Reference Frame, and Width and Height** in arcminutes, and you've added a brand new FOVI of custom dimension.

Clicking **Remove** will remove a FOVI from the list. Clicking **Center** will center the FOVI on the screen.

Checking the **Preview** checkbox will reveal a preview of each selected FOVI in the Sky Chart. When the **Preview** checkbox is turned on, the currently selected FOVI is centered on the Sky Chart. This lets you quickly determine which optical system is best for your needs.



Note that if you turn on both the **Preview** checkbox *and* the checkbox next to a FOVI, two identical FOVIs will appear on the Sky Chart (the “preview” FOVI and the actual FOVI). To avoid confusion, make sure to turn off the **Preview** checkbox before closing this window.



**Remember that FOVIs represent the view through your telescope**, and will not appear on the Sky Chart if the chart’s field of view is set to 100° (naked eye) and wider. To see the FOVIs, zoom to a field of view of less than 100°.

The **My FOVI** tab shows the following information for each field of view indicator.

### **Description**

The FOVI description is the combination of the telescope and the eyepiece or detector description. To change a description, highlight the FOVI in the list and click the **Edit** button.

### **Size**

The size column shows the angular dimensions of the FOVI, in arcminutes.

### **Scale/Magnification**

For telescope and camera FOVIs, the scale or image scale, in arcseconds per pixel is displayed. The optical system’s magnification is displayed when the FOVI consists of a telescope and eyepiece.

### **Type**

The **Type** column shows either **Eyepiece** for eyepiece plus telescope combinations, or **CCD** for a camera plus telescope FOVI.

### **Reference Frame**

This column shows the frame of reference to use when displaying the FOVI. See “FOVI Frame of Reference (Reference Frame List)” on page 126 for details about reference frame options.

### **Link to Rotator**

This column allows you to establish a link between a field of view indicator and your rotator hardware. When linked to an active rotator, the position angle of the FOVI as it appears on the star chart will be adjusted to match the current position of the rotator.

Conversely, the rotator hardware may be commanded to move to a new position by dragging a linked field of view indicator.

## **Showing Telrad Finders**

Telrad™ finder FOVIs are shown at all fields of view (but may not be completely visible at small fields) and can be added to the Sky Chart using the **My Chart Elements** command on the **Input** menu.

**To add one or more Telrad Finder FOVIs to the Sky Chart:**

1. Click Input > My Chart Elements.
2. On the **Manage** tab, click the **Add Telrad** button.
3. Under **Command+Click** (Mac) or **Ctrl+Click** (Windows), select **Cursor Position** in the **Snap To** pop-up menu.
4. Position the mouse cursor over the Sky Chart, press and hold the  $\mathfrak{K}$  key on the Mac or the CTRL key on Windows, then click the left mouse button. A new Telrad finder is drawn at the current cursor position.



Figure 56: A Sky Chart showing multiple Telrad finders.

**To position a Telrad finder at a specific coordinate:**

1. From the **Manage** tab on the **My Chart Elements** window, highlight the Telrad you want to move in the **My Chart Element** list by clicking on it or click on the center of the Telrad Finder on the Sky Chart. A selected Telrad finder appears as **My Chart Element #** in the **Object Information Report** on the **Find** window.
2. Click the **Edit** button (or double-click on the element) to show the **Add/Edit Chart Element** window.
3. To enter equatorial coordinates, click the **Equatorial** radio button then enter the right ascension (**RA**) in hours, minutes and seconds and declination (**Dec**) in degrees, minutes and seconds.

To enter horizon coordinates, click the **Horizon** radio button then enter the azimuth (**Azm**) in hours, minutes and seconds and altitude (**Alt**) in degrees, minutes and seconds.

**To Drag and Move a Telrad Finder:**

1. From the **Manage** tab on the My Chart Elements window, select the Telrad you want to move in the **My Chart Element** list, or click on the center of the Telrad Finder on the Sky

Chart. A selected Telrad finder appears as **My Chart Element #** in the **Object Information Report** on the **Find** window.

2. Click and drag the small red rectangle in the center of the Telrad finder to move it.
3. Release the mouse when the Telrad is positioned where you want it.

## Adding or Editing Field of View Indicator Properties

Clicking the **Edit** button or the **Plus Sign** button on the **My FOVIs** tab (**Field of View Indicators** window) shows the **Add/Edit Equipment** window. This window lets you define up to twenty different FOVI elements.

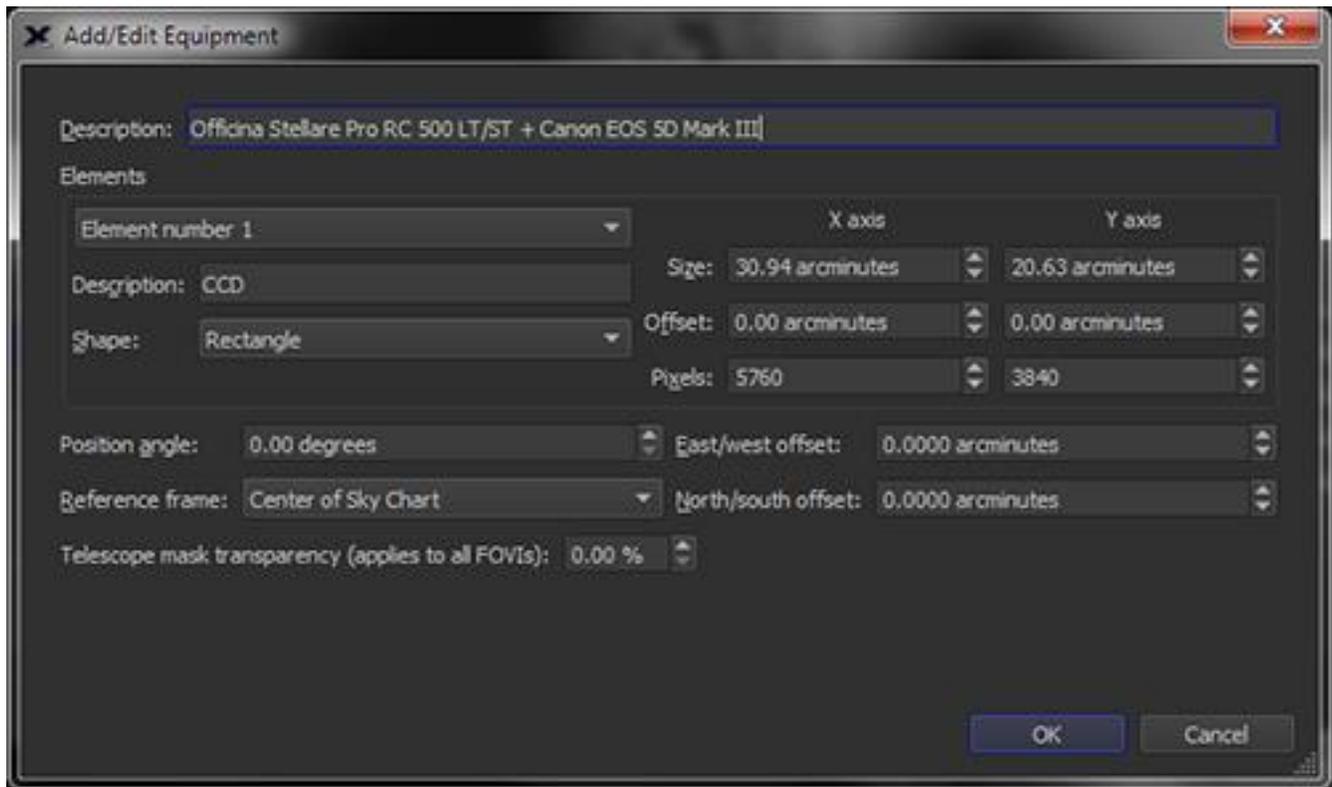


Figure 57: The Add/Edit Equipment window (clicking the Edit button).

### **Field of View Indicator Description (Description)**

Enter a description for your detector, such as *Super CCD with 10 Detectors*.

### **Element Number List**

Up to twenty separate FOVI elements can be defined for each FOVI. For example, if your camera has a built-in autoguider, then the FOVI will have two different elements, one for the imaging detector and one for the autoguider.

### **Element Description (Description)**

Enter a text description for the element, such as “ST-237 guider mounted to my guide scope”.

### **Shape**

Specify the shape of the element. An element can be:

- Circular (or elliptical)
- Rectangular
- Marker (a small cross that is offset from the main FOVI)
- Off-Axis Guider (a rectangle that represents the position of an off-axis guider).

### **OAG PA**

When a FOVI element’s **Shape** is defined as **Off-Axis Guider**, enter the position angle of the off-axis guider, in degrees.

### **Position Angle**

Enter the position angle, measured counterclockwise from north, of the FOVI element. This is the native position angle of the FOVI before any offsets due to a linked rotator are applied, so this value may be changed freely without effecting the position or orientation of linked hardware.

This field is automatically populated with the correct angle for FOVIs generated from a successful Image Link (page 312), allowing users to accurately predict the position and orientation of their imaging system's actual field of view. For FOVIs linked to rotators, it is recommended that this field be set to 0 degrees, and the position angle of the FOVI instead synchronized to the imaging system's actual field of view using the rotator offset (page 603).

### **To rotate a FOVI on the Sky Chart**

Clicking *on the FOVI line* reveals two small red “handles” to indicate it is selected.

- Click and drag the center handle to unpin it from the center of the window and pin it to a specific RA/Dec position on the Sky Chart.
- Click and drag the outer handle to rotate the FOVI about its center.
- The FOVI’s current position angle is also displayed.

Hint: When accurate FOVI position angles are required, the FOVI’s position angle can be adjusted by one-tenth of one-degree increments by clicking and dragging the mouse cursor away from the center of the FOVI. When the cursor is positioned further from the center of the FOVI, small changes in the mouse position results in small changes to the FOVI’s position angle.

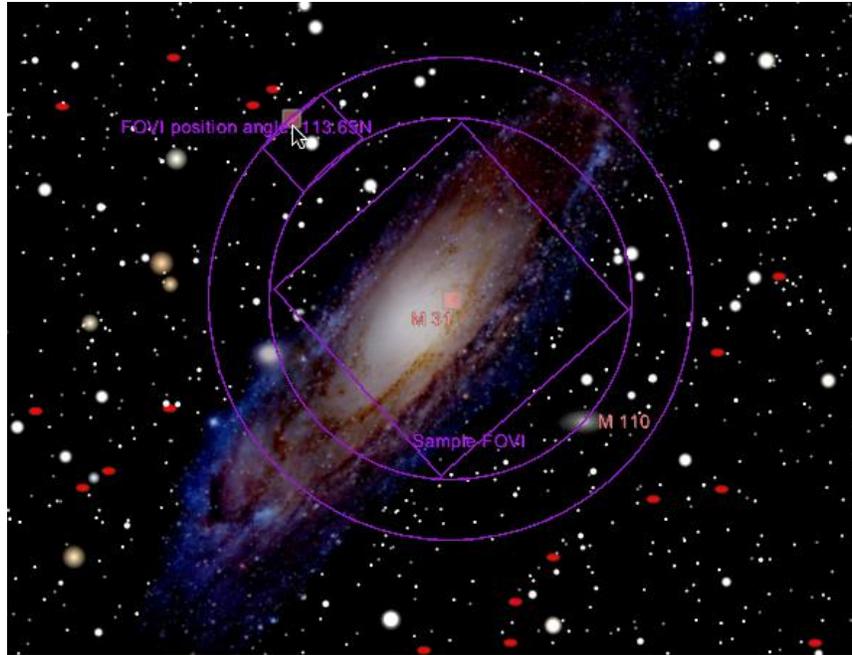


Figure 58: Click and drag on the small red square to change the FOVI's position angle.

### ***FOVI Frame of Reference (Reference Frame List)***

Select the frame of reference for the detector or detector/telescope combination.

- **Sky Chart:** The FOVI is pinned to the center of the Sky Chart.
- **Equatorial:** The FOVI is displayed specific equatorial coordinate.
- **Telescope Crosshairs:** When connected to a telescope, and the field of view 35° and smaller, the FOVI is displayed with the telescope crosshairs symbol in the center of the FOVI. At wider fields of view, only the telescope cross hair appears (two concentric yellow circles).

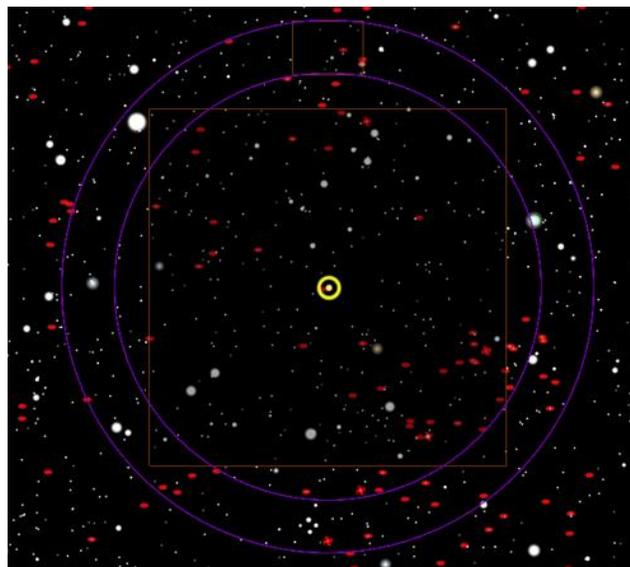


Figure 59: Sky Chart showing a Telescope Crosshairs FOVI at fields of view 35° and smaller.

- **Telescope Mask:** Use this option to simulate the view through a telescope. Regions outside the FOVI are “masked” and therefore not visible.



Figure 60: A Sky Chart showing a telescope mask FOVI.

**Size, X/Y**

Enter the physical size of the camera’s detector, in mm.

**Offset, X/Y**

Enter the offset of the element from the Element Number 1, in mm.

**Pixels, X/Y**

For CCD cameras, enter the number of pixels in each axis. This value is used to compute the scale of images acquired with the camera, in arcseconds/pixel.

**East/West offset**

Specify the number of arcminutes to shift the center of the FOVI to the East or West. A number greater than zero shifts the FOVI West, a negative number shifts it East.

**North/South Offset**

Specify the number of arcminutes to shift the center of the FOVI to the North or South. A number greater than zero shifts the FOVI South, a negative number shifts it North.

Clicking the **Plus Sign** button shows slightly different options.

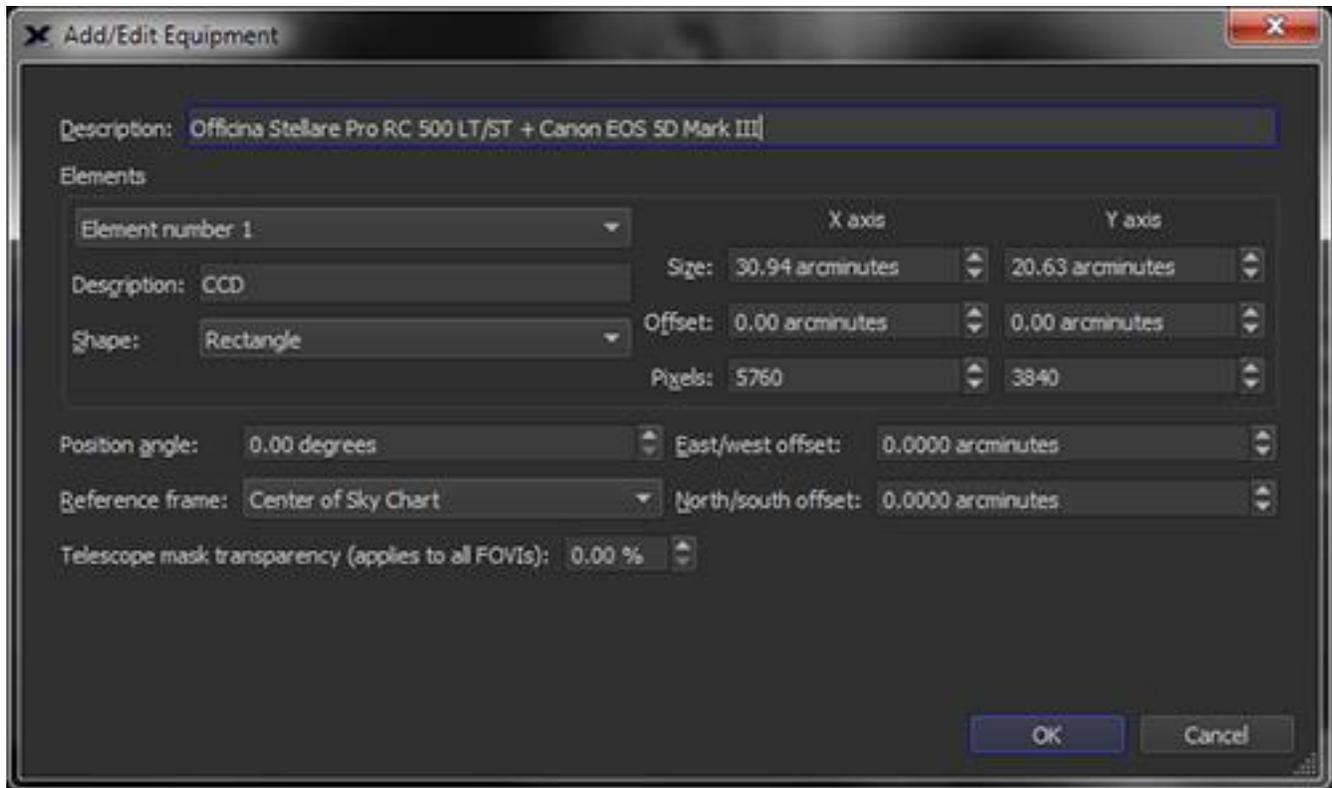


Figure 61: The Add/Edit Equipment window (clicking the plus sign button).

Enter the FOVI's **Description**, **Shape** and **Reference Frame** (described above) and the **Width** and **Height**, in arcminutes.

## FOVIs and the Sky Chart

FOVIs that are displayed on the Sky Chart are configurable *and* customizable.

They can be:

- Clicked and dragged to any part of the screen
- Copied and “pinned” to a specific equatorial (RA/Dec) coordinate
- Rotated to any angle
- Used as the telescope cross hairs
- Used to create a telescope mask
- Used to control a camera rotator

### ***How to Position a FOVI on the Sky Chart***

Select the FOVI on the Sky Chart by clicking on it, or click on the center marker (if the FOVI has a visible center marker). Two small reddish squares, and the position angle, appear when the FOVI is selected. The center square can be dragged to move the FOVI; drag the outer square to change the position angle.

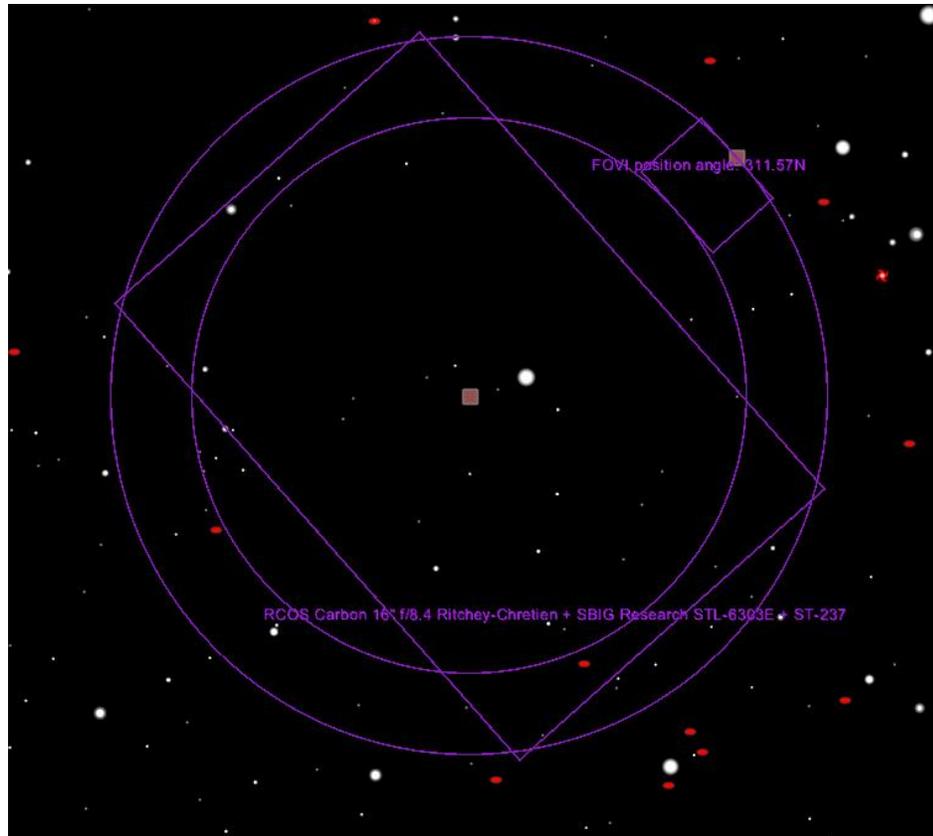


Figure 62: Clicking on a FOVI shows the position angle, and rectangles to position and orient it.

### ***How to Use a FOVI as the Telescope Cross Hair***

1. Click the Field of View Indicators command from the Display menu.
2. Click on the My FOVIs tab.
3. Highlight the FOVI that you want use as the telescope cross hair.
4. Click the **Edit** button.
5. On the Add/Edit Equipment window, select Telescope from the **Reference Frame** list.
6. Click **OK**.

When the Sky Chart's field of view is small enough to resolve the FOVI, and the telescope is connected, the telescope's cross hair will include the FOVI, too.

### ***Object Paths***

Sometimes the best way to say something is with a picture. This is certainly true with a complex concept like planetary motion. Tracing out motion paths of solar system objects is the perfect way to demonstrate their motion and to plan for upcoming observation sessions. *TheSkyX* allows you to do so with ease and flexibility.

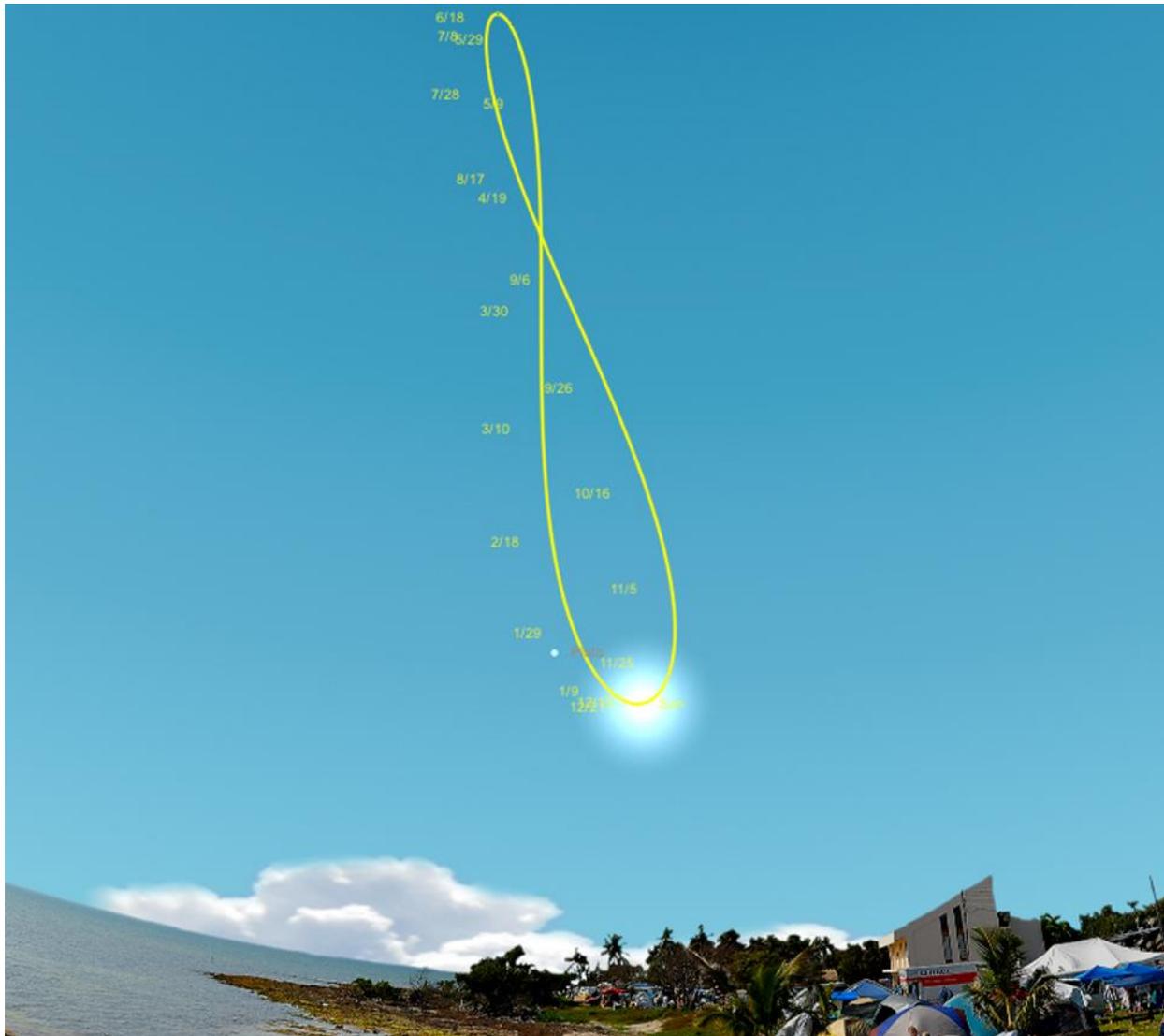


Figure 63: An object path showing the Sun's analemma.

## Generating an Object Path

Selecting the **Object Paths** command from the Tools menu will bring up the **Object Paths** window. In it, you will see a list of solar system objects, along with various drop-down menus and buttons that control the various object path functions. On the left, you will see a list of solar system objects: the eight classical planets, plus Pluto, the Sun, Moon, comets, and asteroids. On the right, you will see information pertaining to the path that *TheSkyX* is currently set to create, including the number of items selected, the chosen time increment, the count of time increments, and the path style.

To get our feet wet, let's try out the object path tool on an observer's favorite, the planet Mars.

**Note: This process works the same way with any object.** If Mars is not in your sky right now, you can always choose another object, or adjust your Sky Chart to the next time Mars is visible.

1. Choose **Object Paths** from the **Tools** menu.
2. From the Select Solar System Object list, select Mars.
3. Looking over to the right side of the window, you will now see that **Items Selected** now says **1**.
4. By default, *TheSkyX* sets the time increment to **1 day**, which is changeable by using the pop-up menu. Let's leave it at 1 day for now.
5. The **Count** is set at **30** by default, which means that the system will calculate a path for 30 of the chosen time increments. In this case it is 30 days.
6. The **Path Style** may be changed from a connected line to a dotted line, each with various point styles. Experimenting with this feature will allow you to best decide which option is right for you.
7. Then, click the **Create Path** button, and a new path appears in the Sky Chart, revealing the path taken by Mars starting with the current system time and ending in the next 30 days.

In this example, the generated path shows the position of Mars in the sky each day at the same time. So, if the clock is set at 12:00 a.m. when you generate the path, it will show the position of Mars each day at 12:00 a.m.

Clicking the **Show** button in the **Object Paths window** will zoom in and center the path in the Sky Chart.

What if you would like to see the path that an object takes through the sky during a single day? *TheSkyX* makes that easy, as well. Using Mars as our example again, following these easy steps will lead you to success.

1. Select **Object Paths** from the Tools menu.
2. Choose Mars from the Select Solar System Objects list.
3. Ensuring that the **Create Paths** button is highlighted on the right, change the time increment to **1 hour**.
4. Change the frequency to **24** by either typing it into the field or by using the field's arrow buttons.
5. Select the path style that is best for you.
6. Click **Create Path**.

You will now see a path on the Sky Chart reflecting Mars' motion through the sky over the next 24 hours.

Remember, clicking the **Show** button in the **Object Paths window** will zoom in and center the path in the Sky Chart.

Once you get the hang of the example path, try out several different paths, changing the variables to achieve different effects.

### **Updating Object Paths**

Should you wish to update object paths based upon new time and date settings, simply click the **Update All** button.

### **Clearing Object Path Data**

If you would like to clear paths from the Sky Chart, click **Clear All Paths**.

## **Create Paths Options**

TheSkyX allows you to create object paths with a great amount of flexibility. The following is a detailed explanation of each option under the **Create Paths** menu.

### **Items selected**

This area denotes how many objects are selected for which paths will be drawn. You may select as many objects as you wish from the list on the left.

### **Time increment**

Here, you can select the desired increment of time for the object path. This input behaves similarly to **Date and Time Control** (page 140), where virtually any time increment can be specified using a <number>+<keyword> sequence. The time keywords include:

- **year** = 365.2425 days
- **week** = 7 days
- **day** = 1 Earth day
- **hour** = 1 hour of time
- **minute** = 60 seconds of time
- **second** = 1 second of time

Each keyword must be preceded by a number as shown in the examples below. Plural or singular keywords are acceptable.

5 hours 3 minutes 25.2 second  
15 days  
6 years  
7 weeks

### **Count**

Using this function lets you choose how many time increments you want to include in the object path. Selecting **1 hour** as the time increment and **24** as the count generates a path that is 24 hours in length, or about one Earth day.

### **Path style**

Using the drop-down menu, the path style can be changed so that is drawn as a smooth connected line, a dotted line with points at each position, a dotted line with a graphical representation of the object at each position, or a continuous line with either dots or graphic objects at each position.

### **Interactive Object Paths**

If you would like to create a path “interactively” using *TheSkyX*’s **Date and Time** control as the object moves, turn on the **Interactive** checkbox. When in the **Interactive** mode, paths will be created for the selected solar system objects as the time is changed using **Date and Time** controls.

When the **Interactive** checkbox is on, a **Stop** command is issued to the date time controls so that you can choose the desired skip increment. Use the **Step Forward** or **Go Forward** (or **Backward**) controls to see the paths as they are generated.

Click the **Remove Interactive Paths** button to remove all paths from the Sky Chart. Note that paths can be up to 500 “time increments” long. Once they reach this maximum length, the object will continue moving but the path will no longer be recorded.

## **Path Labels**

*TheSkyX* affixes labels to paths so that you can reference an object’s position at any given time along the path.

To change labels for one or more object paths, first select the object(s) on left of the **Object Paths** window. If more than one path is selected, the first selected will be the template for the other paths (other paths will inherit the position, frequency and label type of the first selected).

When creating paths interactively, make sure to set the desired labeling options **before** changing time using the **Date and Time** controls.

To see the label data, or to adjust how labels are generated, click the **Path Labels** button near the top right side of the Object Paths window. You will see several options, such as the position of the label, label frequency, and options for the label data (day, month, date, etc.). Let’s change the label parameters in our Mars example to show us the date and time of several points along Mars’ path.

1. Click the **Path Labels** button in the Object Paths window.
2. The label position is set at **top**, and the frequency at **6**, by default, so let’s just leave those as they are for now.
3. In the **Label Options** drop-down menu, select **Date and time**.
4. Click the **Update** button.

You will now notice that the path labels in the Sky Chart now show the date and time of six points along the generated path. If you want to change the label details again, simply follow the previous steps, substituting the new parameters under the Path Labels section.

### ***Label List***

In the Path Labels section, you will notice a label list under the label parameters. *TheSkyX* allows you to view and change any label along your generated path. Scrolling in this list will reveal the label and the date and time of each incremental point along the generated path. (In our example above, we generated a 30-day long path, so the label list contains data for 30 days.) You can change any label to anything you like by double clicking on a label cell and entering text. Clicking ***Update*** will update your path and show the new labels.

### ***Path Labels Options***

*TheSkyX* affixes labels to object paths based upon default parameters or those selected by the user. Understanding these will help you to get the most out of *TheSkyX*'s object paths function.

### ***Position***

A label's position can be changed here. You can elect Top, Bottom, Left, or Right.

### ***Frequency***

This function adjusts the frequency at which labels appear on the object path. The frequency can be changed by directly entering a number into the field, or by using its arrow buttons.

### ***Label option***

Here, you can change the data content of labels. Labels can display date, time, date and time, day and month, or day only. Additionally, labels can be turned off completely by selecting ***None***.

### ***Label list***

This list shows all labels on a given object path and lists the labels as well as the date and time of each point along the path.

You can change the content of any label by double-clicking in a label's cell and entering text.

## The Calendar



Mankind has been using calendars of one kind or another to mark the passage of time for thousands of years. *TheSkyX's* Calendar charts the phases of the Moon, sunrise and sunset, and viewing opportunities for a special kind of satellite event called an *Iridium flare*, monthly. You can display and print a calendar for a single month or the entire year.

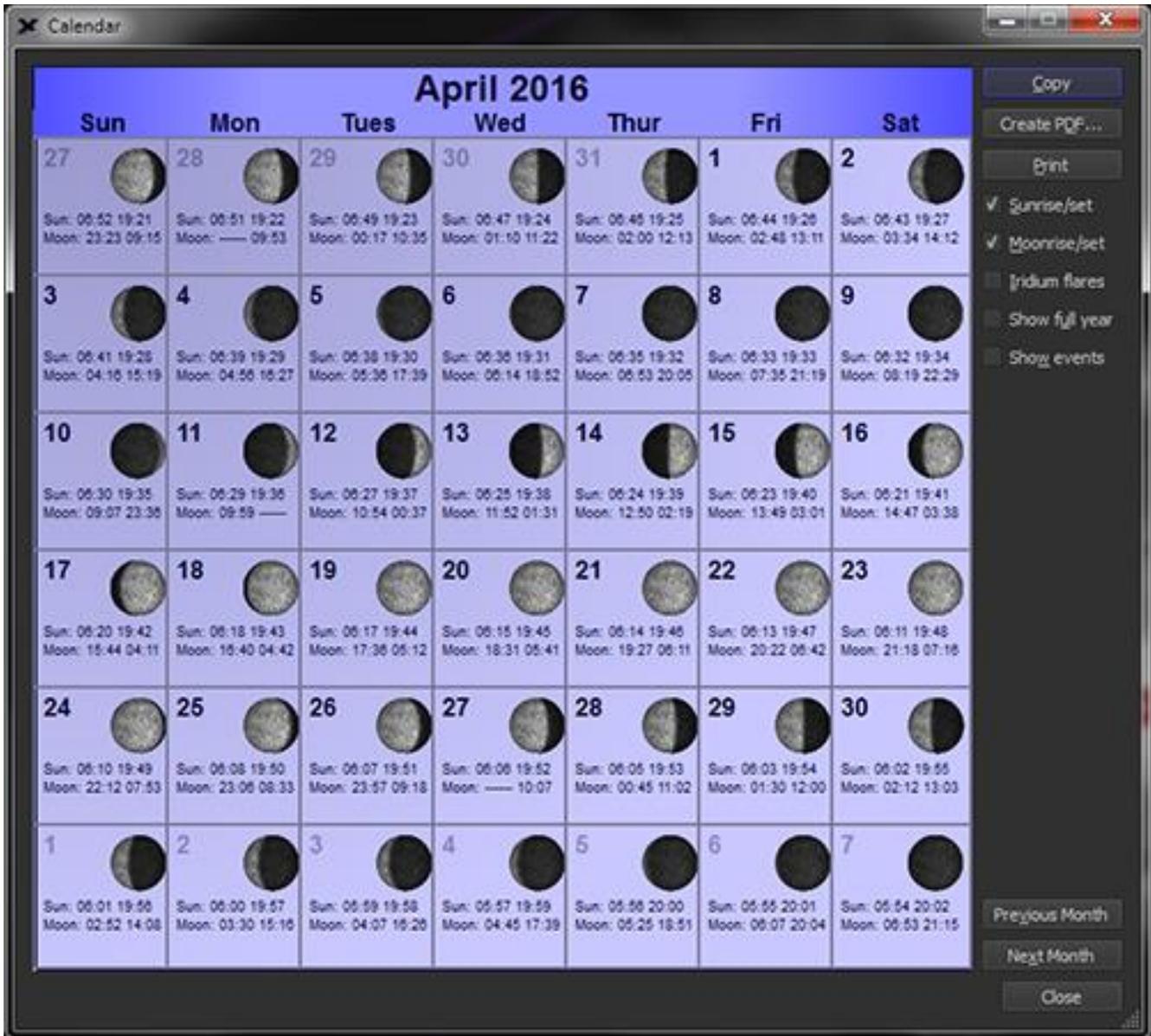


Figure 64: The Calendar window (*Calendar* command, *Tools* menu).

**Copy Calendar to Clipboard (Copy button)**

The current month’s calendar can be exported by copying it to the Clipboard using the **Copy** button, and then pasted into other applications that accept graphics (in *Portable Network Graphics* or PNG format).

Please include the Software Bisque copyright if you publish a calendar on the web or in a monthly astronomy bulletin.

**Create a Calendar as a PDF (Create PDF button)**

Calendars created as Portable Document Format (PDF) documents can be emailed and viewed, or printed using free software on Windows, or freely with the Preview application on the Mac.

PDF calendars, by default, are saved to the directory named:

Software Bisque/TheSkyX <Edition Name Here>/Exported Data

In your home folder (the one with the house icon in Finder on the Mac or the current user's *My Documents* folder on Windows).

**Print Calendars (Print button)**

Clicking the Print button sends the calendar to your printer. Make sure that your printer is turned on and ready to go before doing so.

**Show Sun or Moon Rise and Set Times (Sunrise/set, Moonrise/set checkboxes)**

Turn on the **Sunrise/set** or **Moonrise/set** checkbox to show the local sunrise (moonrise) and sunset (moonset) times for each day on the calendar.

**Show Times of Iridium Flares (Iridium Flares checkbox)**

To show the predicted times for flares in the calendar, *TheSkyX* must first generate an Iridium flare report. To do so, click the **Iridium Flares** command on the **Tools** menu, specify the desired search parameters, then click the **Find Flares** button to generate a report of upcoming flares.

After an Iridium flare report is generated, turning on the **Iridium Flares** checkbox on the **Calendar** window shows the magnitude, time, direction and altitude of each flare in the Iridium flare report.

**Show Yearly Moon Phase Calendar (Show Full Year checkbox)**

Turn on the **Show Full Year** checkbox to view the phases of the Moon for the current year.

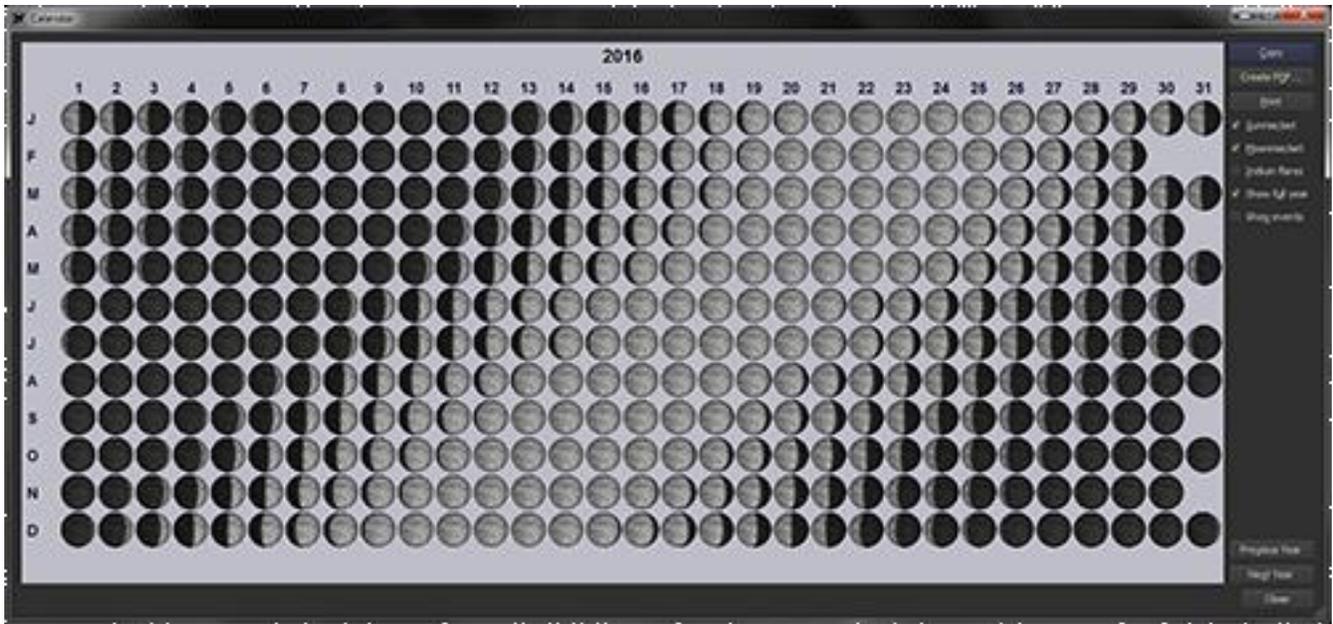


Figure 65: Phases of the Moon for one year.

### ***Future and Past Calendars (Previous/Next Month/Year buttons)***

When the **Show Full Year** checkbox is off, click the **Next** or **Previous Month** button to view a future or past month's calendar.

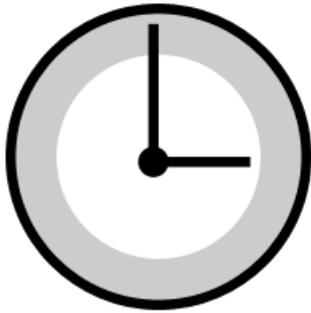
If you select the **Date & Time** tab, a small calendar for the current month will be displayed. Here's a very interesting feature: if you click on any date in the calendar, the Sky Chart automatically shifts to show you what the sky will look like on that date, for the current time. Notice also that the four major phases of the Moon are displayed in the calendar.

For a more detailed calendar, go to the **Tools** item in the Main Menu. Scroll down to **Calendar** and select it. A larger, printable calendar is displayed. Note that you can select various kinds of information to be included in the calendar by checking the appropriate boxes on the right-hand side of the window.

## **Exploring the Sky Chart**

In this section, we'll focus on how to adjust and navigate the Sky Chart. The best way to learn our program is simply to use it. Feel free to play around with the various buttons and menu commands you see in the tool bars. *TheSkyX* won't break, and it won't bite you.

## **Changing the Date and Time**



The clock built into your computer is constantly tracking the date and time. *TheSkyX* reads this and displays whatever is above your horizon right now, but it can also show you the sky for different times of day or night.

By default, *TheSkyX* starts up using the computer's clock to show time advancing at **1× (real time)** with the **Go Forward** button pressed (meaning time is advancing how you'd expect).

From the **Input** menu, select the **Date and Time** command to show the **Date and Time** window (Figure 66).

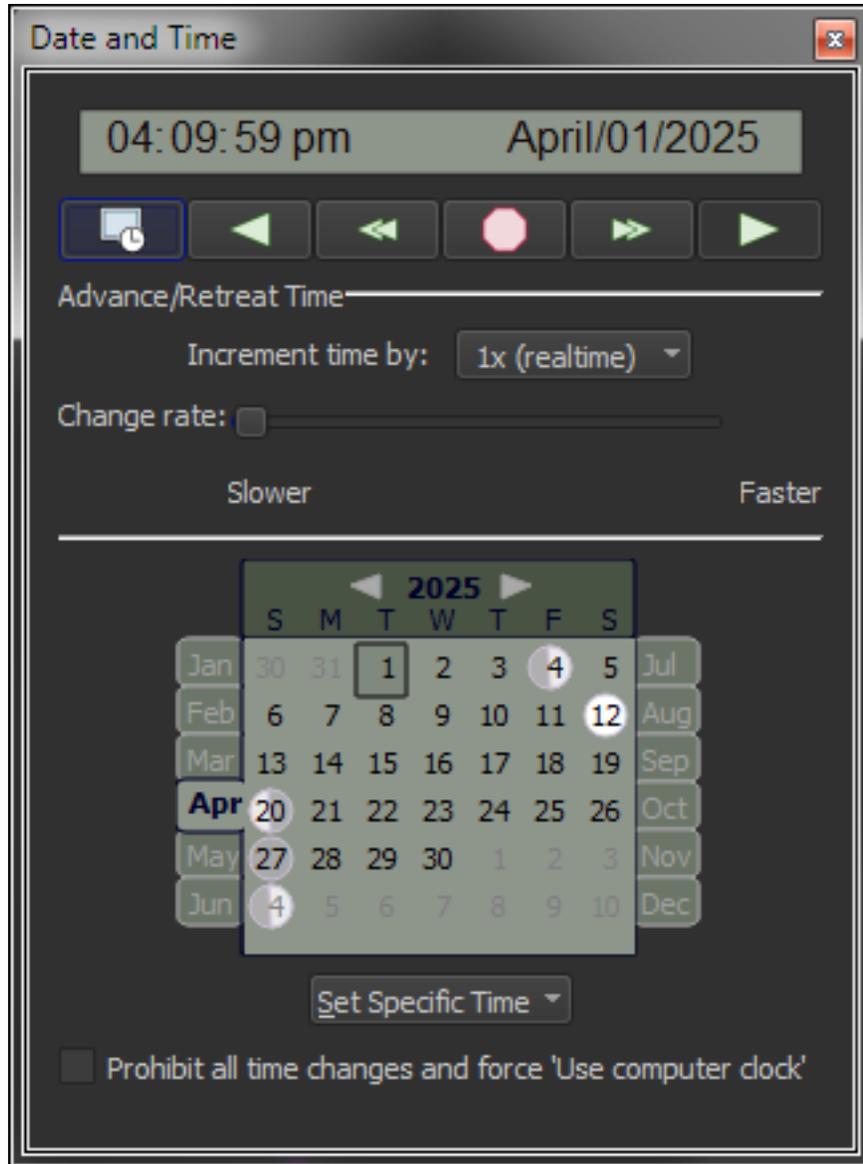


Figure 66: The Date and Time window (*Date and Time* command, *Input* menu).

### **Entering the Date and Time (Date & Time Control)**

Use *TheSkyX's* Date & Time control that is located near the top of the Date and Time window to enter any date, after January 1, 4,712 BC and before December 31, 10,000 AD.



Figure 67: The Date & Time control on the Date and Time window and on the Date & Time Toolbar (*Display > Date & Time Toolbar*).

Do to so, click the mouse on the date or time element you wish to change, then type the desired value for:

- hours
- minutes
- seconds
- AM/PM
- month
- date
- year

To set a specific month, click the month text to highlight it, then press the key for the first letter in the month. For example, press “D” for December. Pressing the “J” key repeatedly toggles the months January, June and July. If your mouse has a scroll wheel, use it to move up and down through the months. Or, use the up/down arrow keys on the keyboard.

To toggle between **AM/PM**, highlight the text, use the scroll the mouse wheel or up/down arrow keys on the keyboard.

The current month can also be selected using the calendar on the **Date and Time** window.

### **Formatting the Date and Time**

The format of the date and time can be changed to suit your preferences. Double-click on the Date & Time control to show the date and time formatting options. See “Have it Your Way with Preferences” on page 201.

## **Calendar Control**

TheSkyX’s Calendar control on the Date and Time window provides two mouse-click access to any date for the current year. If necessary, click the **Date and Time** command from the **Display** menu to turn this window on; click the **Date & Time** tab on the stacked windows to bring it to the front.

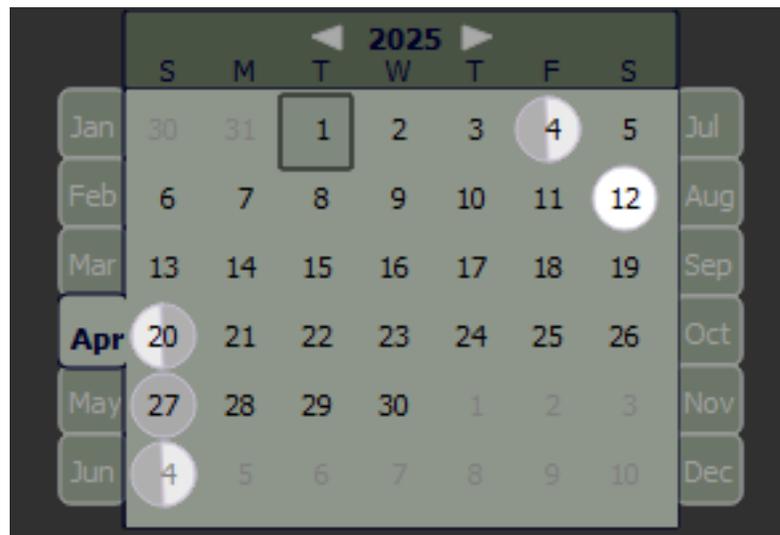


Figure 68: The Calendar control on the Date and Time window (*Date and Time* command, *Display* menu).

The top of the calendar control shows the year. Click the forward/backward arrows to advance/retreat one year at a time.

The edges of the calendar show the months of the year. Click any tab to bring it forward.

Black numbers for dates indicate the days in the current month, light gray numbers are shown for the prior or next month. The current day is highlighted light red. Click on any day to highlight it; the Sky Chart is adjusted accordingly. Click the month name tab to reveal the calendar for that month.

### Time Controls

Buttons for controlling the flow of time are available by clicking the *Date and Time* command on the *Display* menu and on the *Date and Time Toolbar*.

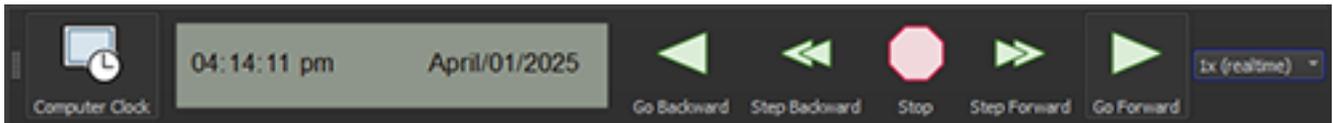


Figure 69: Time Controls on the Date and Time window (*Display* menu) and the Date and Time Toolbar (from left to right: *Computer Clock*, *Time Editor control*, *Go Backward*, *Step Backward*, *Stop*, *Step Forward*, *Go Forward*, *Time Skip Increment*).

### Use the Computer's Clock (*Computer clock*)

When the Computer Clock button is clicked, *TheSkyX* gets the date and time from the computer's clock. It also resets the time skip increment to **1x (real time)** and sets the **Go Forward** time skip option.

### Verifying *TheSkyX's* Time

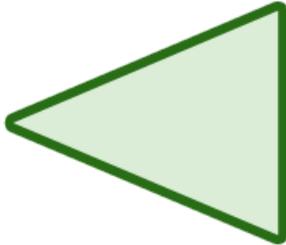


Accuracy is of the utmost importance in your observations. Select the **Verify *TheSkyX's* Time** command from the **Tools** menu to check *TheSkyX's* time against the U.S. Naval Observatory's

Master Clock. You can also click the corresponding toolbar button if you have the Orientation Toolbar activated (check **TheSkyX > Preferences > Toolbars**).

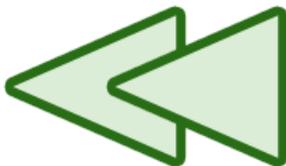
Note: This tool is valid for U.S. locations only, and requires an internet connection.

***Move Backward in Time (Go backward)***



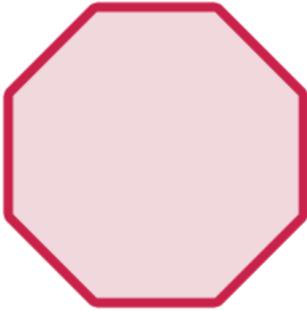
Even though time marches on, *TheSkyX* can make time go backward by clicking the **Go Backward** button. This can be handy to replay an astronomical event and is sort of like having your own DVD player on history.

***Step Backward in Time (Step backward)***



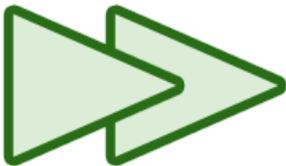
Unlike the **Go Backward** button, the Step Backward button can be used to incrementally retreat time by the Time Skip Increment amount. Use this to find the first contact of an eclipse, or determine the precise time when a minor planet occults a star, for example.

**Stop Time (Stop)**



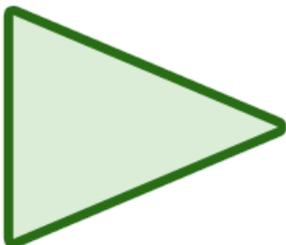
Use the **Stop** button to halt the motion of stars and other objects from your earth-based perspective.

**Step Forward in Time (Step forward)**



Use the **Step Forward** button to incrementally advance time by the Time Skip Increment amount.

**Go Forward in Time (Go forward)**



Use the **Go Forward** button to advance time. When the **Time Skip Increment** is set to **1× (real time)**, TheSkyX is showing you how the real sky looks at any instant.

### Advancing or Retreating Time (Increment Time By)

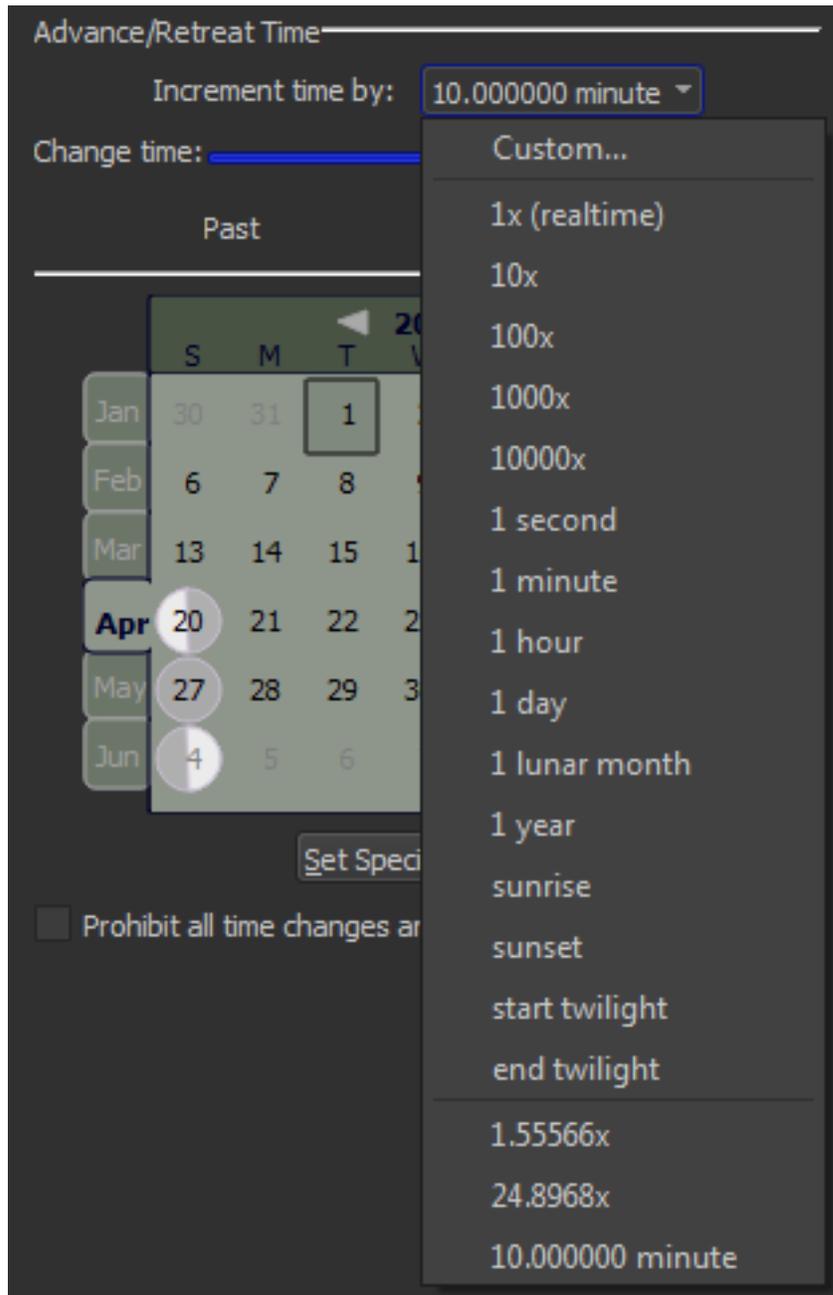


Figure 70: Increment Time control.

Use the Increment Time By control to specify the rate or interval to advance or retreat time.

The default time interval options include:

- **1x (real time)**: Time advances or retreats based on the computer's clock.
- **10x, 100x, 1000x**: Time changes by a factor of 10, 100 or 1000 times the normal rate.

- 1 second
- 1 minute
- 1 hour
- 1 day
- 1 lunar month
- 1 year
- **Sunrise:** The time skip interval is the length of time between sunrises for each day.
- **Sunset:** The time skip interval is the length of time between sunrises for each day.
- **Start Twilight:** The time skip interval is the length of time between morning astronomical twilight for successive days.
- **End Twilight:** The time skip interval is the length of time between evening astronomical twilight for successive days.
- Custom: Click the **Custom** command to show the **Custom Time Flow Increments and Rates** window.

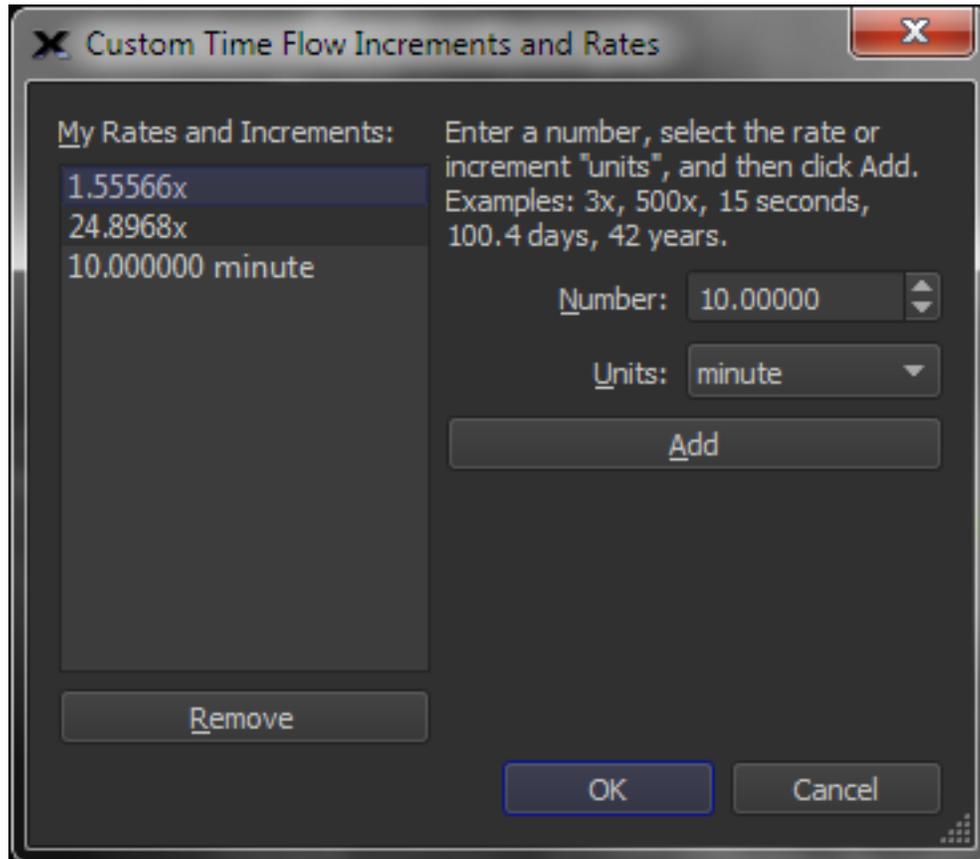


Figure 71: Define custom rates and time skip increments using the Custom Time Flow Increments and Rates window.

### ***User-Defined Rates and Time Skip Increments (My rates and increments)***

This list shows the rates and increments that you've defined by clicking the Add button to the right.

### **Define a Numerical Increment or Rate (Number)**

Enter any decimal number for the rate or increment you wish to define. For example, 2.56 days, or 500x.

### **Define the Flow Rate or Time Skip Increment Unit (Unit)**

Specify the unit for the rate or time skip increment. The lower case “x” unit means “a rate that is N times greater than actual time. Only whole numbers (integer) values are permitted for time skip rates.

### **Add Rates and Increments (Add)**

Once you’ve entered a number and a rate, click Add to add it to the **My Rates and Increments** list.

Custom rates are saved automatically, and restored when *TheSkyX* is opened.

### **Remove Rates and Increments (Remove)**

Select one or all the rates and increments, then click the **Remove** button to remove them from the list.

### **Quickly Change Time (Change Time)**

The **Change Time** slider on the **Date and Time** window allows you to quickly advance or retreat time at the current rate.

This control is useful for reviewing lunar eclipses, occultations and Iridium flares.

Now that you’re familiar with the time controls, below the calendar there is an item called **Set Specific Time**. Click it.

You’ll see a list of different “times”—not in hour and minute format, but in terms of astronomical events. The list of common events includes:

- **Now:** *TheSkyX* uses the computer’s clock to show time
- **Sunrise:** The time of day when the rising Sun reaches the “*refracted horizon*” – the line on the refracted sky that corresponds to the observer’s horizontal.

Hint: Refraction caused by the earth’s atmosphere bends light, so, at sea level, the Sun’s upper limb is visible about 3 minutes *before* it is above the local horizon.

- **Noon:** The time of day when the Sun is centered on the meridian. This is not necessarily 12:00 p.m.
- **Sunset:** The time when the Sun appears just below the “*refracted horizon*”.
- **Midnight:** 12:00:00 a.m. local time.
- **Morning (Begin Astronomical Twilight):** The time when astronomical twilight begins.

- **Evening (End Astronomical Twilight):** The time when astronomical twilight ends.
- **New Moon:** The date and time in the current month when the Moon's phase is zero percent.
- **First Quarter:** The date and time in the current month when the waxing Moon's phase is approximately 50 percent.
- **Last Quarter:** The date and time in the current month when the waning Moon's phase is approximately 50 percent.
- **Full Moon:** The date and time in the current month when the Moon's phase is approximately 100 percent.
- **Moonrise:** The time of day when the rising Moon intersects the refracted horizon.
- **Moonsset:** The time of day when the setting Moon is below the refracted horizon.
- **Vernal Equinox:** The date and time for the current year when spring begins in the northern hemisphere.
- **Summer Solstice:** The date and time for the current year when summer begins in the northern hemisphere.
- **Autumnal Equinox:** The date and time for the current year when autumn begins in the northern hemisphere.
- **Winter Solstice:** The date and time for the current year when winter begins in the northern hemisphere.

The last item in the list allows you to enter the Julian Date of an event.

The Moon's phase events search the current month. For example, if *TheSkyX's* month is set to any date in July 1592, the New Moon is July 24, even if the date is later than July 24.

When you select any of these options, the Sky Chart shows you what the sky will look at that time for the current date. Try several of the options and watch how the chart changes.

You can make time speed up and even go backwards. In the **Tools** menu, choose the item called **Time Skip**. Try one of the various options. The Sky Chart will continue moving backward or forward in time until you select **Stop**, or the **Use Computer's Clock** option.

Finally, you can also enter a specific date and time by selecting the **Input** item from the Main Menu and choosing **Date and Time** (note there is also a shortcut key for this displayed, within the menu – *TheSkyX* will always display shortcut keys in the menu whenever they are available).

### ***Prohibit All Time Changes and Force 'Use Computer Clock'***

Setting the date and time in *TheSkyX* is normally free flowing; you can simulate the night sky from one hundred years ago just as easily as tonight's sky with a few keystrokes or mouse clicks.

Setting the incorrect date and time when controlling a telescope can result in personal injury or damage your equipment.

When this checkbox is turned on, changes to *TheSkyX's* time settings are not allowed so that Sky Chart always uses the computer's clock to establish the date and time. It is turned on automatically when controlling a telescope, and turned off automatically when a telescope connection is terminated, or *TheSkyX* is closed. To avoid confusion, the state of this checkbox is not saved or restored.

## Reports

*TheSkyX* makes generating calendar reports of Sun and Moon activity, equinoxes and solstices, planet ephemerides and meteor showers a snap. Set the Sky Chart to any year you choose, and select **Tools > Reports** to see a wealth of astronomical data specific to the given year.

### ***Equinox/Solstice Report***

This report displays the date and exact time of each equinox and solstice for the Sky Chart's current year. To see a different year's values, simply change the Sky Chart's year in the Date and Time tab or toolbar.

### ***Meteor Radiant Report***

Keep on top of meteor shower activity with this handy report. With the ***Meteor Radiant Report***, you can instantly see the ***Month/Day, RA, Dec, and Hourly Rate*** of each meteor shower for the Sky Chart's current year. Just as with the other reports, you can obtain values for a different year by changing the date in the Date and Time tab or toolbar.

### ***Planet Report***

This is a "catch all" report that lists a variety of solar, planetary and lunar ephemerides and other useful information such as Earth distance, longitude of each visible planet's central meridian, Moon-specific information and more. You can obtain values by changing the date in the Date and Time tab or toolbar.

### ***Sun & Moon Report***

This report lists times for ***moonrise, moonset, sunrise, sunset***, and the ***beginning*** and ***ending of*** (astronomical) ***twilight*** for each day of the Sky Chart's current month and year. To see values for a different month or year, simply change the date in the Date and Time tab or toolbar.

### ***Sky Database Reports (All SDBs)***

This report shows the name, search prefix, object count, object type and the associated text file for every Sky Database.

### ***Copying Reports***

Any of these reports can be copied to the clipboard for pasting into another application by simply clicking the ***Copy*** button at the lower left side of the ***Reports*** window.

## The Look Commands

Our eyes can see only a small portion of the sky at a time. *TheSkyX* can show you the entire sky at once, but it's often more useful to focus the display on one part of the sky at a time, to match what you can see in the real night sky with your unaided eyes.

Changing the direction of your view is accomplished with the **Look** commands. These can be found in the **Orientation** menu, but they are also available to you as buttons in the **Orientation** tool bar.

By default, the Sky Chart is displayed looking south. Click the **East** button in the **Orientation** tool bar. Note that the star field has changed; the compass direction displayed at the bottom of the screen indicates E, for east. Experiment with the other compass direction buttons.

In addition to the compass direction buttons, a set of arrow buttons can be used to shift your viewing direction incrementally. Click the right arrow button. Notice how the view shifts slightly to the left (how far the Sky Chart shifts depends on your field of view, discussed below), just as if you were outside, looking at the real sky, and turning your head to the right. The left, right, up and down buttons function similarly (if your computer's monitor is small, or the screen resolution is low, the entire toolbar may not fit on the screen, so you may need to click the >> symbol to display the up and down buttons), mimicking the movement of your head in the indicated directions.

You can also press and hold the CONTROL key then drag the mouse to adjust the position of the Sky Chart.

## Orientation Options

A variety of options exist for orienting the Sky Chart. You may choose from a terrestrial sphere, or celestial sphere orientation, or a free rotation mode.

### **Terrestrial Sphere**

Choose the **Terrestrial Sphere** command from the **Orientation** menu to orient the Sky Chart as if from a vantage point on Earth's surface and according to terrestrial (azimuth and altitude) coordinates.

In this orientation, the simulated planets, stars and other objects move across the sky from east to west, just like the actual night sky. Detecting motion of the actual celestial objects using the unaided eye takes patience. While the stars may appear stationary at first glance, careful observation reveals the effects of earth's persistent on-axis rotation.

A magnified view of the night sky through a telescope with no clock drive quickly reveals the apparent motion as stars drift out of the field. The same is true for the simulated Sky Charts. When the **Terrestrial Sphere** option is selected, narrower fields of view, the apparent motion of the stars becomes obvious.

If you're working at smaller fields of view, and wish to "stop the world from turning" use the **Celestial Sphere** option.

### **Celestial Sphere**

To view the Sky Chart from the origin (center) of the celestial sphere, select the **Celestial Sphere** command from the **Orientation** menu. Objects are shown based on their equatorial positions and do not move as time advances.

### **Free Rotation**

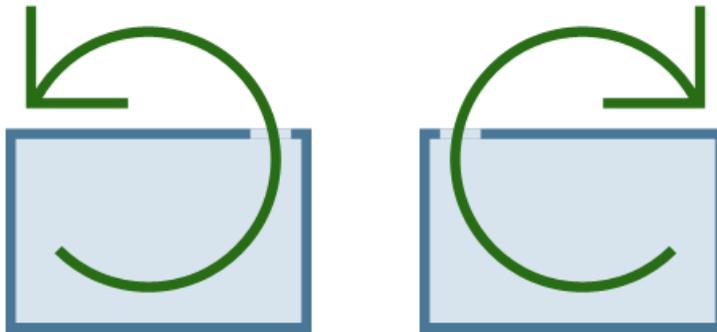
Choosing the **Free Rotation** command from the **Orientation** menu allows you to freely rotate the Sky Chart in any direction without being constrained to any coordinate system or convention.

**Note:** Each of these options is also available as a button on the **Orientation Toolbar** (page 209).

## **Rotating the Sky Chart**

While in Free Rotation mode, you can rotate the Sky Chart freely, in any direction, with commands from the **Orientation** menu, or by using the **Rotate Tool** found in the **Tools** menu.

### **Rotating Clockwise and Counterclockwise**



First, select **Free Rotation** from either the **Orientation** menu or from the Orientation Toolbar. Then, select either **Rotate Clockwise** or **Rotate Counterclockwise** from the Orientation menu. You can also use the keyboard shortcut **Alt++** (that is, press and hold down the **Alt** key while pressing the plus key; the Mac keyboard labels this key with the word **Option**, too) to rotate clockwise. Similarly, **Alt+-** rotates the Sky Chart counterclockwise.

### **Rotate Tool**

You can also rotate the Sky Chart to any position angle you choose by using the Rotate Tool. Click **Tools > Rotate Tool** to display it. A brownish-red position angle indicator appears on the Sky Chart with a label indicating the current position angle.

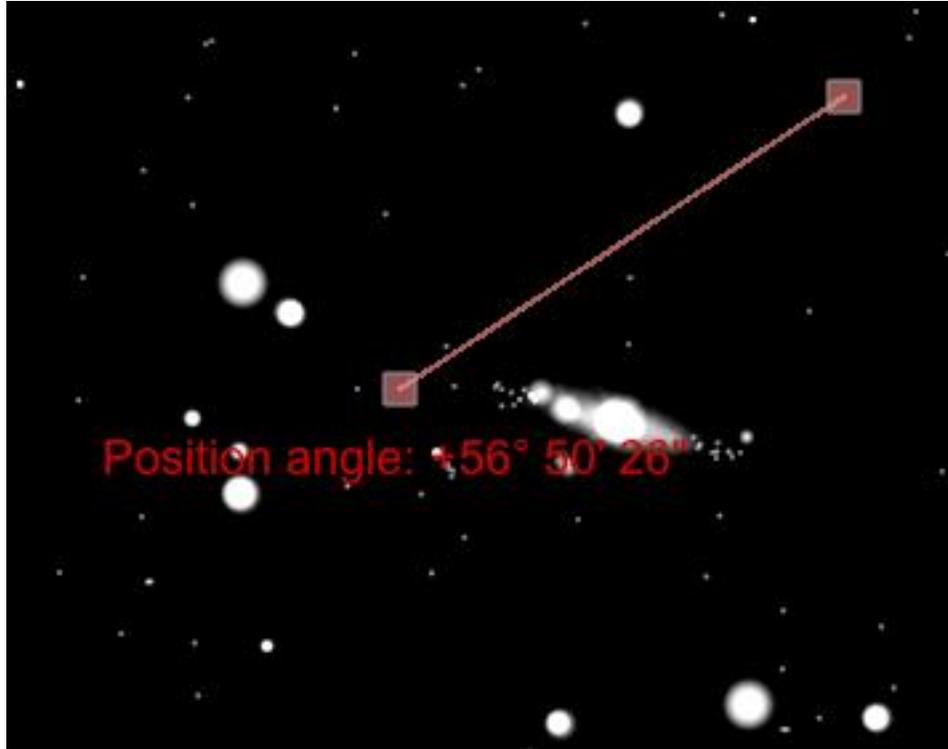


Figure 72: The Rotate Tool (Rotate Tool command, Tool menu).

To use the Rotate Tool, first center the Sky Chart at the rotation position. To change the position angle, click and drag the square at the end of the position angle indicator. Notice that the position angle readout changes as you drag the indicator.

You can also set a position angle using the Rotation settings under the **Orientation > Navigate** command. See the **Navigate Command** section for more details.

Position angle in *TheSkyX* is measured from the celestial pole, through east.

## Angular Separation & Position Angle



Determining the angular separation and position angle of two objects is a snap with *TheSkyX*.

### **Angular Separation & Position Angle Tool**

Select **Tools > Angular Separation & Position Angle** to bring up the tool. You will notice that a pale green indicator with two square endpoints and a square center point appears in the Sky Chart. To determine the angular separation and relative position angle between two objects, simply click and drag the endpoints so that they overlap the objects for which you wish to

determine angular separation and position angle values. You can hold down the Control key (Windows) or Command key (Mac) to snap the endpoints to the nearest object for greater accuracy. It's that simple! The desired values will appear in the label below the indicator. Determining angular separation and position angles has never been so simple or as elegant as it is in *TheSkyX*.

Once you are finished with this tool, deselect it by returning the **Tools > Angular Separation & Position Angle** command.

Note: The Angular Separation & Position Angle tool works in terrestrial or celestial sphere mode and in free rotation mode. You can also click and drag the Sky Chart to adjust the view at any time.

## **Field of View**

You probably know that a circle can be divided into 360 degrees. Imagine a pie cut into six equal slices. The angle between the edges of a given slice is  $360/6 = 60$  degrees. Astronomers measure angles in degrees, and fractions of a degree: each degree is divided into sixty minutes, and each minute is divided into sixty seconds.

When you look up, you can see only a portion of the entire sky. Imagine for a moment that the sky is an immense spherical bowl above your head. You're seeing an area of the sky that spans an angle.

Assuming you have normal peripheral vision, that angle is about sixty degrees – one slice of our imaginary pie in the sky. Another way of saying this is your *field of view* is sixty degrees wide. Some people can see a little more, some a little less, but sixty degrees is about average for adults.

When you look at the sky with binoculars or a telescope, what you see is magnified – in effect, you bring the sky closer, making it easier to see detail and faint objects. The downside of magnification is that it always reduces your field of view, sometimes to just a fraction of a degree. The greater the magnification, the smaller the field of view.

*TheSkyX* allows you to set the field of view to any angle, from 235 degrees to a fraction of a degree. This is very useful when you're trying to understand how much of a constellation or star field might be visible in a pair of binoculars or a small telescope.

## **Setting the Field of View**

A simple way to change the field of view is to use the **Zoom In** and **Zoom Out** buttons. The current field of view is displayed next to these buttons. Click on that pop-up menu. A list of preset fields of view is displayed. Some of these correspond to the field of view of a typical pair of binoculars or amateur telescope.

The **Wide Field** option shows you the sky from horizon to horizon, 180 degrees. The **Naked Eye** option gives you a 100-degree field of view – a bit wider field than what you can see with your eyes, but we wouldn't want you to miss anything.

You can also define a **zoom box** to zoom in to an area of the Sky Chart. Place your cursor on one corner of the area you want to zoom in on. While pressing the shift key, click and hold while you move your cursor to the opposite corner, then click anywhere inside the zoom box to enlarge it (you can click outside the zoom box to cancel this operation).

## **Stellar Cartography**

Just as you would use a map to find your way around a city, state, or country, celestial maps or *star charts* are designed to help you find your way around the sky.

Use your mouse or track pad to move the arrow around the Sky Chart. You'll notice that when the tip of the arrow touches an object, an information box describing that object is automatically displayed. The kind of information displayed depends in part on the nature of the object, but one thing that is always displayed is the location of the object. This is indicated by two different sets of coordinates.

## **Cosmic Coordinates**

Maps of the Earth identify the location of landmarks with two numbers: latitude and longitude. Latitude is measured in degrees north or south of the equator, and longitude is measured in degrees east or west of the Prime Meridian.

A similar system is used for objects in the sky. The *celestial equator* divides the sky into two hemispheres, north and south. The celestial equivalent of longitude is called *right ascension* (*TheSkyX* uses the abbreviation RA) and the equivalent of latitude is called *declination* (Dec). Right ascension is measured in hours, minutes, and seconds, from 0 to 24. This may seem odd at first, but there's a very good reason for this peculiar convention: the Earth is rotating. It turns around once on its axis in 24 hours, but from our terrestrial perspective, it looks like the sky is rotating around the Earth every 24 hours. Right ascension is measured eastward from the constellation Aries, the Ram. Specifically, 0 hours RA, the First Point of Aries, is the position in the sky where the Sun crosses the celestial equator on the first day of spring.

Declination is measured in degrees north or south of the celestial equator. The celestial equator is 0 degrees declination. The north celestial pole is located at 90 degrees declination (Polaris, the North Star, has a declination very close to 90 degrees). The south celestial pole is at *minus* 90 degrees declination. You can also translate right ascension into degrees: a complete circle has 360 degrees; dividing 360 by 24 gives 15, so every hour of right ascension is equal to 15 degrees.

Imagine a line running across the sky from due north to due south, splitting the sky in two. This line is called the *meridian*. Better yet, turn on the **Meridian** checkbox under the **Reference Lines & Photos** group on the **Chart Elements** window (page 254) to view it on the Sky Chart. When a celestial object crosses the meridian, it is also at its highest altitude in the sky. This is called the *transit time*. The best time to observe a celestial object with a telescope is when it's crossing the meridian.

This brings us to another way of identifying the location of an object in the sky: altitude and azimuth. Altitude is simply the number of degrees the object is above the horizon, from 0 (on the horizon) to 90 (directly overhead). Be careful not to confuse altitude with declination – they are not the same thing.

Azimuth indicates the compass direction of an object. Specifically, it is the number of degrees east of north that you need to turn to see the object. Due east, for example, is 90 degrees azimuth.

The problem with using altitude and azimuth for astronomical objects of course is that these numbers are constantly changing as the Earth rotates. *TheSkyX*, however, can calculate these numbers instantaneously, making it easier to know what direction to look when you're outside in the dark, trying to find an object at a specific time.

## Understanding Projections

Ever since we discovered that the Earth isn't flat, but spherical, cartographers have been looking for ways to represent a curved surface on a flat surface.

A sphere cannot be projected onto a plane without introducing distortion. In the most commonly used projection – called the Mercator projection – objects get larger the farther they are from the equator. This causes Greenland to look nearly as large as the entire United States on a world map. Navigators adopted the Mercator projection because a straight line on a Mercator projection, called a *rhumb line*, represents a constant compass bearing from true north.

Other projections have their own combinations of strengths and weaknesses. *All* projections are compromises – the “best” projection is the one whose advantages outweigh its disadvantages for an application.

By default, *TheSkyX* uses the *stereographic* projection for fields of view greater than 60°. A stereographic projection is said to be “conformal.” Although (as with all flat maps) the overall projection is distorted, all lines of declination and right ascension intersect at right angles, as they do on the celestial sphere.

The advantage of stereographic projection is that, over small areas of the display, object shapes are only slightly distorted. Constellations remain easy to identify. Compare this with the *polar* projection of a planisphere. There is almost no distortion near the poles, but constellations near

the horizon are badly stretched out of shape. (A planisphere is one of those rotating star charts that approximate what's visible in the sky at a given date and time.)

When the Sky Chart is set to a field of view of 60° or less, the projection automatically switches to an *orthographic* projection, which displays the sky more as it would appear on the surface of a sphere. (This is the only projection used at 60° fields of view and smaller.)

### Projections

By default, *TheSkyX* uses a stereographic projection for 60° fields of view and greater. The Projections command from the Display menu changes the projection. In the **Projections** window, click the radio button of the projection you want.



Figure 73: The Projections window.

The selected projection is applied to the Sky Chart immediately. It takes effect only when the field of view is greater than 60°—no change occurs if the current field of view is 60° or less.

- **Stereographic:** The default for fields of view equal to and greater than 60°. It keeps lines of right ascension and declination at right angles and minimizes local distortion. Conformal. 235° maximum field of view.

- **Orthographic:** Displays the sky more as it would appear on the surface of a sphere. It's the default (indeed, it's the only available projection) for angles of view 60° and less. Conformal. 180° maximum field of view.
- **Mercator:** Shows the celestial sphere like a conventional map. It allows wider fields of view, including a 360° view that shows the entire celestial sphere. Conformal. 360° maximum field of view.
- **Gnomonic:** This is the “pinhole camera projection.” It displays meteor paths as straight lines, as seen when viewing a meteor shower. Non-conformal. 150° maximum field of view.
- **Azimuthal Equal-Distance:** The distance between objects having an angular separation on the celestial sphere is the same at any part of the Sky Chart. Non-conformal. 300° maximum field of view.
- **Azimuthal Equal-Area:** The areas of any sections of the celestial sphere subtending a solid angle are the same at any part of the Sky Chart. Non-conformal. 235° maximum field of view.

## Stars and Constellations

There are some 6,000 stars visible to the naked eye. Most of these stars can only be seen from locations far from the bright lights of a city or town. If you really want to see the stars, you either must go to Hollywood or get out of Dodge.

### Star Names

Some of the brighter stars have proper names, but most don't – there are just too many to give each one a name. Instead, astronomers have devised a system that assigns names to naked-eye stars based on their brightness and the name of the constellation they belong to. Following a centuries-long tradition, the brightest star in a constellation is designated by the first letter of the Greek alphabet, Alpha, followed by the genitive form of the Latin name of its constellation. For example, the brightest star in the constellation Orion is called Alpha Orionis. It also has a proper name: Rigel. (We'll talk more about constellations later. Right now, we're going to focus on individual stars.) When the letters run out, stars are identified by various alphanumeric designations.

A funny thing about Rigel: even though it's the brightest star in Orion, its designation is *Beta* Orionis. Astronomers originally thought that Betelgeuse, another star in Orion, was a little bit brighter, but improvements in *photometers* in the 20<sup>th</sup> century revealed that Rigel is the brighter star (it's possible that Betelgeuse might have been brighter in the past, when astronomers first began to designate stars with Greek letters).

### Bright Stars and Dim Stars

Long before the invention of the telescope, astronomers also came up with a *numerical* system for classifying stars by their brightness. They decided that the brightest stars would be called

First Magnitude. Those half as bright as First would be called Second Magnitude, then Third Magnitude, and so on down to Sixth Magnitude, which denotes the dimmest stars visible to the naked eye.

We use a modified form of this system today. The brightest star in the nighttime sky is called Sirius. It's in the constellation Canis Major, the Big Dog, and it's sometimes called the Dog Star. Its magnitude is *minus* 1.4, which we write as  $-1.4$ . This may seem a little confusing, but it isn't that hard to understand. A couple of centuries ago, astronomers decided to make the magnitude scale more precise. They knew the Sun and Moon and some of the planets are brighter than the brightest stars, so these were given negative magnitudes. They also realized that a First Magnitude star is a bit more than twice as bright as a Second. To keep Sixth Magnitude as the faintest star visible to the naked eye, astronomers recalibrated the magnitude system to follow a *logarithmic* scale. Each stellar magnitude is about 2.5 times brighter than the next lower magnitude so that the difference of five magnitudes is a brightness factor of (exactly) 100.

With a telescope, you can see stars much dimmer than Sixth Magnitude. *TheSkyX* database includes stars down to about 14<sup>th</sup> Magnitude.

On a clear, moonless night, people who live in cities or suburbs can rarely see stars dimmer than Third Magnitude. If you're just starting to learn the names of the brighter stars and constellations, you should set the magnitude filter in *TheSkyX* to Second or Third magnitude. That way, when you go out at night to compare what you see on your computer to what you can see in the real sky, you won't be confused by a screen display that shows more stars than you can see from your location.

## Setting the Magnitude Limit

This command tells *TheSkyX* to only display stars, galaxies, clusters, or any other object type, or combination of object types, that has magnitude information, that are brighter or fainter than a selected magnitude. Controls for editing the magnitude limits are found on the **Chart Elements** window on the **Display** menu.

The following example demonstrates how to change the magnitude limits for all celestial objects.

1. Make sure the Chart Elements window is visible. If it's not, select the **Chart Elements** command from the **Display** menu to show it.
2. Highlight the **Celestial Objects** text by clicking on it. This selects the 40 chart elements in the Chart Elements node.
3. Click the **Edit Attributes** button.
4. Near the bottom of the Chart Elements window you'll see a tab labeled **Magnitude Limits**. You can enter a value between 30.0 and  $-6.0$ , or change the magnitude using the sliders.

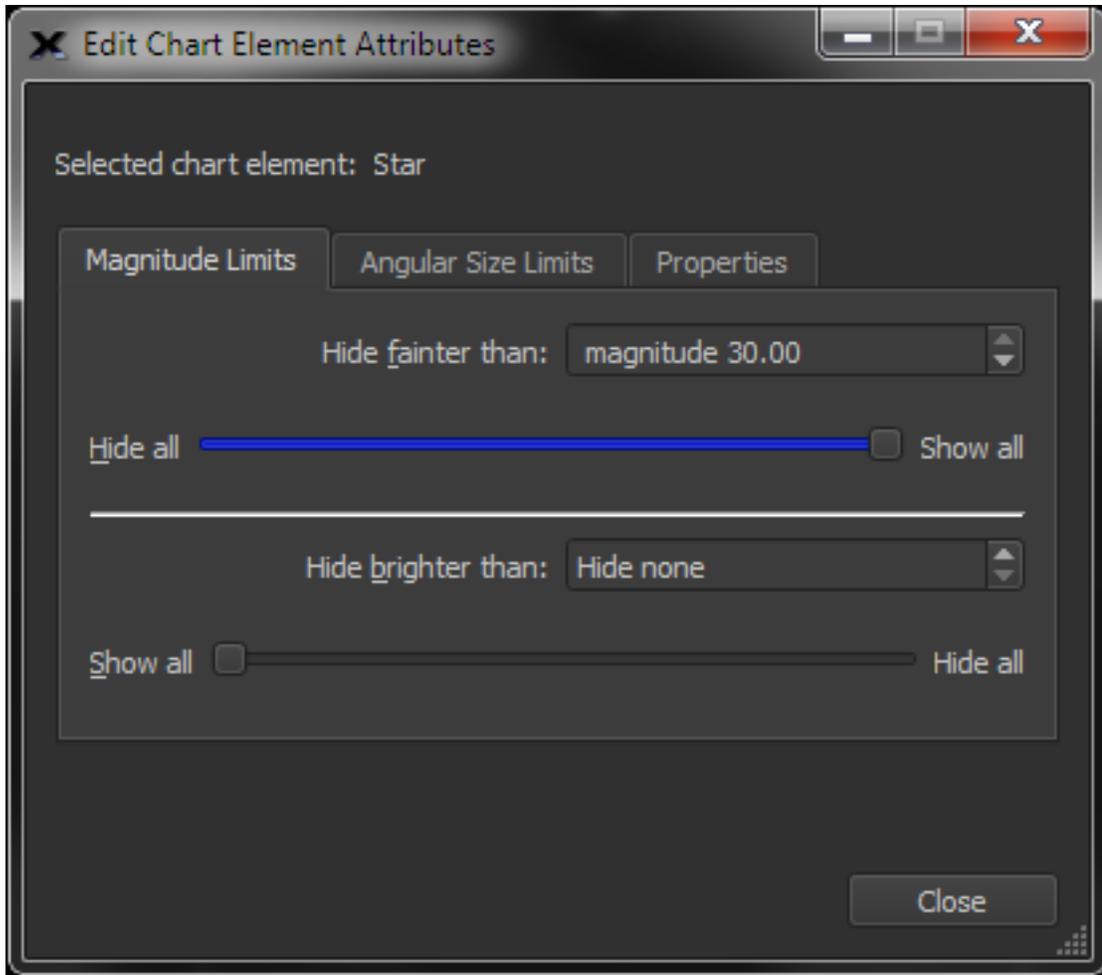


Figure 74: Magnitude Limits tab on the Chart Elements window.

The attributes of chart elements (including lower and upper magnitude, angular size, font properties and colors) can be changed individually or as a group based on the items that are selected in the Chart Elements list.

***Number of Selected Chart Elements (Selected)***

This text shows the name of the selected chart element or the number of selected chart elements in the Chart Element list.

***Show Only Brighter Stars (Hide fainter than)***

Specify the magnitude of the *faintest* objects to be displayed on the Sky Chart. For example, if you live in a light polluted city and want to approximate the stars you can see on typical night's sky, enter magnitude 1 or 2.

### **Show Only Fainter Stars (Hide brighter than)**

The **Hide Brighter Than** controls provide additional filtering, displaying objects only within a specified brightness range. *Larger* magnitude values represent *dimmer* objects. The brightest objects have negative magnitudes.

As you move the slider the number of stars on the Sky Chart changes to reflect the changing magnitude limits.

### **Other Chart Elements**

Like land maps, star charts can be overlaid with a variety of lines and markings intended to highlight specific celestial features and help you find objects at specific coordinates.

The **Chart Elements** menu lets you display or hide various reference lines and symbols, but you should be aware that even though the cosmos mostly consists of empty space, a star chart can get very crowded very quickly. The celestial equator and lines of right ascension and declination can be added to the Sky Chart, for example. Experiment with this feature by clicking on the box next to a listed chart element to see how it affects the display.

### **A Star to Guide You**

For people living in the northern hemisphere, probably the most noteworthy star is Polaris, the North Star. It always stays in the same part of the sky, every night, 365 days a year. The reason for this is simple: Polaris happens to be located almost directly above our North Pole. As the Earth rotates on its axis, other stars rise and set, but because Polaris is right above the pole, it always seems to stay in the same place.

How high Polaris is above your horizon is a direct way to find your latitude. If Polaris is 40 degrees above the local horizon, for example, you must be somewhere on the 40<sup>th</sup> latitude line. Philadelphia and Denver are both very close this latitude, as are Naples, Italy and Beijing, China. The stars you can see on any given date and (local) time are essentially the same for these cities, and any other place along this line of latitude.

More than anything else, latitude determines what you can see in the sky. The North Star is not visible from the Southern Hemisphere, as are most of the stars and constellations near it. And there are all sorts of stars and constellations visible from the Southern Hemisphere that we never get to see in the North (the Moon and planets are visible from both hemispheres). *TheSkyX* can show you what the sky would look like from any place in either hemisphere.

### **Double Stars**

A little more than half of all stars travel in pairs, orbiting each other in space. The American astronomer Henrietta Leavitt once quipped that three stars out of every two are double. Most of them appear as single stars to the naked eye. You need good binoculars or a small telescope

to resolve them as double stars (there are also triple stars and groups consisting of four or even more stars).

Some double stars are true *binaries*, meaning they are gravitationally bound to each other and orbit a common point in space. Others only appear to be double because they happen to lie along the same line of sight from Earth, but are in fact many light years apart and not tied to each other by gravity.

One of the best-known double stars in the sky is called Mizar. It's located in the handle of the Big Dipper.

## **Finding Mizar**

Mizar is visible only from the Northern Hemisphere, and is easiest to find in the evening sky in Spring.

Select the **Find** tab from the vertical tabs on the left side of *TheSkyX's* window.

Type Mizar into the **Search For** text input, then click the **Find** button. A double red "bull's eye" will encircle the star in the Sky Chart.

The Big Dipper is one of the northern sky's most recognizable *asterisms* (this term is described below). Being able to find it will help you find other nearby constellations, such as Cassiopeia. Once you've mastered these constellations, others will be easier to learn.

Another good thing about being able to find the Big Dipper: it will make it easy for you to find Polaris, and therefore true north. The two stars at the end of the cup of the dipper point to Polaris. Imagine a line connecting these two stars. Extend it in the direction the cup is pouring, about five times the distance between the two stars. The star you see at the end of that line is Polaris.

## **Variable Stars**

Fortunately for us, and everything else that lives on Earth, the Sun radiates energy at a very nearly constant rate. But there are some stars that change in brightness dramatically over the course of a few months, and in some cases, just a few days or even hours. These are called *variable stars*, and *TheSkyX* distinguishes them with a small red "v" to the lower left of the star.

The most notorious variable star is called Algol, a name derived from an Arabic word that means demon. Located in the constellation Perseus, its rhythmic dips in magnitude can easily be observed with the naked eye. Every 2.867 days, over the course of just a few hours, Algol falls from second magnitude (2.1) to third (3.4) and back. During these periodic dimmings, you can gauge its changing brightness by comparing it to other nearby stars. The evening sky in Autumn is the easiest time to find this fascinating object (it is only visible from the Northern Hemisphere).

It may have been considered demonic in ancient times, but today we know this innocent star has a companion that orbits it every 2.867 days. Algol dims when that companion passes in front of it from our perspective. Such stars make up a special class called *eclipsing binaries*.

## **Classifying Stars**

Stars differ not only in their brightness, but also in their size, surface temperature, and chemical composition. The one thing they have in common is that they are all spherical – although some spin so fast they tend to bulge in the middle!

All stars are basically immense balls of intensely hot gas that generate heat and light through a process called *nuclear fusion*. The temperature and density in the core of a star are so great that lighter atoms smash into each with enough force to fuse into heavier atoms. In our own Sun, for example, atoms of hydrogen fuse to produce atoms of helium (this process involves several intermediate steps). The fusion process releases energy in the form of electromagnetic radiation – light.

By spreading starlight into a spectrum, astronomers can learn the temperature and chemical makeup of stars. After studying thousands of stars, it became clear that stars fall into various categories, or classes. Some are massive and bright, and have relatively short, tumultuous lives. Others are small and dim, and can shine steadily for tens of billions of years.

A letter and number system is used to define stars in terms of their most important physical characteristics, and these designations are displayed when you point to a star in the Sky Chart. A more complete discussion of *spectral classes* and the physics of stars can be found in any introductory astronomy text.

## **Giants and Dwarfs**

When you see a bright star in the sky, there are two possibilities: the star is close by and relatively average in size, or it is far away and gigantic.

Rigel is the brightest star in the constellation Orion. It is nearly 800 light years away, but is the seventh brightest star in the sky. It is a whopper, with a diameter of about 100 million kilometers. The Sun, by comparison, is about 1.4 million kilometers across.

Astronomers distinguish between *apparent* magnitude and *absolute* magnitude. Apparent magnitude is how bright a star looks in the sky. Absolute magnitude refers to how bright a star would appear if it were located exactly 10 parsecs (32.6 light years) away. The apparent magnitude of Rigel is about 0.2, but its absolute magnitude is nearly  $-7.0$ .

## More about Constellations

The desire to find order in nature, even where none exists, seems to be built into the human brain. When you look up at the sky on a dark, clear night, the sheer number of stars can be overwhelming. Our distant ancestors must have been in awe of those countless lights randomly scattered across the sky like diamonds.

Because of our instinctive need to find order, cultures across the globe have organized stars into distinctive patterns called *constellations*. These patterns are purely a product of the human imagination. Nature had nothing to do with creating them.

The constellations we recognize today have mostly come down to us from the ancient Greeks. Many of them represent mythological figures. Orion, for example, one of the most prominent constellations visible in northern wintertime, represents a heroic hunter who first appeared in one of the great epics of classical Greek literature, *The Odyssey*. Orion is accompanied by two hunting dogs that are also immortalized in constellations: Canis Major and Canis Minor, the big and little dogs, respectively.

When you look at Orion, it isn't hard to imagine the figure of a hunter with a raised arm wielding a club. You can see one classic representation of this figure by going to the **Display** menu and selecting **Constellations & Asterisms Options**. You can display line drawings, mythical figures, and constellation boundaries by checking the appropriate boxes. You can also use the slider labeled **Transparency** to adjust how bright these renderings appear.

For many other constellations, the connection between its array of stars and what it is supposed to represent is difficult to see, to say the least. They're a little more like abstract art, intended to represent the idea of a thing rather than the thing itself.

Drawing lines between the stars of a given constellation provides a simple "stick figure" view of that constellation. When astronomers think about constellations at all, this is how they usually think of them. The more fanciful mythological drawings of constellations became popular in the early 17<sup>th</sup> century, especially in the gorgeous star charts engraved by the great German celestial cartographer Johann Bayer (Bayer is also credited with creating the system that designates stars with Greek letters and the genitive name of their constellations, as described previously).

When the constellations we recognize today were originally created, many stars were left over – that is, not all stars fit into the established patterns. To avoid confusion, astronomers designated boundary lines between the constellations. Not unlike borders between countries, any star that falls within the borders of a given constellation is said to belong to it, whether it was included in the original depiction of that constellation or not.

## Asterisms

There are familiar patterns of stars that don't quite qualify as constellations. Astronomers call these patterns *asterisms*. The Big Dipper and the Pleiades (the Seven Sisters) are probably the two most familiar examples. In Japan, the Pleiades are called Subaru. You've probably seen them driving around your neighborhood.

## Some Tips on Using Star Charts

Learning how to connect what you see on a star chart to what you see in the real sky takes some time. We're going to show you a step-by-step process that will make it easier for you to find common stars and constellations. With a little patience and practice, you'll soon become an expert.

First, when you go outside and look at the sky, you need to know what direction you're facing. You need to know how to find true north. City streets often lie along north/south and east/west lines, but this isn't always the case. If you aren't sure which way is north at your viewing location, use a magnetic compass to find it.

When hundreds of stars are displayed on your chart, finding individual stars and constellations can be very challenging. But if you limit the number of stars in the chart to just a dozen or so of the brightest stars, you'll have a much easier time learning the sky.

## Printing a Sky Chart

Printing a sky chart to take with you when you go outside is also very helpful. *TheSkyX* can print any chart it displays. You can print an "all sky" chart, or select a part of the sky you're interested in learning.

Choose the **File** command from the main menu. Near the bottom of the menu, you'll see two items: **Print** and **Print Setup** (if you have more than one printer connected to your computer, **Print Setup** can be used to select the printer you'd like to use). Select the **Print** command.

The **Print Chart** tab of the **Export Chart** window is displayed on the screen. In addition to printing charts, *TheSkyX* allows you export charts as *Portable Document Format* (PDF), *Scalable Vector Graphic* (SVG) and *Postscript* files.

### **To Export a Sky Chart in PDF, SVG or Postscript Format**

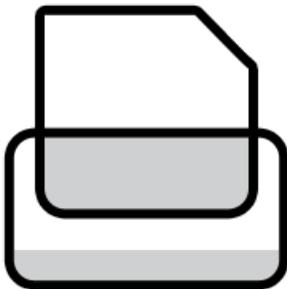
1. Select the desired option from the **Format** list.
2. Click the **Export** button.
3. On the **Export Chart** window, enter the file name to save the chart in this format.
4. Click **Save**.

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Click the **Create Bitmap** tab (or, from the main menu, click the **Export** command from the **File** menu) to view the options for saving Sky Charts as *bitmaps* or *pixmap*s. Click the **Copy Sky Chart** button to copy the current chart to the Clipboard. Click the **Save As** button to save the chart as a *Portable Networks Graphics* (PNG) file.

Turn on the **Create Custom Size** checkbox to specify the **Resolution**, in dots per inch (DPI), **Width** and **Height**, in inches, of the bitmap.

If you want to create high-resolution star charts for publication, individual “layers” of the chart can be exported by turning on the desired checkboxes in the **Chart Layers** tab.



Clicking the **Print** button on the **Print Chart** tab sends the chart to the currently selected printer. *TheSkyX* uses the current **Map Like** display settings (page 251) and prints stars in black, leaving the sky white. The size of the star is proportional to its magnitude. Non-stellar objects are also printed using the symbols that appear in the **Map Like** Sky Charts.

You can choose the orientation of the printout and other printing parameters by clicking the **Page Setup** button. When you’re ready to print, simply click the **Print** button.

The best time to start learning the sky is a clear, cloudless night, when there is no Moon or at most a crescent Moon. Moonlight can interfere as much as city lights when it comes to seeing the stars, and if the Moon is close to Full, you probably won’t be able to find any but the very brightest stars and planets. You also want to be in an open space, a place where there are no tall buildings, trees, or annoying artificial lights to interfere with your viewing. Make sure that you have a clear view to the north.

When you get to your observing site, give your eyes at least a few minutes to adapt to the darkness. You’ll need a flashlight to read the chart of course, but you should use one that has a red filter. These can be bought at most stores that sell telescopes, or you can simply tape a piece of transparent red film over a standard flashlight. Using only red light will help preserve your night vision. If you take your computer outside with you, the **Display > Show Night Vision Mode** command will help preserve it, too.

## **An Interstellar Perspective**

Our Sun is but one of billions of stars in the Milky Way galaxy. For centuries, astronomers have been charting the positions of other stars in our galaxy, and have accurately determined the distances to many thousands of them. This information allows us to step outside our solar system, in effect, and see what the Sun and other stars in our part of the galaxy would look like from dozens of light years away.

The constellations are only figments of our imagination. A constellation's stars may seem to be close together, but are usually very far apart and often have no mutual relationship at all. (Except for being part of the same galaxy, the Milky Way.) The sky looks flat because there are no reference points to help us perceive the distance to the stars with just our eyes. Since the human mind is pretty good at creating order from random patterns, seeing pictures in the sky is no surprise. *TheSkyX* has a 3D stars tool that can help you to understand the spatial relationship between stars that we see at night.

### **Viewing the 3D Star Map**



Selecting **3D Stars** command from the **Tools** menu brings up the **3D Stars** window. Immediately upon opening the window, the viewer will pan across a 3D rendering of the heavens, with the position of our Sun marked in the center. Click and drag on the star field to get a feel for the nature of the 3D space.

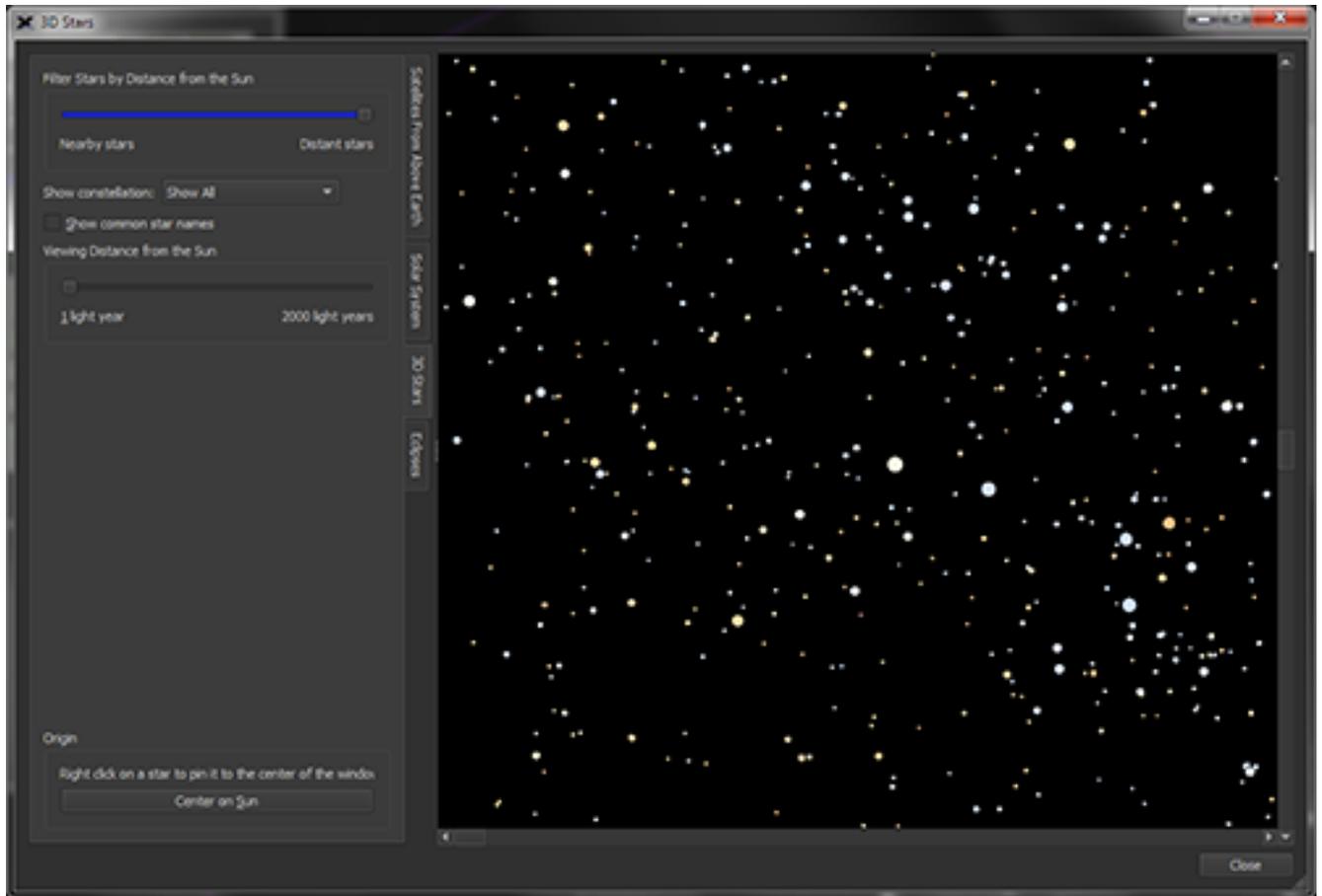


Figure 75: The 3D Stars window.

### 3D Star Map Controls

On the left, you will see the controls that operate the 3D Stars tool. On the top, you will see a slider that allows you to view visible stars from those relatively nearby to those quite distant.

The bottom slider, labeled **Viewing Distance from the Sun**, ranges from 1 to 2,000 light years. A light year is a fundamental “cosmic yardstick” used to describe the distance to the stars. One light year is equal to the distance that light travels in one year. Since light travels at approximately 300,000 kilometers per second in a vacuum, then a little math tells us that a light year is equal to about 9.5 trillion kilometers: that’s far! Another interesting fact about light years is that the number of light years distant an object is tells us how long it takes light to arrive here from that object. So, if an object is 2,000 light years away, that means it took the light we see from that object 2,000 years to reach us. Also, it means that we see that object, not as it exists today, but as it existed 2,000 years ago. The further we look out into space, the further we see back in time.

Using the **Filter Stars by Distance from the Sun** slider will allow you to see the general stellar structure of our galaxy by displaying stars up to 2,000 light years away from our home solar system. Using this can help you to get a feel for the relative distance of many stars, including well-known favorites, such as Betelgeuse and Rigel in the constellation Orion. Notice that the

number of stars that disappear grows as you move the slider to the left, meaning that most of the stars we see at night are quite close to us, relatively speaking.

### **Viewing a Single Constellation**

If you would like to focus on a single constellation, you can do that, as well. Using the **Show constellation** pop-up menu, select a constellation; you can choose from any of the 88 official astronomical constellations. Let's use the functions of the 3D Stars tool to explore the region around a famous constellation, Orion, the Hunter.

1. Choose the **3D Stars** command from the **Tools** menu.
2. Select **Orion** from the **Show constellation** drop-down menu. You will now see the constellation of Orion, the Hunter in the viewer, surrounded by the constellation boundary box. These boxes are used by astronomers to describe regions of the sky found near the 88 constellations.
3. Check **Show common star names** to show the names of the more "famous" stars, the A-listers, if you will. In Orion, the stars of his shoulders, knees, and belt are labeled, as well as the brightest star of his head.
4. Use the **Filter Stars by Distance from the Sun** slider to hide or reveal stars based upon their distance from the Sun. Move the slider to the left, and take note of when each star in Orion disappears.
5. Now, using the **Viewing Distance from the Sun** slider, adjust the distance back and forth and observe the effect on the constellation's appearance.
6. Try sliding the same slider about one-quarter of the way to the right. Then, click and drag on the constellation. You will see an exploded view of Orion's stars through 3D space. This gives you a great view of the relative distance of each of Orion's stars. Experiment with various viewing distances to get a feel for how it works.
7. Use the **Filter Stars by Distance from the Sun** slider to see an excellent demonstration of each star's distance, as they appear and disappear, based upon their distance.

Experimenting with the sliders and with different constellations will serve to give you a good grasp on relative stellar distances. The next time you look up at Orion, think about space in 3D and the vast distances over which that light travelled to get to your eyes.

## **Closer to Home: Atmospheric Phenomena**

As we mentioned earlier, some of the most interesting things we can see in the sky are happening right above our heads, in the upper atmosphere.

### **Meteors and Fireballs**

You've probably seen a so-called shooting star (maybe you've even wished on one). A shooting star isn't really a star at all, but a grain of space dust. When one of these particles hits our atmosphere, it's traveling at tens of thousands of kilometers an hour. Friction makes it glow white hot, turning it into a *meteor*. It may seem surprising that a speck of dust at the edge of

space could create a streak of light visible from the ground, but even the brightest meteor is rarely bigger than a pea.

The flying dust grains that cause meteors mostly come from the tails of *comets*. Several tons of this material fall to Earth every single day. If you get away from the lights of the city and watch the sky on a moonless night for an hour or two, you'll see at least a few meteors – maybe quite a few. They're falling everywhere, all the time.

Occasionally something much larger than a speck of dust falls to Earth and creates a spectacular *fireball*. Fireballs can blaze across the sky with such intensity that they literally light up the landscape. They can range in size from a few centimeters to several meters. Bits and pieces of them sometimes survive the fiery descent through our atmosphere and crash into the ground. These fragments are called *meteorites*.

Meteorites are chunks of *asteroids* and they fall into three main categories, based on chemical composition. *Iron meteorites* are the most commonly *found* because they are very distinctive, consisting of ninety percent iron with a bit of nickel mixed in. They are extremely dense, and have magnetic properties.

*Stony meteorites* look more like common rocks. They are the most common *form* of meteorite but aren't found as often as iron meteorites for two reasons: they look like ordinary, everyday Earth rocks, and they can't be located using a metal detector.

The third class is the *stony irons*, which, as the name suggests, are a mixture of the iron and stony types.

A few people around the world make a good living hunting and selling meteorites. A decent-sized specimen can be worth thousands of dollars to a museum or a private collector. A really big meteorite with an unusual composition can be worth millions. Something to think about next time you see a fireball...

### ***Meteor Showers***

The dust trails left by comets that have visited the inner solar system follow predictable orbits around the Sun. Several times a year Earth passes near one of these cosmic debris trains, resulting in a meteor shower. Halley's Comet, which has a 76-year orbit, is responsible for two annual meteor showers, the Eta Aquarids in early May, and the Orionid shower in mid-October.

Have you ever looked at a set of railroad tracks and noticed, as they stretch into the distance, how they seem to converge to a single point? A similar effect can be seen during a meteor shower. The debris "train" of the shower's parent comet follows the tracks of an imaginary railroad. If you pay attention to the direction most of the meteors in a shower seem to be coming from, they all converge back to the same point in the sky – the "vanishing point" of the tracks of the debris train. This is called the *radiant*. *TheSkyX* plots the radiant for all annual meteor showers and estimates the date and time they are expected to peak.

To display meteor shower radiants, select the **Chart Elements** tab from Display menu. Within the list of elements, there is an item called **Reference Objects**. Click it, and a new list of items is displayed. Check the box next to **Meteor Shower Radiants**.

The radiants for all meteor showers will now be displayed on the Sky Chart. If you move the cursor to the center of any radiant, details on that shower, including when it is expected to peak, will be displayed.

### ***The Northern (and Southern) Lights***

The Northern Lights, or *aurora borealis*, can be as stunning as any fireworks display. They appear as curtains of colorful, shifting light, suspended high up in the night sky. Unfortunately, they are generally only visible from high latitudes, and when they might occur is notoriously hard to predict.

Auroral displays are caused by charged particles from the solar wind striking the Earth's upper atmosphere. Our planet's magnetic field guides these particles toward the poles, which is why auroras are only visible from high northern and southern latitudes (the auroral light show is called the *aurora australis* in the southern hemisphere).

## ***Our Celestial Backyard: The Solar System***

Our Sun is one of countless stars in the universe. The planets that circle the Sun are its family, figuratively speaking, and it would be hard to deny that Earth is its favorite child. The planet we call home is located at just the right distance to be neither too cold nor too hot for liquid water and life to flourish on its surface. But the rest of the Sun's family – the solar system – is full of diverse and fascinating characters. Some of them may once have harbored some form of primitive life. These bodies are much, much closer than even the next nearest star, and so astronomers like to say they inhabit our celestial backyard.

Finding a planet in *TheSkyX* is simple. Simply go to the **Edit** menu and choose **Find**. Type the name of the planet in the **Search For** box. Information about the planet will be displayed. You can center the planet in the Sky Chart by clicking the **Center** button near the bottom of the screen. Note that this same procedure applies to every object in *TheSkyX*'s database. If you're unsure of an object's name or catalog number, click the **Advanced** button to view a comprehensive list of searchable objects.

### **The Moon**

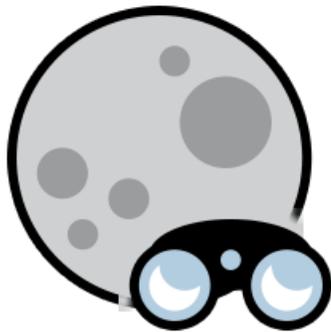
The most familiar object in the night sky is undoubtedly the Moon. It's been Earth's constant companion for more than four billion years. Scientists believe that the Moon was formed shortly after the birth of the solar system, when a molten planet about the size of Mars smashed into the Earth. That planet is no longer around, but much of the fallout from its impact settled into orbit around us and aggregated into the Moon.

The Moon is *tidally locked* to the Earth. Our gravitational pull, over millions of years, slowly put the brakes on the rotation of our satellite. Today the Moon makes one complete rotation for every single orbit it makes around the Earth. Because of this, the same side of the Moon always faces the Earth. We had no way of seeing the far side of the Moon until spacecraft were sent there in the late 1950's. Some people mistakenly call the far side of the Moon the dark side of the Moon. With all due respect to Pink Floyd, the Moon has no "dark" side. Over the course of a lunar day (about 29.5 Earth days) the far side of the Moon gets just as much sunlight as the side facing us.

As the Moon orbits the Earth, it goes through its familiar *phases*, from New to Full and back again. *TheSkyX* can tell you the phase of the Moon on any date, at any time. It is automatically displayed on the star chart in its current phase and proper location whenever it is above the horizon. The orbit of the Moon is not a perfect circle, but an *ellipse*, meaning it has an oval shape (in fact, all orbits, from artificial satellites to planets to stars circling the centers of galaxies, are ellipses). *TheSkyX* will tell you the current distance between the Earth and Moon.

The Moon is one of the most interesting things to look at in binoculars or a telescope. Even a little magnification will reveal the larger lunar craters, and help you see the *mare*, the so-called lunar "seas," which are really cooled lava basins. The Moon has no atmosphere, so liquid water cannot exist there. Our single natural satellite is dry as a bone, but there is some evidence that small amounts of water ice might reside in the permanently shadowed craters near the Moon's poles.

### ***Moon Photo Viewer***



*TheSkyX* includes a detailed map of the Moon based on photographs taken by a spacecraft called Clementine. Clementine was launched into space on a converted intercontinental ballistic missile – a Cold War sword was turned into a lunar plowshare that yielded a rich scientific harvest, giving scientists important new information on the morphology (shape) and mineralogy of the Moon.

To access the Clementine Moon map, go to the ***Tools*** menu and choose ***Moon Photo Viewer***. Your lunar journey begins with a photo showing the region near the feature *Tranquillitatis*, better

known as the *Sea of Tranquility*. As you move the mouse cursor over the photo, different features are highlighted in red, and the Moon's longitude and latitude are shown to the left. (To highlight larger features, place the cursor near its center.)

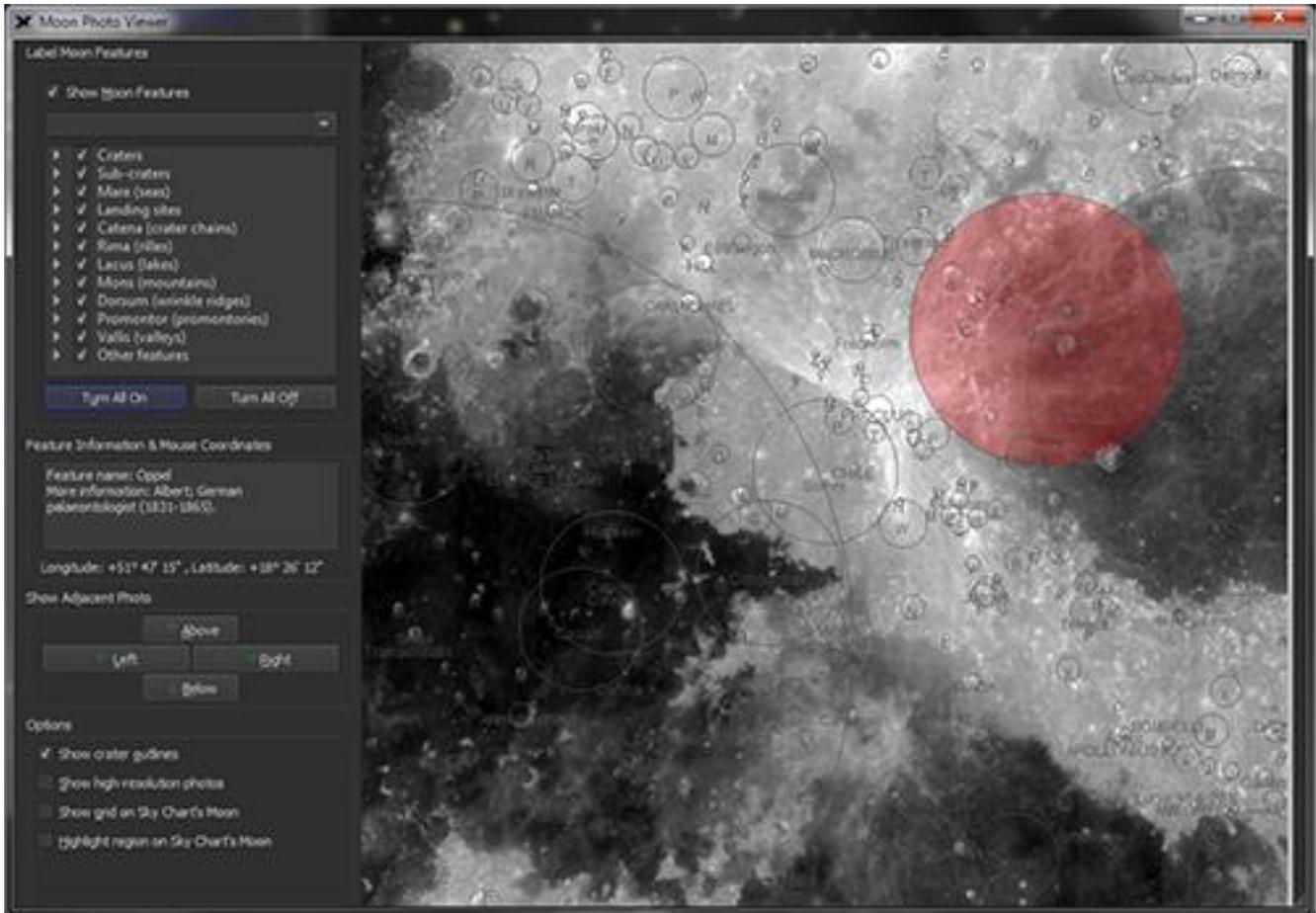


Figure 76: Moon Photo Viewer window.

You can use the Sky Chart's Moon with the Moon Photo Viewer to locate a feature in a photo on the Earth-based view of the Moon. Or, you can click on the Sky Chart's Moon to show the photo of that region.

Do to so, first position the Moon Photo Viewer window so that the Sky Chart is also visible on your screen.

#### Lock On and Frame the Sky Chart's Moon:

1. Clicking the **Find command** from the **Edit menu**.
2. On the Find window, type **Moon** and then click the **Lock On** button.
3. On the **Find** window, click the **Frame** button.

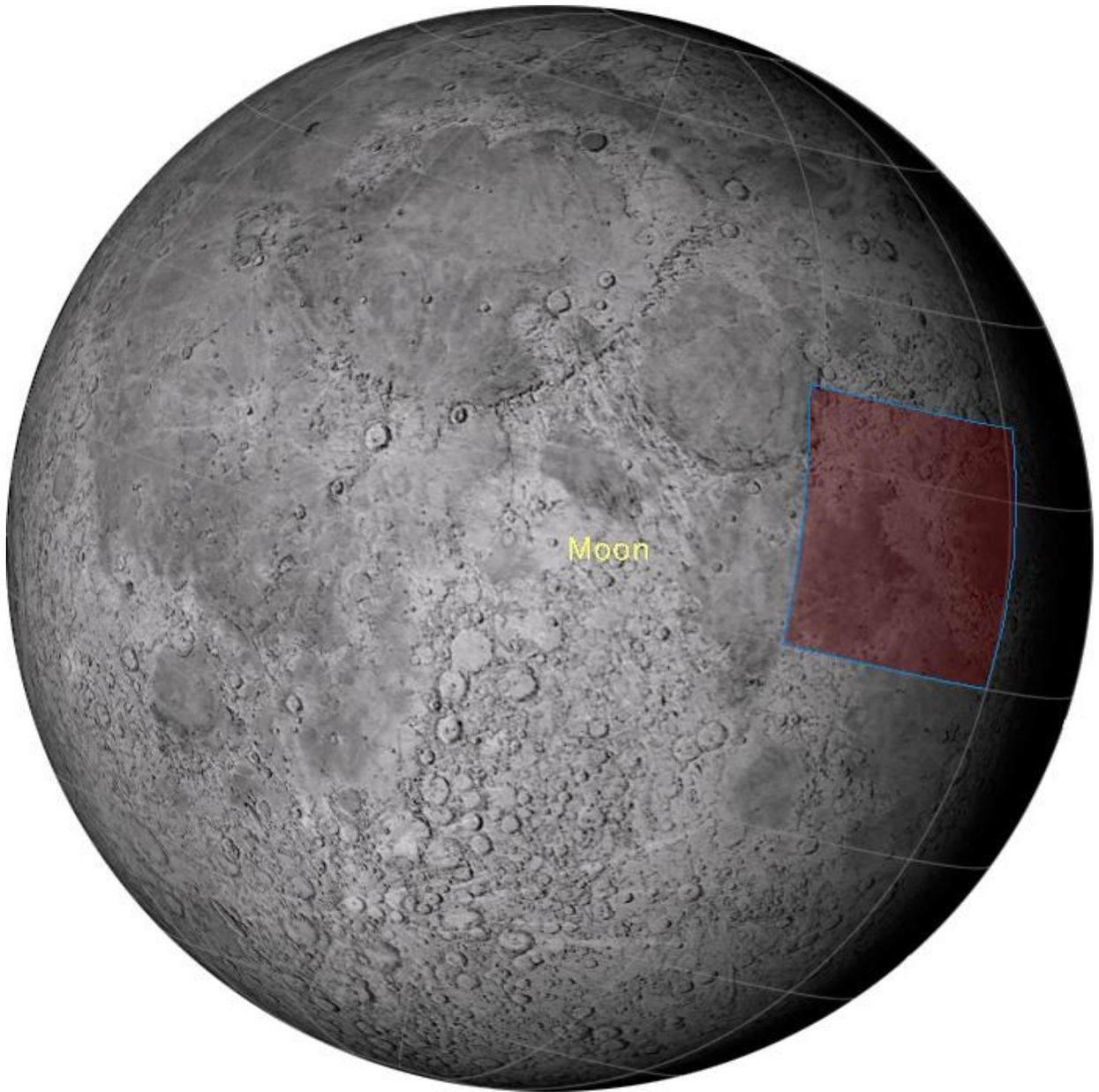


Figure 77: The Sky Chart Moon showing the position of the current Clementine photo (red rectangle) and the Moon grid lines.

The Moon is now fixed to the center of the Sky Chart. Make sure that the **Highlight Region on Sky Chart's Moon** checkbox is turned on (page 174). You can now click on the Sky Chart Moon to show the photo of that region on the Moon Viewer window. Or, you can change the Moon Viewer Photo by clicking the **Left/Right/Above/Below** buttons and the Sky Chart's Moon will highlight this region in red.

### **Label Moon Features**

Many interesting lunar features can be labeled on the Clementine photos, including:

- Craters
- Sub-craters
- Mare (lunar “seas”)
- Landing Sites
- Catena (crater chains)
- Rima (rilles)
- Lacus (lakes)
- Mons (mountains)
- Dorsum wrinkle ridges
- Promontor promontories
- Vallis (valleys)

Turn on the **Show Moon Features** checkbox to display the selected features. The **Turn All On** and **Turn All Off** buttons can be used to show or hide all features.

### **Feature Information & Mouse Coordinates**

Placing the mouse cursor over the photo reveals additional information, including the precise lunar latitude and longitude and details about the feature. When the **Show Crater Outlines** checkbox is turned on, the crater beneath the mouse cursor is also highlighted in red.

### **Show Adjacent Photo**

Press the Left/Right/Above/Below buttons to navigate the Moon’s surface.

As you scroll around, you might notice black rectangular regions on some photos. These show areas where no photographic data was acquired during the survey.

### **Options**

The Moon Viewer window offers the following display options.

#### **Show Crater Outlines**

Turn on the **Show Crater Outlines** to display yellow circles around the craters on the photos.

#### **Show Grid on the Sky Chart’s Moon**

Turn on **Show Grid on the Sky Chart’s Moon** to show lines of latitude and longitude on the Sky Chart’s Moon.

#### **Highlight Region on Sky Chart’s Moon**

Turn on this checkbox to show the location of the current photo on the Sky Chart’s Moon. You can also click anywhere on the Sky Chart Moon to show the Clementine photo for that area.

#### **Show High-Resolution Photos**

PROFESSIONAL

Turn on this checkbox to show 100-meter resolution Clementine photos in *TheSkyX Professional Edition*.

#### Setting the Moon's Font

The font used to label Moon features on the Clementine photos is the same font used to label the Sky Chart's Moon. If you wish to change this font, edit the Moon's font attributes from the Chart Elements window (page 236) .



**Figure 78: TheSkyX's Moon shows simulated shadows based on the Moon's topography and the current phase.**

*TheSkyX* incorporates elevation data from lunar space missions to create a realistic view of the Moon's surface. (Hardware Acceleration is required for this feature to work; see "Hardware Acceleration" on page **Error! Bookmark not defined.**14 for details.)

### **The Classical Planets**

Not counting Earth, five planets are visible to the naked eye. It has been known since ancient times that the planets slowly change position relative to the stars, which appear to be fixed, never moving with respect to each other from year to year. In fact, the word planet derives from an ancient Greek term that means "wanderer."

All planets in our solar system orbit the Sun (you probably know that the Sun is a star, not a planet). Their orbits lie more or less in the same plane, so as they circle the Sun, their paths are restricted to a narrow band in our sky, which is called the *ecliptic*. The constellations that lie in this plane received special attention from ancient astronomers. Collectively they are known as the *Zodiac* constellations.

The farther a planet is from the Sun, the longer it takes to complete a single orbit. Planets farther from the Sun therefore move more slowly through the Zodiac.

*TheSkyX* can locate any planet wherever it happens to be on a given night. Below we describe some general features of the planets, starting from the closest in, then moving out to the edge of the solar system.

### ***Mercury***

Mercury is the closest planet to the Sun. It takes only 88 days to travel around the Sun once. This is another way of saying that a year on Mercury is 88 days long.

Because Mercury is so close to the Sun, it can be spotted only shortly after sunset and shortly before sunrise, when it is near the “edge” of its orbit from our perspective. It is hard to see much surface detail on Mercury in even the most powerful telescope, but the Mariner 10 spacecraft made three “fly-bys” of Mercury in 1974 and 1975. Pictures from that spacecraft revealed Mercury strongly resembles our Moon, with a heavily cratered surface. It is comparable to our Moon in size, but much denser. Being so close to the Sun, the surface of Mercury is very hot, as you would expect. The average daytime temperature there is above 400° C.

### ***Venus***

Commonly known as both the morning and the evening “star,” Venus is the brightest natural object in the sky after the Sun and Moon. Its beautiful radiance has dazzled mankind throughout history. Venus is so bright that, from a very dark location, it can cast shadows.

When astronomers first eyed Venus through telescopes, they discovered that the planet is perpetually enveloped in clouds. They never part, keeping the surface of the planet forever shielded from direct view. This fact led to a great deal of fevered speculation about what might be hidden beneath those relentless clouds. Could Venus harbor steamy, tropical rainforests, inhabited by alien dinosaurs or even more exotic forms of life?

Much to the disappointment of science fiction writers, astronomers discovered in the early 1960’s that the surface temperature of this deceptively serene-looking planet is hot enough to melt lead. Venus is a hellish, uninhabitable desert. The reason for this is a runaway greenhouse effect. The Venusian atmosphere is almost entirely carbon dioxide (CO<sub>2</sub>), a gas notorious for its effectiveness at trapping heat. The fact that high concentrations of CO<sub>2</sub> have raised the surface temperature of Venus so far above what we would otherwise expect is one reason some worry about rising CO<sub>2</sub> levels on our planet. If Venus had the same mix of nitrogen and oxygen in its atmosphere as we have in ours, it would almost certainly be a lovely place to spend your vacation.

When Galileo began to systematically observe Venus with his telescopes, he discovered it goes through phases like the Moon. This helped convince him that the Sun, not the Earth, is the center of motion in the solar system. Venus, like Mercury, is an “inner” planet, meaning that they lie closer to the Sun than we do. This is why these planets are visible only in the early evening or pre-dawn skies – from our location in the solar system, they never appear to travel very far from the Sun.

### **Earth**

Earth is the third planet from the Sun. Scientists sometimes refer to Earth as the Water Planet because more than 70 percent of our surface is covered by liquid water, and water is essential for life. Our world is the only planet in the solar system that can support life as we know it.

A day is defined as the amount of time it takes for Earth to make one complete *rotation* on its axis. A year is defined as the time it takes Earth to make one complete *orbit* of the Sun. The length of a day and year are different on other planets because they rotate at different rates and have different orbits.

The axis about which our planet turns is tilted relative to the plane of our orbit. This is why we have seasons. In the summer, our northern hemisphere is tilted toward the Sun, so the days are longer, and sunlight strikes the Earth more directly, making the northern hemisphere warmer (the opposite is true in the southern hemisphere) than it is in winter. In the wintertime, our northern hemisphere is tilted *away from* the Sun. The days are thus shorter and colder (again, the opposite is true in the southern hemisphere).

A *solstice* occurs when our axis is tilted directly toward or away from the Sun. The winter solstice is the shortest day of the year, and the summer solstice is the longest (depending on your latitude, this may or may not correspond to the times of earliest sunrise and latest sunset – the explanation is a little more complicated than what we’re prepared to discuss here).

An *equinox* occurs when the center of the Sun is directly above the Earth’s equator. There are two of these each year, one in spring (the *vernal* equinox) and one in fall (the *autumnal* equinox). Equinox is derived from Latin and means “equal night.” During an equinox, night and day are both just about 12 hours long.

Like all planets, the orbit of the Earth is not perfectly circular, but slightly elliptical. The Earth is about a million kilometers closer to the Sun in December than June.

### **Mars**

The next planet out from the Sun is Mars. It is about half the size of our planet and takes a little more than two years to go around the Sun once. Mars is very similar to Earth in two important ways. Its day is just over 24 hours long, and its axis of spin is tilted about 23 degrees, almost the same tilt as Earth. This means that Mars has seasons, just like we do. But they last twice as long, since a Mars’ year is about twice as long as one of ours (687 Earth days, to be more precise).

Like Venus, the atmosphere of Mars is almost entirely CO<sub>2</sub>. Unfortunately, it is an extremely thin atmosphere, about 1/100<sup>th</sup> the pressure of our atmosphere at the equivalent of Martian sea level. During the day, the surface temperature of Mars near the equator can rise above freezing, but that same night it will drop well below –100° C. A little more greenhouse effect on Mars would be a welcome thing. As it is, the air on Mars is too thin to support liquid water on its surface, another blow to all those science fiction writers who imagined alien beings and ancient civilizations on Mars.

Still, Mars is the only other planet in our solar system whose surface is directly accessible to astronauts. Even though liquid water can't exist on Mars today, there is lots of geological evidence to suggest that in the distant past, the atmosphere of Mars was much thicker, and water flowed there freely. This gives scientists hope that Mars may have once harbored simple forms of life. If life did thrive there in the distant past, it may still survive today, perhaps in small "oases" deep underground, where organisms would be protected from the harsh conditions on the surface.

The best time to look at Mars in a telescope is during an *opposition*. About every 26 months, Mars and Earth line up on the same side of the Sun. This is when Mars is at its brightest and closest, and therefore appears at its best in a telescope. *TheSkyX* can calculate the dates of future oppositions and even tell you how large, in arcseconds, the disk of Mars will appear in an Earth-bound telescope.

As Mars approaches opposition, it briefly exhibits *retrograde* motion. This is a fancy way of saying that Mars looks like it turns around and moves backward in the sky for several days. This is simply a trick of perspective. As our two planets orbit the Sun, Earth catches up to and passes Mars. When we pass, Mars appears to move backward with respect to the far more distant stars.

Looking at Mars through a telescope, the first thing an observer usually notices on the disk of the planet are the *albedo* features. These are bright and dark markings that mostly correspond to variations in the coarseness of Martian surface dust. They were first systematically charted and named by the Italian astronomer Giovanni Schiaparelli in the 19<sup>th</sup> century. He mistakenly believed that the dark features were seas and lakes, and he used the Latin terms *mare* and *lacus* accordingly. Today we know there is no surface water on Mars, but like Earth, the Red Planet does have polar caps. Unlike our polar ice, they are made not just of frozen water but carbon dioxide or "dry ice" as well. During an opposition, you can usually glimpse either the northern or southern cap in a small telescope.

There is a huge difference between seeing Mars in a telescope and looking at images of Mars taken by orbiting spacecraft. Beginning with the Mariner 4 fly-by in 1965, American, Russian, and European spacecraft have revealed Mars to be a world of geological wonders. Huge craters, towering volcanoes, and immense systems of canyons mark and etch its surface.

Mars is orbited by two small moons, named Phobos and Deimos (ancient Greek words for fear and terror, respectively). They are much smaller than our Moon, irregularly shaped, and difficult to see in most amateur telescopes. Some scientists believe these moons are wayward *asteroids*.

### ***The Asteroid Belt***

A ring of interplanetary debris circles the Sun between the orbits of Mars and Jupiter. These rocky fragments are thought to be remnants from the original disk of material that formed the planets. The gravity of Jupiter prevented these bodies from aggregating into a planet in their own right. There are literally millions of asteroids, but collectively their mass is only about 1/10 the mass of our Moon.

Ceres is the largest asteroid, and the first to be discovered back on New Year's Day in 1801. *TheSkyX* does not include asteroids in its main database, but you can add information on asteroids through the ***Input > Small Solar System Bodies*** menu.

### ***Jupiter***

Jupiter is the king of the planets. Ten times wider than Earth, it has more mass than all the other planets in our solar system combined. Nearly a billion kilometers from the Sun, it takes twelve years to complete a single orbit.

Jupiter has a family of dozens of moons of various sizes and shapes, forming, in effect, a "mini" solar system. At last count, astronomers have charted over 60 moons orbiting this giant world. Many of these bodies are small as a typical asteroid (some of them might even be asteroids that were captured by Jupiter, caught like flies in its gravitational web).

Jupiter is attended by four large moons comparable in size to our own Moon. Because they were discovered by Galileo when he first turned his telescope on Jupiter in 1609, we call them the *Galilean satellites*.

*TheSkyX* includes telescope and spacecraft images of Jupiter, and can plot the orbits of its Galilean satellites. This is a particularly useful feature if you have a telescope. The moons shift position night to night as they orbit Jupiter, and you can track these motions with a modest telescope, or even a good pair of binoculars. Also, when a Galilean moon passes in front of Jupiter, it casts a shadow on the disk of the planet that can be observed in small telescopes. These *shadow transits* are fascinating to observe, and *TheSkyX* graphically shows when they will occur. It also provides timings for another interesting phenomenon involving Jupiter's moons, an *occultation*. These occur when one of the moons enters the giant planet's shadow and passes behind it. Interesting Historical Note: by timing the occultations of the Jovian moon Io, the astronomer Ole Romer was able to make a rough estimate of the speed of light way back in 1676.

### ***Saturn***

Author's comment: I'll never forget the first time I saw Saturn through a telescope. I was 11 years old. The telescope was small enough to fit in a lunchbox, but it was made by an extraordinary

man named Max Bray, and was more than a match for Saturn. In the eyepiece, I saw a small white disk nestled inside a perfect set of white rings. It took my breath away. Everyone I know who has ever seen Saturn in a telescope remembers it. The most fun I've ever had in over three decades of being involved in astronomy is showing someone Saturn in a telescope for the first time. The planet is best known of course for its extraordinary rings.

Saturn takes nearly 30 years to complete one orbit around the Sun. During this period, our view of the rings is slowly changing. Sometimes they are spread relatively wide and are easy to see, but about every 15 years they line up edge-on to our view. These "ring plane crossings" last a few days or so, and during this time all that can be seen of the rings is a dark, thin line crossing the disk of the planet.

Like Jupiter, Saturn is attended by numerous moons of various shapes and sizes. Titan, the largest, has a mostly-nitrogen atmosphere about one-and-a-half times thicker than the Earth's.

## **Going Farther**

Saturn is the farthest planet that was known to man in ancient times. The invention of the telescope revealed innumerable new worlds never before seen by human eyes, including previously unknown planets in our own solar system.

### ***Uranus***

The seventh planet out from the Sun, Uranus is the first planet discovered by telescope. The astronomer William Herschel is credited with recognizing it as a planet over two hundred years ago, in 1781 (other astronomers had seen it, but mistook it for a star – Herschel initially thought it was a comet). Like Jupiter and Saturn, it is a giant, much larger than Earth, and its atmosphere is mostly made of hydrogen and helium. But there are also significant amounts of water, ammonia, and methane ice in this frigid world, and so astronomers refer to it as an *Ice Giant*.

At a distance of almost 3 billion kilometers, Uranus takes 84 years to make a complete trip around the Sun. Its axis of rotation is tilted 98 degrees to the plane of its orbit, as if the planet had been flipped on its side. Like all the giant planets, Uranus has an extensive family of moons, at least 27. They are named after characters taken from the works of Shakespeare and Alexander Pope. The largest, Titania, is about half the size of Earth's Moon.

On a dark, moonless night, Uranus is just barely visible to the naked eye – if you have very sharp vision and know exactly where to look. *TheSkyX*, of course, can tell you where to find it. Uranus is relatively easy to find in a good pair of binoculars.

### ***Neptune***

The next planet out, Neptune, is similar in size and composition to Uranus. It is also considered an Ice Giant. The existence of Neptune was predicted by mathematical analysis of the orbit of Uranus. Deviations in the predicted orbit of Uranus led astronomers to believe that some other

large body farther out in the solar system periodically tugs at Uranus. This theory was confirmed when Neptune was discovered close to its predicted position.

In a telescope, Neptune appears cool blue in color. It was first spotted by none other than Galileo, when it happened to be near Jupiter in the sky, but Galileo assumed that this faint blue object was a star, not a planet, and so he is not credited with its discovery.

It takes Neptune over 184 years to make a single orbit of the Sun. Discovered in 1846, it has yet to make a single orbit since it was first recognized as a planet. It lies some 4.5 billion kilometers from the Sun, and is attended by 13 diverse moons. The largest, Triton, is 2700 kilometers in diameter, just a little smaller than our own Moon. Triton orbits Neptune in a *retrograde orbit*, which means that it travels backwards relative to the direction of rotation of Neptune itself. This suggests that Triton did not form with Neptune, but came into being somewhere farther out in the solar system and was later captured by Neptune's gravity.

### ***Pluto and the Ice Dwarfs***

We all used to be taught that there are nine planets in the solar system. That is no longer the case. Pluto has been demoted. Today it is not considered a full-fledged planet, but an *ice dwarf*, one of perhaps hundreds of such objects that inhabit the outer reaches of the solar system.

Many people, including a lot of astronomers, are unhappy that Pluto has lost its status as a planet. Controversy is still raging over the decision to reclassify it. If you're wondering who gets to decide whether Pluto is a planet, the authority rests on a group called the International Astronomical Union (IAU). Founded in 1919, the IAU has some 10,000 members, all professional astronomers. Its main purpose is to promote and protect the science of astronomy internationally, but it also has sole authority for classifying and naming astronomical objects. Despite some groups that claim otherwise, you cannot have a star named after yourself or a loved one without going through the IAU.

During their August 2006 meeting, the IAU membership voted on a new, more rigorous definition of a planet that had been developed by one of its working groups. This new and improved classification scheme included the category "dwarf planets" to cover objects in our solar system that had recently been discovered beyond the orbit of Pluto. Unfortunately for Pluto fans, it perfectly fits the new category, hence the demotion.

### ***Land of the Comets: The Kuiper Belt and the Oort Cloud***

One of the most beautiful things you'll ever see in the sky is a bright comet. Comets are refugees from the outer fringes of the solar system. Mixtures of ice and dust, the astronomer Fred Whipple famously described comets as "dirty snowballs."

Astronomers believe that most comets spend their lives in either the *Kuiper Belt* or the *Oort Cloud*. Named for the astronomers who first theorized their existence, these regions of space, far beyond the orbit of Pluto, are thought to be repositories of matter left over from the formation of the solar system.

A gravitational nudge from a nearby star or a passing cloud of interstellar dust can send an object from this region careening into the inner solar system. When a comet gets close to the Sun, its ice begins to sublimate. The escaping gas and dust form the *coma* and *tail* that give comets their distinctive appearance.

Most comets are unexpected strangers to our part of the solar system, but some have settled into predictable, short-term orbits. Halley's Comet is probably the most famous example. *TheSkyX* charts the orbits of several periodic comets. Most of them can only be seen on rare occasions with a telescope, but you never know when a new comet will be discovered and grace our sky in spectacular fashion, as comets Hyakutake and Hale-Bopp did in the late 1990's.

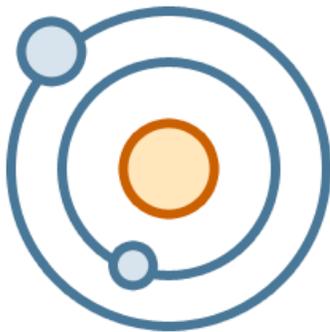
You can also enter the *orbital elements* of newly discovered comets into *TheSkyX* database using the **Input > Small Solar System Bodies** command. The position of the comet from night to night can then be displayed in the Sky Chart. Orbital elements can be downloaded from [Harvard University's Center for Astrophysics](http://www.harvard.edu/~cfa/astrophysics/) website.

## A 3D View of the Solar System

Planetary motion is complex. It took humans thousands of years to figure it all out. Fortunately for us, computers make the tough math a breeze, and they allow us to create useful simulations of the motions of solar system objects.

### Modeling Planetary Motion

The planets move in predictable orbits about the Sun, and with the easy-to-use Solar System Tool, you can model their positions and motions with ease.



### The Planets

For a 3D solar system simulation including the eight classical planets, plus Pluto, select **Solar System** from the **Tools** menu. A window then opens showing the solar system simulator. On the right, you see the simulation. You can click and drag on the simulated solar system to change the orientation and view it from varying angles. Time can also be moved forward or backward using

the **Time Skip** item in the **Tools** menu, or the corresponding toolbar buttons. Alternately, you can adjust the time using the **Date and Time** item in the **Input** menu.

On the left are the menus and controls that affect what you see in the simulator. There is a slider that lets you control the viewing distance from 1 to 50 A.U., or *astronomical units*. An astronomical unit is a basic unit of distance used to describe the distance between objects within the solar system. One A.U. equals the average distance from the Earth to the Sun, about 150 million kilometers. Try out the distance slider to get a feel for how it works.

There are also checkboxes used to toggle on or off the ecliptic grid, orbit depths, and the background stars.

### **Small Solar System Bodies: Comets**

Small solar system bodies include comets and asteroids. *TheSkyX* can display the orbits of these objects in the solar system simulator. By default, there are none available to show, so you will have to download some from the internet. Let's start by downloading some comet data

1. With the Solar System window open, select Input > Small Solar System Bodies. A new window appears with three tabs at the top, Comets, Asteroids (Small Database), and Asteroids (Large Database). Select the Comets tab.
2. A window opens labeled **Comets Available for Display**. Here, you will see the total number of comets available for display, as well as a list of their names with checkboxes. It is with these checkboxes that you can toggle comets on or off in the Sky Chart or in the solar system simulator.
3. You have three options for importing comet data into *TheSkyX*. You can import them from an existing file, or you may download comet data directly in *TheSkyX* using internet databases. You may download individual comet data by name, or you can download all the data for all observable comets at once. For our example, let's download all observable comets at once. To do this, simply click **Observable**.
4. The data will then download, and the observable comets will now appear in the list above, on the Sky Chart, and in the solar system simulator.

Note: Be sure that your computer is connected to an active internet connection before attempting to download comet data.

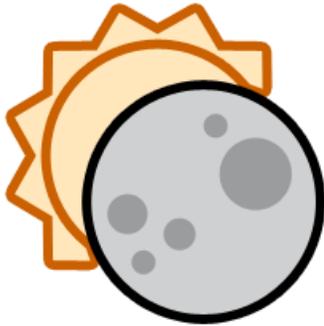
### **Small Solar System Bodies: Asteroids**

The process is very similar when downloading asteroid data from the **Asteroids (Small Database)** tab. There, you can choose to import asteroid data from an existing file, by orbital characteristic, such as distant, critical, or unusual, or you may import by asteroid name.

Should you decide to import asteroids from the **Asteroids (Large Database)** tab, you will have to visit one of the websites provided and download a file with the desired data. You can then select the file with the **Choose** button to reveal the asteroids in the Sky Chart and solar system simulator. Additionally, the checkboxes you see under the **Asteroids (Large Database)** tab toggle

important display options such as computing asteroid positions at startup and 24-hour object paths for imported asteroids.

## Eclipses



One of the most spectacular phenomena in nature is a total eclipse of the Sun. If you've seen one, you'll never forget it, and chances are you'll want to see as many as you can in your life. *TheSkyX* can predict eclipses literally thousands of years in the future. It can tell you where the eclipse will be visible and how long it will last, so naturally it's a great tool for planning a trip to see one of these extraordinary events.

There are three kinds of solar eclipses: *total*, *annular* and *partial*. In a total eclipse, the Moon passes in front of and completely covers the disk of the Sun, making it possible to see the Sun's *corona*, its extended atmosphere, and eruptions of surface plasma called *prominences*. This is truly a unique coincidence: the Sun is 400 times bigger than the Moon, but the Moon is 400 times closer to the Earth, so in our sky, they have almost the same *angular diameter*, about half a degree. No other moon in our solar system can treat its home planet to a total eclipse.

Like a total eclipse, an annular eclipse occurs when the Moon goes right in front of the Sun. Due to differences in orbital positions, the angular size of the Moon is a bit smaller than the Sun. At the peak of an annular eclipse, a ring or "annulus" of light appears around the Moon.

In a partial eclipse, the Moon covers a portion of the Sun, so the corona and prominences aren't visible. Still, a partial eclipse can be fascinating to observe – if you use an appropriate filter to protect your eyes.

The Solar and Lunar Eclipse Finder lists *hybrid* eclipses that include both total and partial eclipses during the event. For example, the eclipse in April 2023 near Australia begins as an annular eclipse, becomes a total eclipse, and then reverts to an annular eclipse. This type of eclipse is designated as *Hybrid A-T-A*.

**NEVER LOOK DIRECTLY AT THE SUN WITHOUT A SAFE FILTER!** You can instantly and permanently damage your eyesight by looking at the Sun without proper protection.

Lunar eclipses occur when the Moon passes into the shadow of the Earth. If the Moon orbited the Earth in the same plane as the Earth orbits the Sun, a lunar eclipse would happen every month, when the Moon is in its Full phase. But because the orbit of the Moon is tipped about five degrees relative to the orbit of the Earth around the Sun, lunar eclipses only happen about once every eighteen months when the orbits are aligned.

You might imagine that when the Moon passes into our shadow it completely disappears, but it doesn't. Dust in our atmosphere scatters a little bit of sunlight into our planet's shadow. Because dust mostly scatters red light, the Moon typically takes on a dim red or copper glow during the total phase of a lunar eclipse. How dark the Moon becomes depends mostly on how much dust happens to be in the air at the time of the eclipse. One of the fun things about viewing a lunar eclipse is that you never know exactly what shade of red or how dark the Moon will appear.

### Viewing Eclipses

Selecting **Solar and Lunar Eclipse Viewer** command from the **Tools** menu bar brings up the **Solar and Lunar Eclipse Viewer** Window.

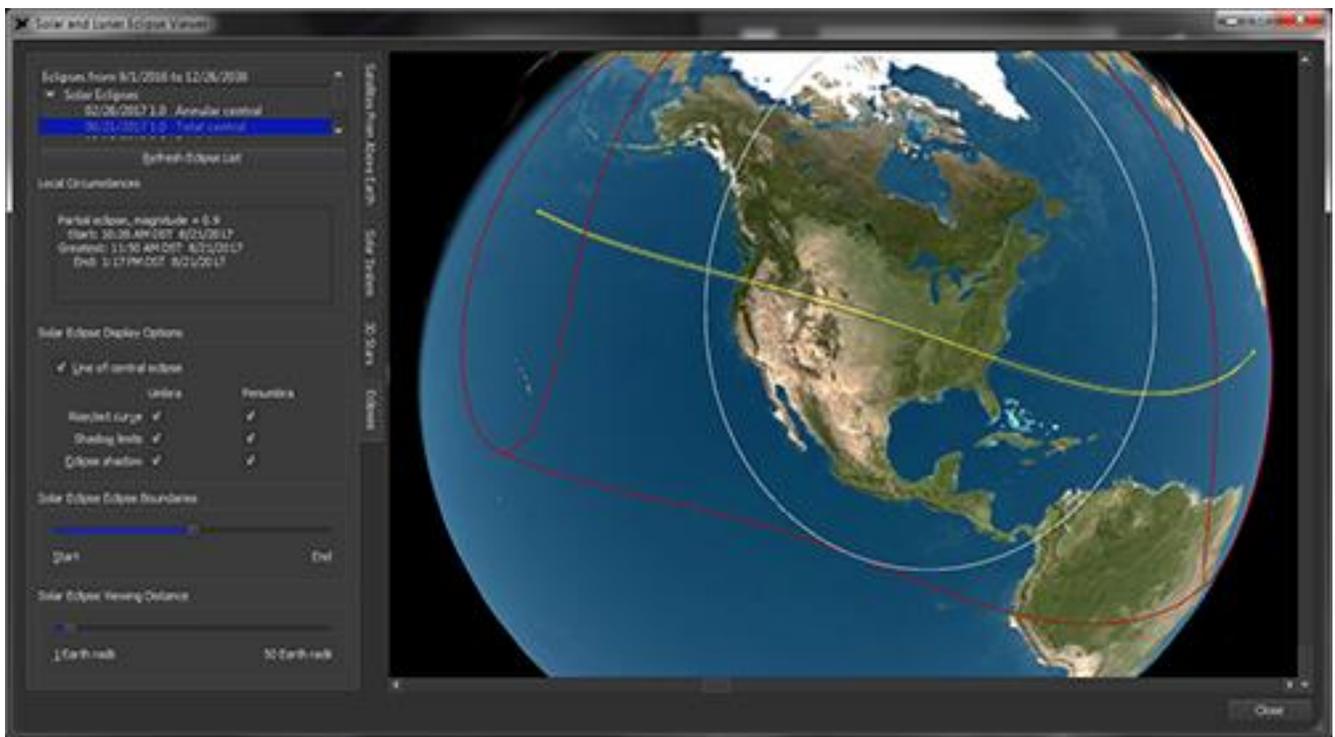


Figure 79: The Solar and Lunar Eclipse Viewer window.

In it, you will see a list of upcoming eclipses, a box displaying local circumstances for a selected eclipse, the eclipse viewer, and several checkboxes and sliders used to control the viewer.

### Solar Eclipse Viewing

While using protective eyewear is certainly not necessary when viewing a solar eclipse in *TheSkyX*, the importance of using proper protection when observing the actual Sun at any time

can never be overstated. Experienced observers should consider the following guidelines when observing a total eclipse:

1. get a proper eclipse viewing filter – do NOT improvise – and use it right up until the sky darkens rapidly,
2. enjoy the total phase naked eye as nature intended,
3. use the filter again as soon as the corona has been outshone by the diamond ring.

In the eclipse viewer, solar eclipse paths are viewed on a three-dimensional Earth globe, showing the eclipse shadow's path, rise and set curves, and umbral and penumbral limits.

To view a solar eclipse, scroll down the list near the top of the window and select a solar eclipse. Immediately, you will notice that the eclipse viewer will update to show the pertinent data on the Earth globe. A **small green circle** indicates your home position, as entered in the location section of *TheSkyX*. Additionally, you will notice a black circle along with colored lines representing important data about the selected eclipse. The following is a brief description of these markings.

The **Black Circle** marks the umbral (darker) eclipse shadow as projected onto Earth. This is the region where eclipse totality is possible.

The **Yellow Line** represents the line of central eclipse. It shows the eclipse's center line path over the globe. **Yellow Ovals** at the beginning and end points of the yellow line represent the umbral rise and set curves

The **Grey Line** represents the limits of the umbral shadow.

The **Red Lines** show both the rise and set curves and the shadow limits of the penumbra (lighter shadow).

The **White Line** marks the penumbral shadow on the Earth globe.

These markers can be toggled on or off by using the checkboxes under **Solar Eclipse Display Options** on the lower left of the window.

Once you have selected an eclipse from the list, you will notice that the **Local Circumstances** box now displays the local information regarding the eclipse, such as its local visibility, magnitude, start and end times, and moment of greatest eclipse. Once an eclipse is selected, the Sky Chart automatically updates to display the eclipse from your selected location.

Using the slider immediately below the **Solar Eclipse Display Options**, you can view the path of the eclipse in progress, ranging between its start and end points. Simply slide it to the left to move toward the start point, and sliding it to the right will move toward the eclipse's end point.

**Note: Another way to move time is to click *Go Forward in the toolbar*.** Selecting an eclipse automatically stops time in *TheSkyX*, but by restarting it, you can watch the eclipse progress in the viewer in real time, or at any speed you choose.

Below the eclipse start/end slider is the slider marked ***Solar Eclipse Viewing Distance***. With the slider all the way to the left, the eclipse viewer is set to view the globe from a perspective of one Earth radius away. Slide the slider to the right, and you will gradually increase the viewing distance up to 50 Earth radii. If you have a scroll-wheel mouse, you can adjust the viewing distance by moving the cursor over the viewer and rolling the scroll wheel up (for closer distance) or down (for farther distance). Clicking and dragging the mouse will rotate the globe, adjusting the angle at which the eclipse path is viewed.

Note: In case your view of the globe is cut off, this window is resizable by clicking and dragging on the lower right corner.

### ***Lunar Eclipse Viewing***

Also included in the eclipse list are lunar eclipses. These are shown from the perspective of Earth's surface in the Sky Chart.

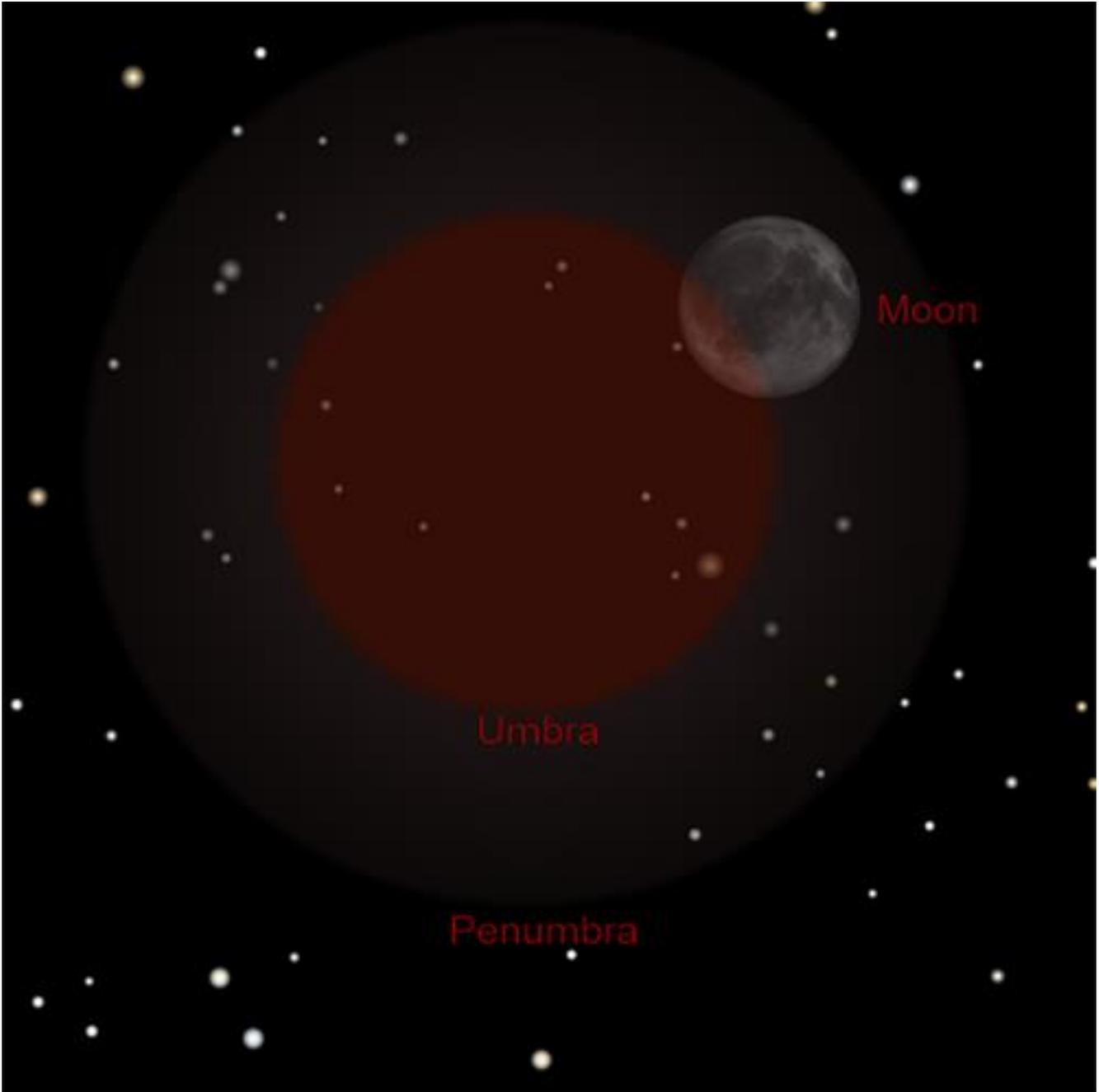


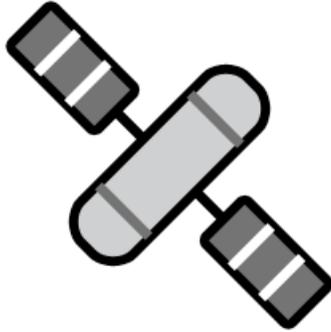
Figure 80: Lunar eclipse showing the umbra and penumbra.

By selecting a lunar eclipse from the list, the Sky Chart will automatically update to show the chosen eclipse. Note that the Moon and penumbra and umbra of Earth's shadow appear with labels.

Looking at the **Local Circumstances** box will show the start date and time for the selected eclipse, as well as the maximum shadow coverage in lunar diameters. As with solar eclipses, time is stopped when an eclipse is selected, but can be started again whenever you wish to view the

eclipse in motion. Using this tool, you can take note of shadow contact times when preparing for the exciting spectacle that is a lunar eclipse.

## **Spacecraft**



Before 1957, nothing made by human hands existed above our atmosphere. But in that year, the Soviet Union launched the world's first artificial satellite, Sputnik. Since then, thousands of satellites have been launched into Earth orbit.

*TheSkyX* downloads *orbital elements* or *two-line elements* (TLEs) from the web to keep track of thousands of satellites and other orbital debris. Using these numbers, *TheSkyX* can calculate where satellites will appear in the sky for any location on Earth.

To manage which satellites are shown, click the ***Satellites*** command in the ***Input*** menu.

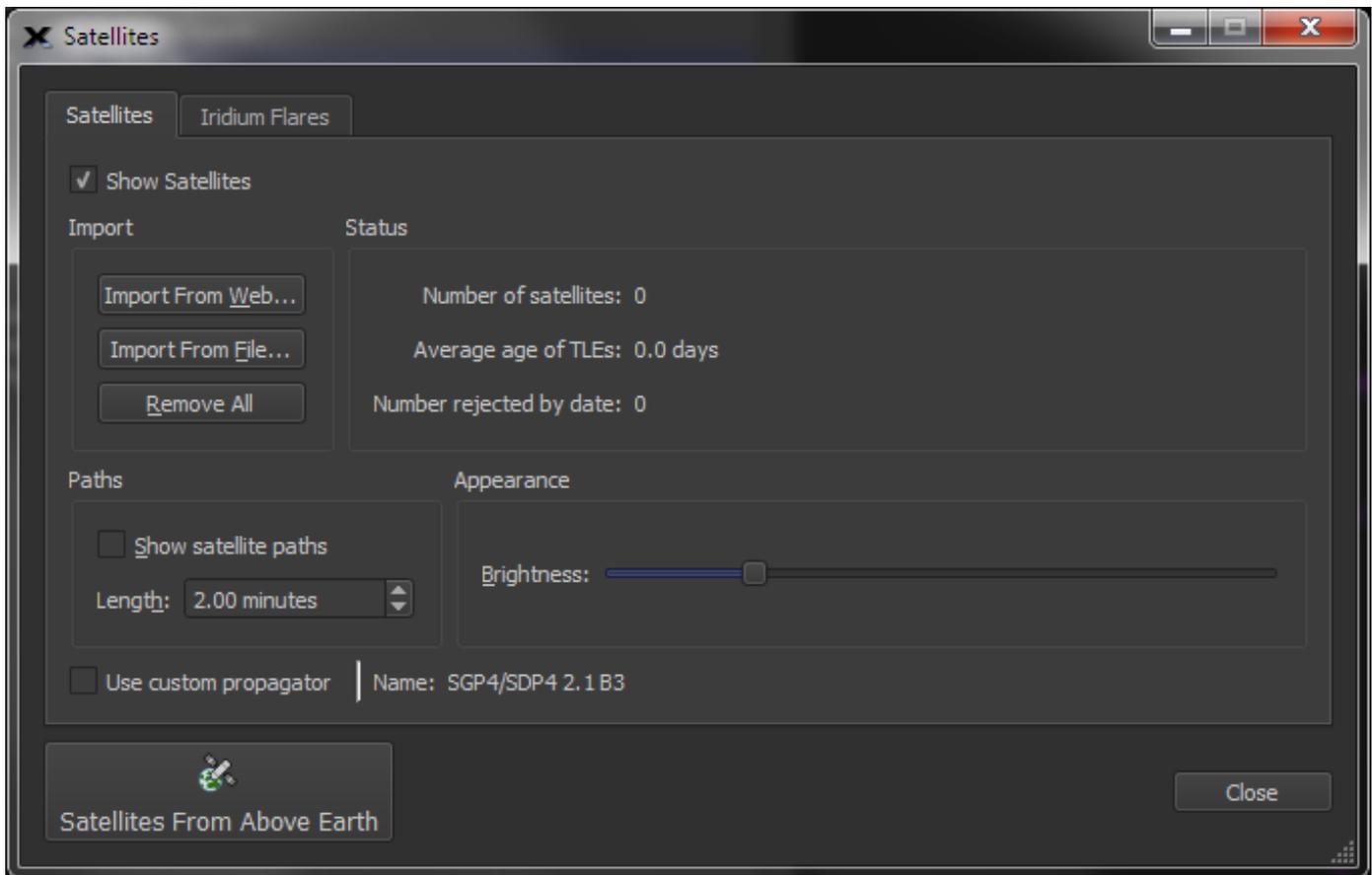


Figure 81: The Satellites window (click the *Satellites* command from the *Input* menu).

Satellite TLE data can be imported from the web or from a text file that contains the properly formatted data. *TheSkyX* uses orbital element information from Space Command Center's TLEs to predict and display satellites' positions. Two-line element data must be updated frequently and are available for most satellites on the web.

Gravitational forces, among other things, constantly perturb the orbit of a satellite around earth, so its position is not precisely predictable over long periods of time. *TheSkyX* automatically updates selected TLEs for each time it is launched.

#### **Download Satellite TLEs from the Web (Import From Web button)**

Current satellite TLE data are retrieved from Dr. T.S. Kelso's [Celestrak web site](#).

Clicking the **Import from Web** button shows the Import Satellites from Celestrak window.

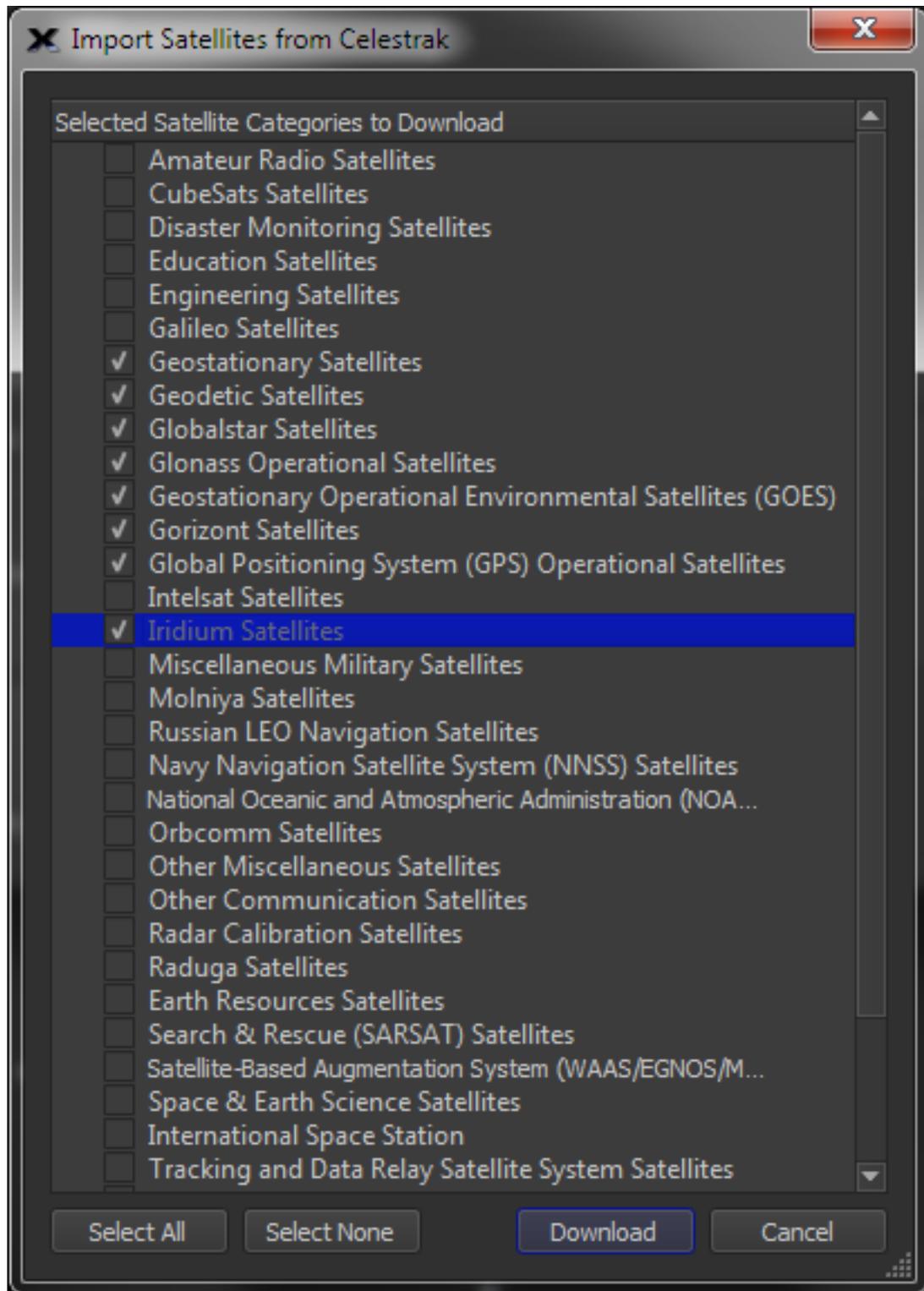


Figure 82: The Import Satellites from Celestrak window.

Turn on the desired categories, then click the Download button to retrieve them from the web. Importing all the satellites will most likely sap your computer's processor, so choose wisely.

### **Import from File**

TLE data residing in a text file, rather than on the web, can be imported and displayed by clicking the Import From File button. The text file must contain TLE data only. For example, the TLE data for the GOES 2 satellite looks like this:

```
GOES 2
10061U 77048A 98127.50441330 .00000045 00000-0 10000-3 0 97472 10061 13.1659 29.4732
0005723 183.8196 16.8163 1.00281760 21356
```

### **Status**

The Status section shows the total number of satellites that were successfully loaded, the average age of the TLE data (the “newer” the better) and the number of TLEs that have been rejected because they are older than 45 days.

Use the **Advanced** tab on the **Find** window to locate a satellite.

### **Show Satellites**

When this option is turned on, satellite positions are computed and displayed on the Sky Chart.

### **Show Satellite Paths**

Turn on this checkbox to draw a line on the Sky Chart that represents the upcoming path that the satellite will follow.

### **Length of Satellite Paths (Length input)**

Enter the length of time, in minutes, of the satellites’ paths.

### **Fun Example: Observing the International Space Station (ISS)**

Watching the International Space Station fly overhead is a truly exciting event. *TheSkyX* can be used to predict when the ISS will travel overhead, and show you its path.

To find the best passes for the ISS, do the following.

1. Click the **Satellites** command on the **Input** menu.
2. Click the **Import From The Web** button.
3. Turn on the International Space Station radio button.
4. Click the **Download** button.
5. Click the **Satellites From Above Earth** button on the **Satellites** window (lower left corner of the window).
6. Select **ISS (ZARYA)** from the list of satellites, then click the **Find Best Passes** button.

A list of the times when this satellite is visible above the horizon is displayed. Double-click the items in the list to show the pass from an above-Earth perspective. Turn on the Update Chart radio button to show the path on the Sky Chart.

## Iridium Flares



Beginning in 1998, a network of sixty-six communication satellites called Iridium was launched into orbit. At any given time, at least one of them is above the horizon for any location on Earth (not counting the territory around the north and south poles). Sometimes, as an Iridium satellite moves across the sky, sunlight bounces off its antennas and solar panels, creating a brief but brilliant *Iridium flare*. *TheSkyX* can calculate when the next flare will be visible from your location (they only happen in early evening or shortly before dawn). Click the **Tools > Iridium Flares** command to find the next flare that you can observe from your backyard.

Choose the *Iridium Flares* command from the **Tools** menu.

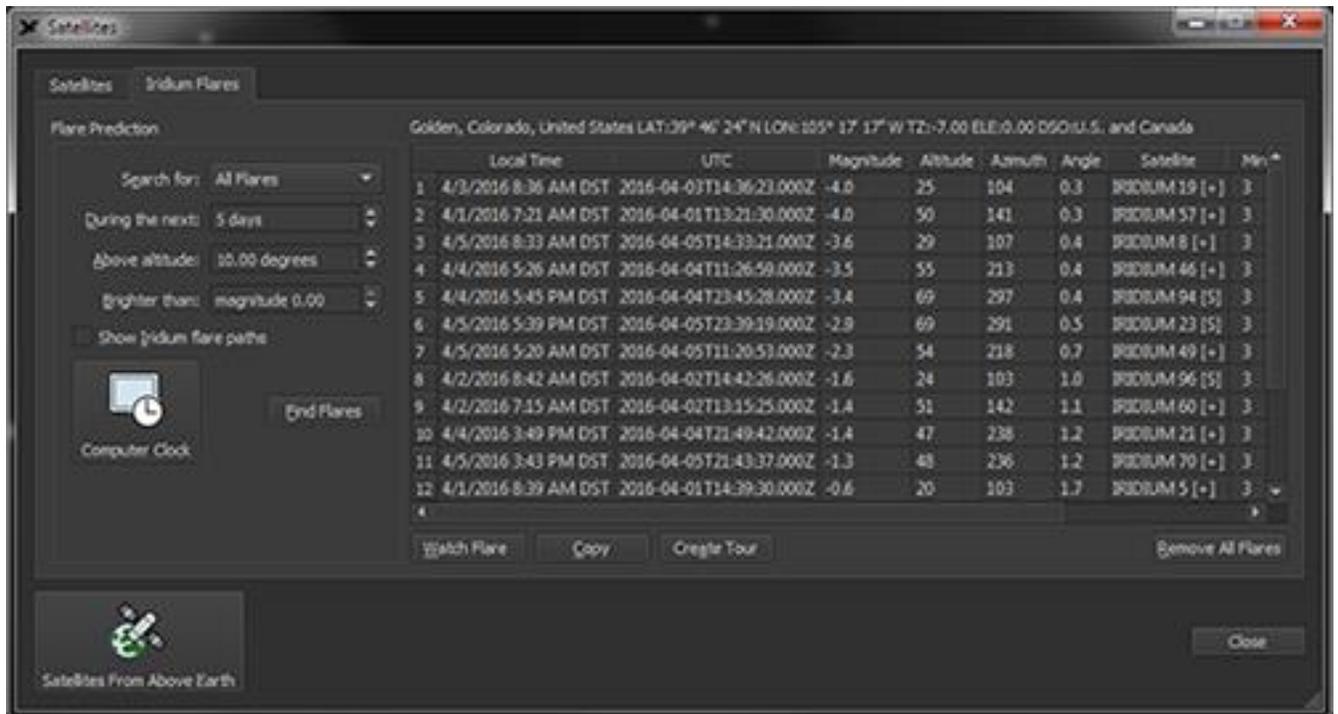


Figure 83: The Iridium Flares tab on the Satellites window (Satellites command, Tools menu).

### ***Specifying the Type of Flare to Find (Search For pop-up menu)***

Flares can be located based on what time of day they occur.

- ***Daytime Flares*** occur between sunrise and sunset
- ***Nighttime Flares*** occur between sunset and sunrise
- ***Dawn/Dusk Flares*** occur during the morning and evening hours

Choose the ***All Flares*** item to search for flares that occur any time, day or night.

### ***Length of Time to Search (During the next)***

Enter the number of days from now to search for flare events. Flare prediction involves some heavy-duty computing, so you may want to limit the length of the search to less than a week so on slower computers.

### ***Minimum Height Above the Horizon (Above altitude)***

Mountains, trees or nearby buildings can hide flares that occur at lower altitudes. Enter the lowest altitude that a flare can be seen from where you will be observing.

### ***Limiting Magnitude of Flare (Brighter than)***

Enter the magnitude of the faintest flare you want to find. Faint nighttime flares are easy to spot; but if you're looking for a daytime or evening flare, make sure to enter magnitude minus 2 or brighter (the lower the magnitude, the brighter the flare).

### ***Show Iridium Flare Paths***

Turn on this option to show a line on the Sky Chart that shows where the flare occurs and how long the flare lasts.

### ***Set Time to Now (Computer clock)***

This button resets *TheSkyX's* date and time to the computer's clock.

### ***Begin Searching for Flares (Find flares)***

Click this button to begin the search for flares. Even a very fast computer requires a minute or more to locate all the flares for the next month.

### ***Iridium Flare Report***

The right side of the window shows a report containing the following information for each flare.

- Local time when the flare begins.
- Coordinated Universal Time when the flare begins.
- Maximum magnitude of the flare.
- The altitude and azimuth position at maximum magnitude.
- The angle, in radians, between observer's line of sight and Sun, subtended at the satellite.

- The name of the Iridium satellite.
- The mirror number on the satellite that is causing the flare and its angle.
- The Julian date of the flare.

Click a column header to sort the column's contents from smallest to biggest (that is, an ascending sort). Clicking a particular header more than once will invert the sort. For example, clicking the Magnitude header once sorts the flares from brightest to faintest. Clicking it twice sorts from faintest to brightest (a descending sort).

### ***Simulating the Flare (Watch flare)***

Now the fun begins. Clicking the Watch Flare button orients the Sky Chart so that the selected flare is visible near the center of the window. If no flare is selected, the first flare in the report will be simulated. A green laser pointer momentarily appears, showing you exactly where to look to view the start of flare. They're *really easy* to miss in the actual sky.

The excitement builds as the satellite's mirror begins to reflect the Sun's light and grow brighter for the next few seconds.

Now that you've seen a simulated flare, your goal is to go outside and actually observe the real thing. Take your friends or family along; after viewing the flare, they'll think you are an astronomy wizard.

## **Satellites from Above Earth**



Often people who have not studied or practiced astronomy are amazed that many satellites are visible to the naked eye. Most times, satellites are observed by chance when someone looks up and catches a glimpse of something moving among the stars. *TheSkyX* has a useful tool that aids with satellite observation and can tell you not only when and where to look, but also the name and purpose of many satellites in the sky.

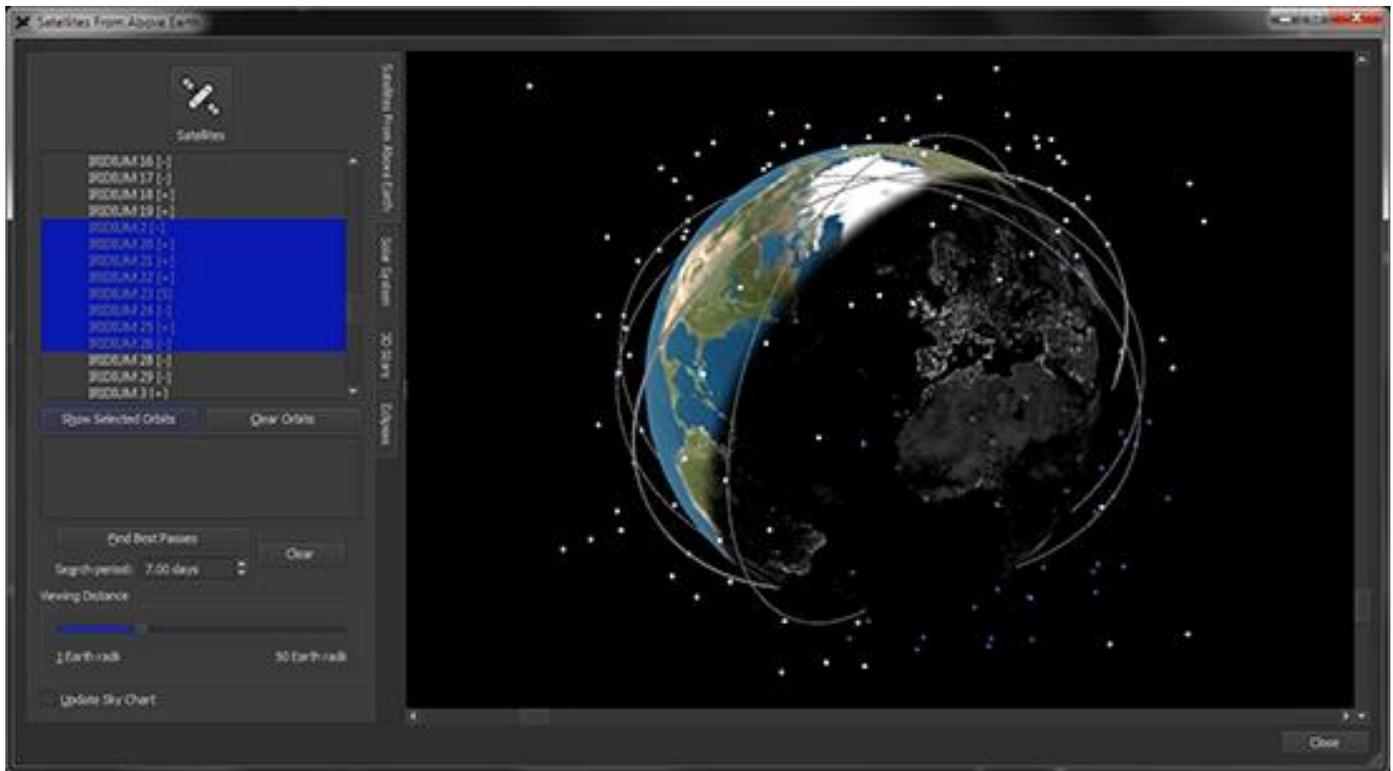


Figure 84: The Satellites Above Earth tab (Tools > Satellites From Above Earth).

### Review: Viewing Satellites and their Orbits

To observe satellites, select the **Satellites from Above Earth** command from the **Input** menu. If this is your first time using the satellites tool, there will not be any satellites listed, and you will have to download some satellite Two-Line Elements (TLE's) before any satellite data can be shown. You can think of a TLE as a big set of numbers that describes a satellite's orbit.

To obtain TLE data, click the **Satellites** button, or select **Satellites** from the **Input** menu. The **Satellites** window appears. From here, you can choose to import satellite data from the web or an existing file. Later, you can also choose to clear all satellite data by clicking **Remove All**.

Note: Ensure that *TheSkyX's* date is set to within 45 days of the current date to avoid date rejection when downloading satellite for import.

Let's start by downloading some satellite TLEs from the web. To do this, simply click **Import From Web...** on the **Satellites window**. You can then choose the satellite category or categories you wish to download from the internet database, Celestrak. After you have selected the desired satellite categories, click **Download**.

Return to the **Satellites From Above Earth window**, and you will see the satellites plotted as points around the Earth globe. Also, note that the satellites are also viewable in the Sky Chart.

On the **Satellites From Above Earth** window, a list featuring your newly downloaded satellites appears on the left. By selecting a satellite(s) from this list and by clicking **Show Selected Orbits**. The satellite orbits will appear in the viewer. Sliding the **Viewing Distance** slider will change the view from a distance of 1 Earth radius up to 50 Earth radii. If your mouse is equipped with a scroll wheel, you can use it to adjust the viewing distance, too. If need be, the lower right corner of the window can be dragged to resize it.

By clicking **Update Chart**, the Sky Chart is updated to show the recent satellite data from a ground-based perspective. Now you will be able to amaze your friends and neighbors with your uncanny ability to “predict” satellite appearances in the heavens!

## Astronomical Conjunctions

When two or more planets appear near one another – within a few degrees or less –the objects are said to be in conjunction. But don’t be fooled. Although the objects appear close by from our earth-bound perspective, the two objects are still hundreds or thousands of astronomical units apart. There’s no need to worry about a collision.

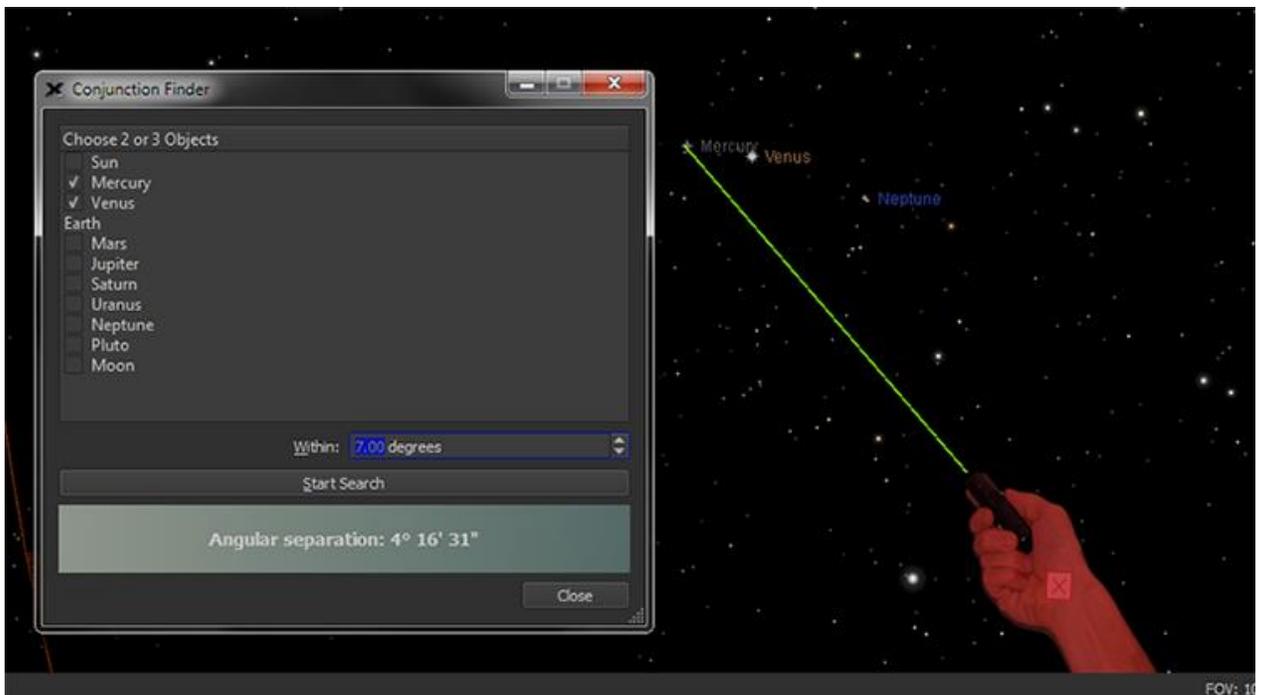


Figure 85: Screen capture when a conjunction is found.

Finding out when two or three planets will be in conjunction is easy with *TheSkyX*’s Conjunction Finder. It can locate conjunctions between any two or three planets and/or the Sun and Moon, as viewed from Earth.

Select the **Conjunction Finder** command from the Tools menu and then mark two or three objects in the Objects list. Earth is listed for reference only; it cannot be selected as part of the search.

Click the Start button to begin the search. *TheSkyX* uses the value entered in the **Within (degrees)** number input to determine how close the objects must fall before a conjunction is reported. Once a conjunction is found, the Sky Chart is updated to show it.

## ***Beyond the Backyard: Our Home Galaxy***

Our Sun is but one member of a huge assemblage of hundreds of billions of stars that comprise our home galaxy, the Milky Way. Our galaxy is also peppered with vast, colorful clouds of gas and dust, called nebulae, and other exotic objects.

The invention of the telescope revealed that there is much more in the night sky than stars and planets. In the 18<sup>th</sup> century, the French astronomer Charles Messier began to catalog some of these mysterious objects to make sure he didn't mistake them for new comets. The Messier Catalog is still in use today. It includes star clusters, and various kinds of *nebulae* and *galaxies*. These so-called "deep sky" objects are favorite viewing targets of amateur astronomers.

There are literally millions of objects in the sky that astronomers want to keep track of. Various catalogs have been developed for this purpose. *TheSkyX* includes several of them in order to chart these objects on the Sky Chart.

### ***The Milky Way***

The ancient Greeks believed that the Milky Way was exactly that: spilled milk. History failed to record whether anyone cried over it. It wasn't until Galileo invented the astronomical telescope that the true nature of the Milky Way was revealed: millions of stars too distant to be resolved by the naked eye. We now know that the stars of our particular galaxy form an immense pinwheel shape, with several spiral arms extending out from its center. When you look at the Milky Way, you're looking at a section of one of these spiral arms (galaxies come in a variety of shapes and sizes, from spherical to irregular – more on this later).

An unfortunate fact of modern life is that the Milky Way is too faint to be seen from within cities and most of their suburbs. You need to be far from city lights and any other source of light pollution to appreciate how extraordinarily beautiful it is. *TheSkyX* can display the Milky Way at various levels of brightness, simulating what you might see from the outskirts of a small town or an isolated mountain peak. Astronomers have come up with the very cool-sounding term *isophote* to describe regions of equal brightness in the Milky Way.

In the **Display** menu, the item ***Milky Way Options*** allows you to choose to display the Milky Way graphically, with isophotes corresponding to two levels of brightness, or as a wide-angle photograph of the Milky Way superimposed in the proper position on the Sky Chart. As with constellation figures, you can adjust the transparency of the Milky Way to simulate how much (if any) of it you can see from your location.

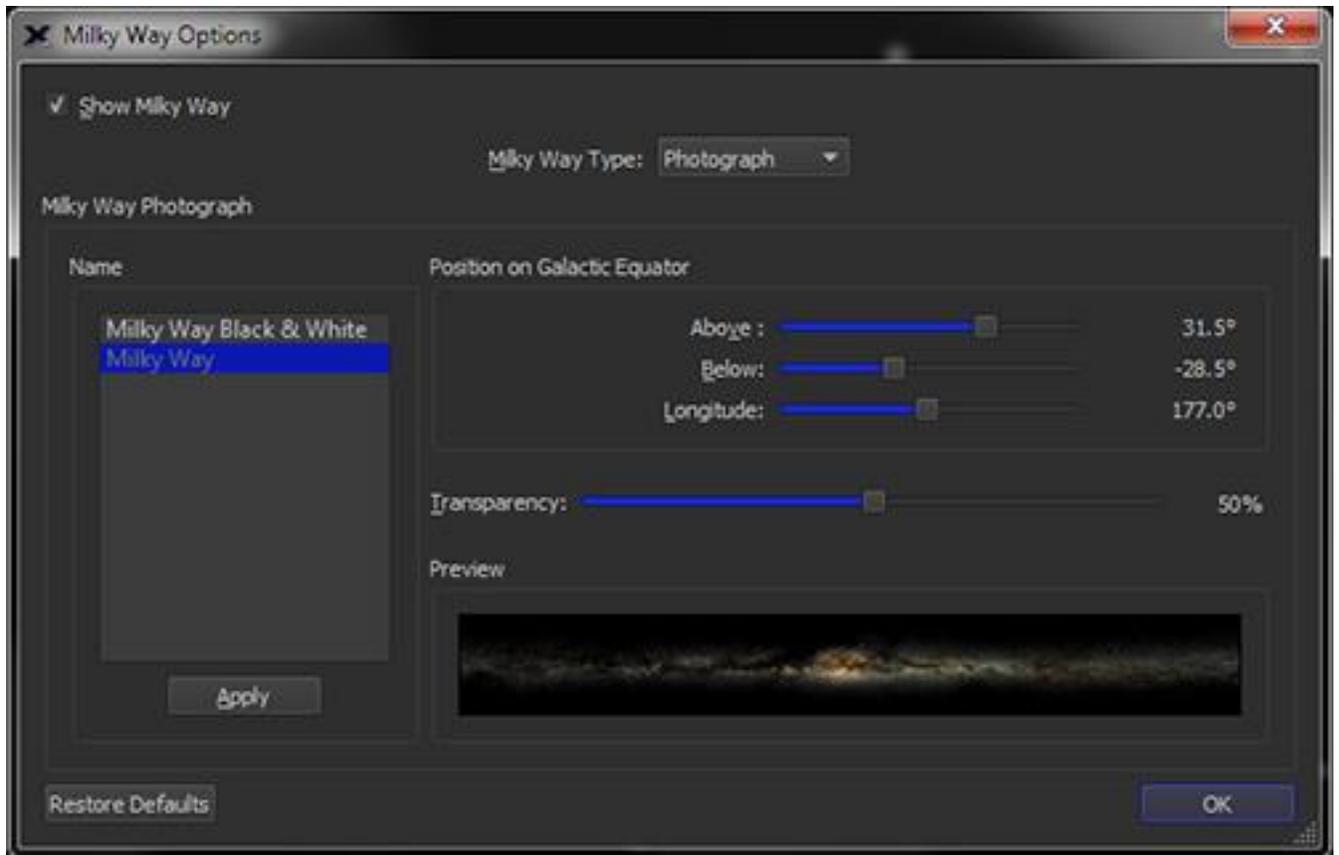


Figure 86: The Milky Way Options window (Click the Milky Way Options command from the Display menu).

### **Turn Milky Way On/Off (Show Milky Way)**

Show or hide the Milky Way photograph or isophote drawings by turning this checkbox on or off.

### **Displaying the Milky Way (Milky Way Type)**

Choose how to show the Milky Way on the Sky Chart.

### **Milky Way Photograph**

Options in this group allow you to configure how the Milky Way Photograph appears on the Sky Chart.

### **Name of Milky Way Photograph (Name)**

A color and black and white Milky Way photos are supplied with *TheSkyX*. Double-click on the name, or highlight it and click the **Apply** button to show in on the Sky Chart.

Note that the Milky Way photo shown in the Photo-Like display mode only.

### **Position on Galactic Equator**

The position of the Milky Way photograph with respect to the galactic equator can be configured. Changes to these settings are applied to the Sky Chart immediately.

### **Degrees Above Galactic Equator (Above)**

Use this slider to adjust how far above the galactic equator (in degrees) the top of the photo will appear.

### **Degrees Below Galactic Equator (Below)**

Use this slider to adjust how far below the galactic equator (in degrees) the bottom of the photo will appear.

### **Longitudinal Position (Longitude)**

Use this slider to adjust where the left edge of the photograph appears on the galactic equator.

### **Transparency of the Photograph (Transparency)**

Use the slider to change the transparency of the Milky Way photograph.

The Milky Way Photo will not appear on the Sky Chart when the **Graphics Rendering Mode** is set to **No Hardware Acceleration** (page 14).

## **Beyond Our Galaxy**

About a hundred years ago astronomers believed that our galaxy, the Milky Way, contained pretty much everything in the universe. But as telescopes became larger and more powerful, it became clear that there are other galaxies beyond the Milky Way – lots of them, in fact. According to the latest estimates, there are some fifty to one hundred *billion* galaxies in our universe comparable in size to the Milky Way.

Our galaxy is also surrounded by a halo of some hundred and fifty-star clusters. These clusters contain hundreds of thousands to millions of stars arranged in relatively compact, spherical shapes. These *globular clusters* are made up mostly of ancient stars, some of them over ten billion years old.

Just as some planets have moons, the Milky Way and many other galaxies are orbited by smaller “satellite” galaxies. The Milky Way has at least two. They were originally described by Persian astronomers, but today we call them the Magellanic Clouds in honor of Ferdinand Magellan, a 16<sup>th</sup> century European explorer who observed and charted them on one of his epic voyages into the Southern Hemisphere. Our galactic companions are most easily seen from that hemisphere, although at certain times of year they can be glimpsed from very low Northern latitudes. They are beautiful objects, and to the naked eye look like small shreds of the Milky Way. Even though they lie only 20 degrees apart in the sky, they are separated by 75,000 light years in space. With a telescope, you can resolve some of their stars, and also see nebulae and star clusters that reside within them.

The Milky Way is just one of billions of galaxies that populate the Universe. Besides the Magellanic Clouds, only one of these other galaxies is visible to the naked eye. It’s called the

Andromeda Galaxy because it lies within the boundaries of that constellation. Every other galaxy requires a good pair of binoculars or a telescope to see.

*TheSkyX*'s database includes thousands of galaxies within reach of amateur telescopes. They can be displayed in the **Non-stellar Objects** section of the **Chart Elements** window.

Galaxies of various shapes and sizes exist right out to the edge of observable space. We live in a truly extraordinary universe. We hope the *TheSkyX* will enrich and expand your appreciation of it.

## Have it Your Way with Preferences

Select the **Preferences** command from *TheSkyX* menu (Mac) or click the **Preferences** command from the **Edit** menu (Windows) to reveal a host of options that allow you to configure the appearance and contents of the toolbars, what information appears on the status and report windows, as well as advanced options.

The **Preferences** window shows four buttons along the top. Click one to view the options associated with it.

### **Toolbars**



The standard set of toolbars and the toolbars you create are listed on the left side of the window. When the check mark next to the toolbar name is on, the toolbar is visible on the main window. Toolbars can also be turned on and off by right-clicking (⌘+click on the Mac) the mouse over the toolbar, and then selecting the desired command from the pop-up menu.

Click the **Customize** button to configure the commands or *actions* that appear on each toolbar, or add new toolbars with the commands you want.

Use the **Toolbar Button Options** to configure the size and appearance of the buttons on the toolbars.

### **Customizing Toolbars**

The default toolbars access the most commonly used commands. You can change the buttons or commands that appear on these toolbars to add or remove buttons, or create custom toolbars with any set of commands that meet your work flow.

#### **To edit the actions on a toolbar:**

1. Highlight the toolbar you wish to edit from the Toolbars list, or click the **New** button and enter the name of a new toolbar.
2. Highlight the desired action in the **Actions** list then click the green right-pointing arrow to add this action to the **Current Toolbar Actions** list.

Once selected in the **Current Toolbar Actions list**, the action can be positioned on the toolbar by pressing the up/down arrows or removed by clicking the left arrow.

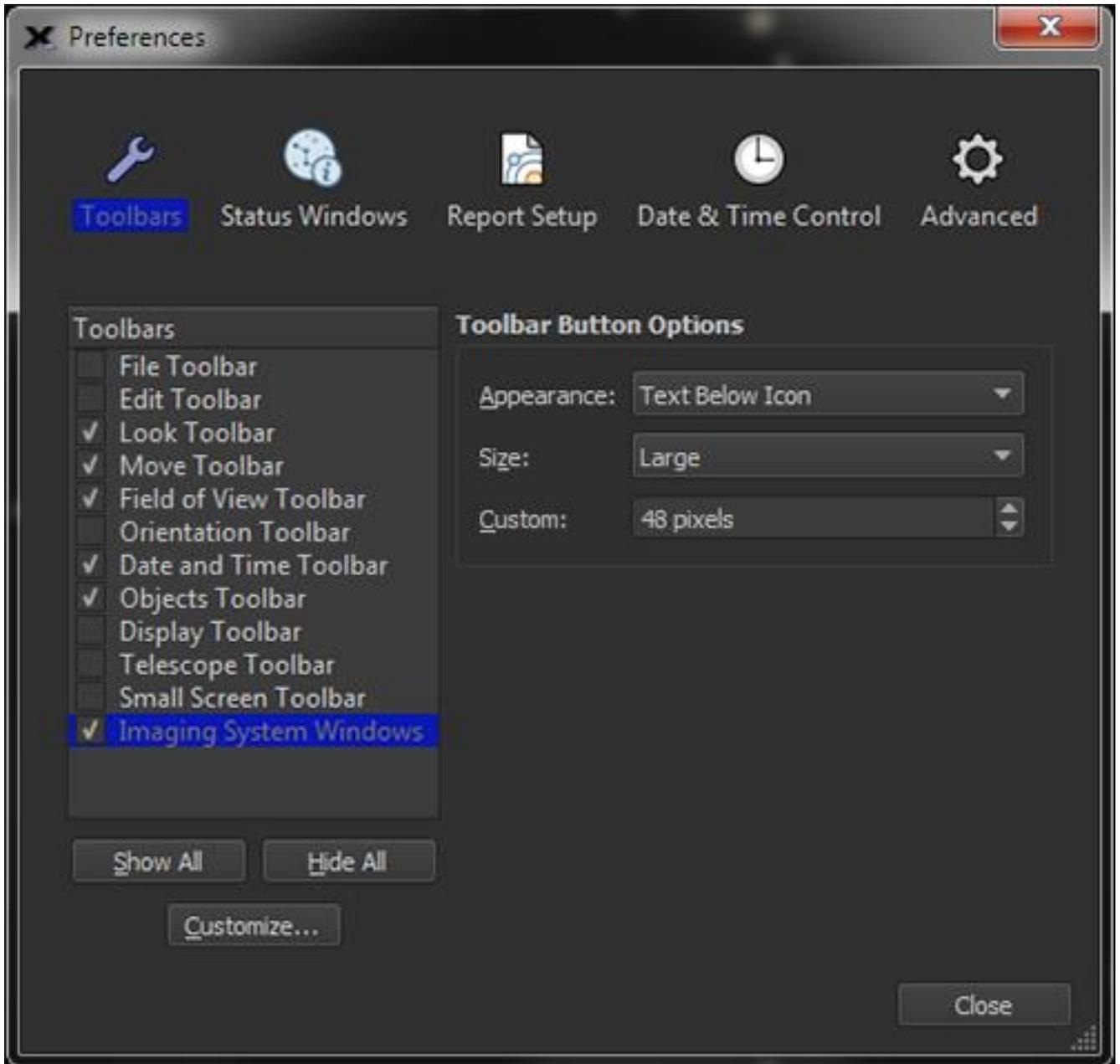


Figure 87: Customize Toolbars window. Click the Preferences command from TheSkyX menu (Mac), or the Preferences command from the Edit menu (Windows), then click the Customize button.

### ***List of All Actions in TheSkyX (Actions List)***

Menu commands, windows and button actions are listed in the **Actions** list on the left side of the window. Each action can be added to (or removed from) a standard or custom toolbar. The **<SEPARATOR>** action places a vertical line between actions on the toolbar.

**List of Defined Toolbars (Toolbars)**

The currently available toolbars are listed on the top right of the window. The names of the standard toolbars are shown in green text and cannot be removed or renamed. Custom toolbar names appear in black text.

**Actions in the Toolbar (Current Toolbar Actions List)**

The list of actions that will appear on the toolbar are shown on the bottom right of the window. Selecting an action allows it to be moved up or down by clicking the up/down arrow, or removed by clicking the left arrow. See “Toolbar Actions” on page 204 for a description of each action.

The right arrow adds the selected action to the toolbar.

**Resetting Standard Toolbars (Restore All Button)**

Click this button to restore all the toolbars with their default buttons.

**Toolbar Actions**

The **Actions** column of the **Customize Toolbars** window lists each toolbar and the toolbar’s default buttons. Scroll down the list to view other actions that can be added to toolbars.

**Display Toolbar**

The screenshot shows a dark-themed toolbar with 17 icons arranged in four rows. The icons are: Solar System (planet orbits), 3D Stars (yellow star with '3D'), Satellites From Above Earth (satellite over Earth), Show Daylight (sun), Show Equatorial Grid (globe with grid), Show Horizon Grid (globe with horizon), Field of View Indicators (orange spiral), Toggle Labels (white tag), Show Constellation Figures (stars with lines), Show Constellation Boundaries (stars with dashed box), Show Ecliptic (sun with orbital path), Star Options (yellow star with wrench), Show Mirror Image (moon with vertical line), Show Night Vision Mode (red star with glasses), Map Like (blue star with lines), and Photo Like (blue star with lines).

**Figure 88: The default Display toolbar.**

| Action                        | Description  |
|-------------------------------|--|
| Solar System                  | Display the solar system model.                    |
| 3D Stars                      | Display stars in 3D perspective.                   |
| Satellites From Above Earth   | Show satellite positions from Earth's perspective. |
| Show Daylight                 | Display the sun and daylight area.                 |
| Show Equatorial Grid          | Show the equatorial coordinate grid on the sky.    |
| Show Horizon Grid             | Show the horizon coordinate grid on the sky.       |
| Field of View Indicators      | Show the field of view indicators.                 |
| Toggle Labels                 | Toggle the visibility of labels for objects.       |
| Show Constellation Figures    | Show the constellation figures (stars and lines).  |
| Show Constellation Boundaries | Show the boundaries of constellations.             |
| Show Ecliptic                 | Show the ecliptic plane.                           |
| Star Options                  | Open the star options menu.                        |
| Show Mirror Image             | Show a mirror image of the current view.           |
| Show Night Vision Mode        | Switch to night vision mode.                       |
| Map Like                      | Switch to map-like view.                           |
| Photo Like                    | Switch to photo-like view.                         |

|  |                                      |   |
|--|--------------------------------------|---|
|  | <b>Solar System</b>                  | Shows the Solar System window (page 182).   |
|  | <b>3D Stars</b>                      | Shows the 3D Stars window (page 182).   |
|  | <b>Field of View Indicators</b>      | Shows the Field of View Indicators window (page 119).   |
|  | <b>Map Like</b>                      | Show the Sky Chart with a white background that simulates a printed star chart.   |
|  | <b>Photo Like</b>                    | Show the Sky Chart with a black background to simulate what a photo of the sky looks like.  |
|  | <b>Satellites From Above Earth</b>   | Shows spacecraft orbiting the Earth (page 189).   |
|  | <b>Show Constellation Boundaries</b> | Turn constellation boundary lines on or off.  |
|  | <b>Show Daylight</b>                 | <p>Turn this option on to simulate the morning, daytime and evening sky.</p> <p>When <b>Show Daylight</b> is turned off, the sky appears black to reveal stars and other objects, even during the day.</p> <p>When the Show Daylight command is turned on, the stars and other objects are filtered by magnitude so that they're not visible, even at smaller fields of view.</p> <p> So that the simulated stars and other objects are visible during daylight hours, be sure to turn off the Show Daylight command. Otherwise, you</p> |

|  |                               |  |
|--|-------------------------------|--|
|  |                               | might scratch your head thing, “What happened to all the objects on the Sky Chart?” Blame the sun! |
|  | <b>Show Ecliptic</b>          | Turn on or off a line that shows the path of the Sun.  |
|  | <b>Show Equatorial Grid</b>   | Turn on or off lines that show a grid of right ascension and declination coordinates.              |
|  | <b>Show Horizon Grid</b>      | Turn on or off lines that show a grid of azimuth and altitude coordinates                          |
|  | <b>Show Mirror Image</b>      | Show the Sky Chart as it appears in a telescope with an odd number of mirrors (page 49).           |
|  | <b>Show Night Vision Mode</b> | Changes <i>TheSkyX</i> ’s window to red to preserve dark adaptation (page 344)                     |
|  | <b>Solar System</b>           | Show or hide solar system objects.   |
|  | <b>Star Options</b>           | Show the Star Options window to configure the appearance of stars on the Sky Chart (page 250).     |
|  | <b>Toggle Labels</b>          | Turn the labels of objects on the Sky Chart on or off.   |
| <b>Edit Toolbar</b>                                |                               |  |
|  |                               |  |
| <p><b>Figure 89: The default Edit toolbar.</b></p> |                               |  |
|  | <b>Copy</b>                   | Copy the current Sky Chart to the Clipboard as a picture.  |

|              |                    |  |
|--------------|--------------------|--|
|              | <b>Find</b>        | Locate objects in <i>TheSkyX</i> 's databases by name, catalog number or from a list of objects (page 59). |
| PROFESSIONAL | <b>Paste Photo</b> | Overlays a photo from the Clipboard on the Sky Chart.  |

**Field of View Toolbar**

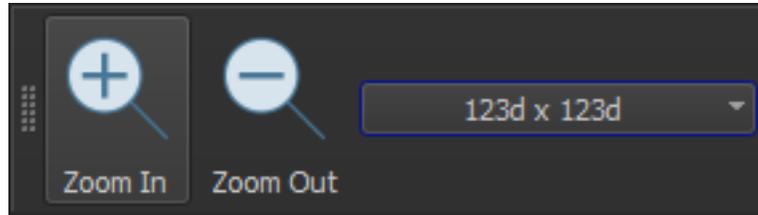


Figure 90: The default Field of View toolbar.

|  |                              |  |
|--|------------------------------|--|
|  | <b>Field of View Chooser</b> | Choose the Sky Chart's field of view from this list of predefined or custom field widths.                              |
|  | <b>Zoom In</b>               | Increase magnification by decreasing the Sky Chart's field width. Click and hold this button to zoom in continuously.  |
|  | <b>Zoom Out</b>              | Decrease magnification by increasing the Sky Chart's field width. Click and hold this button to zoom out continuously. |

**File Toolbar**

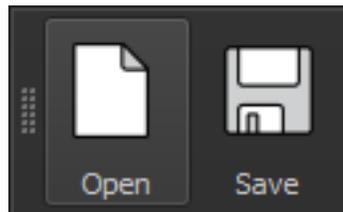


Figure 91: The default File toolbar.

|  |             |   |
|--|-------------|---|
|  | <b>Open</b> | Open or load a Sky Chart Settings file. |
|--|-------------|---|

|  |             |                                      |
|--|-------------|--------------------------------------|
|  | <b>Save</b> | Save the current Sky Chart Settings. |
|--|-------------|--------------------------------------|

**Imaging System Toolbar**



Figure 92: The default Imaging System toolbar.

|  |                       |  |
|--|-----------------------|--|
|  | <b>Autoguider</b>     | Show the Autoguider pane (page 469).   |
|  | <b>Camera</b>         | Show the Camera pane (page 455).       |
|  | <b>Dome</b>           | Show the Dome pane (page 611).         |
|  | <b>Filter Wheel</b>   | Show the Filter Wheel pane (page 596). |
|  | <b>Focuser</b>        | Show the Focuser pane (page 561).      |
|  | <b>Rotator</b>        | Show the Rotator pane (page 603).      |
|  | <b>Telescope</b>      | Show the Telescope pane (page 342).    |
|  | <b>Video</b>          | Show the Video pane (page 436).        |
|  | <b>Video (guider)</b> | Show the Autoguider pane (page 469).   |

**Look Toolbar**

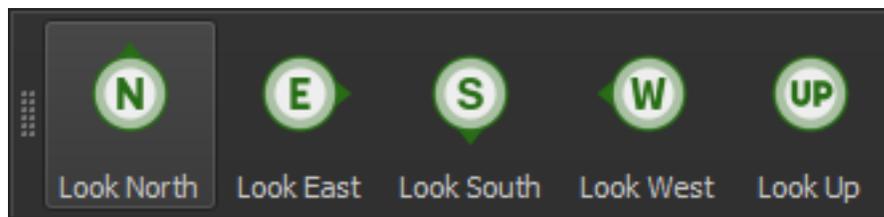


Figure 93: The default Look toolbar.

|  |                   |   |
|--|-------------------|---|
|  | <b>Look East</b>  | Look east at a 100-degree field of view.  |
|  | <b>Look North</b> | Look north at a 100-degree field of view. |

|  |                   |   |
|--|-------------------|---|
|  | <b>Look South</b> | Look south at a 100-degree field of view. |
|  | <b>Look West</b>  | Look west at a 100-degree field of view.  |
|  | <b>Look Up</b>    | Look straight up, at the zenith.          |

**Objects Toolbar**

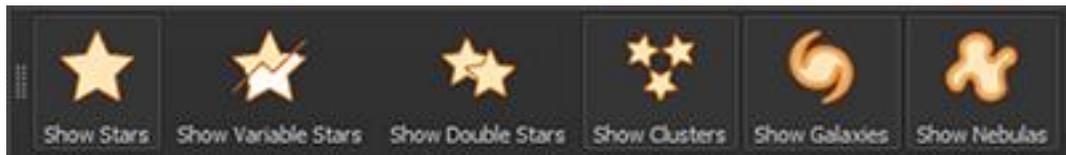


Figure 94: The default Objects toolbar.

|  |                            |                              |
|--|----------------------------|------------------------------|
|  | <b>Show Clusters</b>       | Show or hide star clusters.  |
|  | <b>Show Double Stars</b>   | Show or hide double stars.   |
|  | <b>Show Galaxies</b>       | Show or hide galaxies.       |
|  | <b>Show Nebulas</b>        | Show or hide nebulas.        |
|  | <b>Show Stars</b>          | Show or hide stars.          |
|  | <b>Show Variable Stars</b> | Show or hide variable stars. |

**Orientation Toolbar**

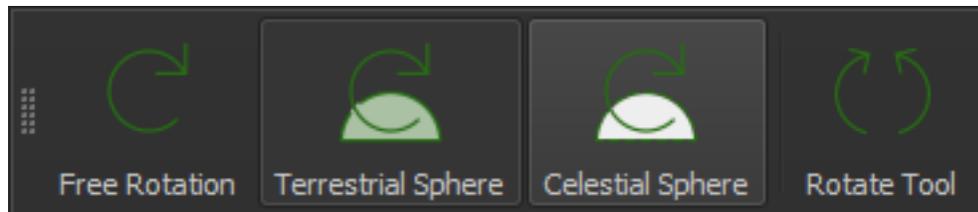
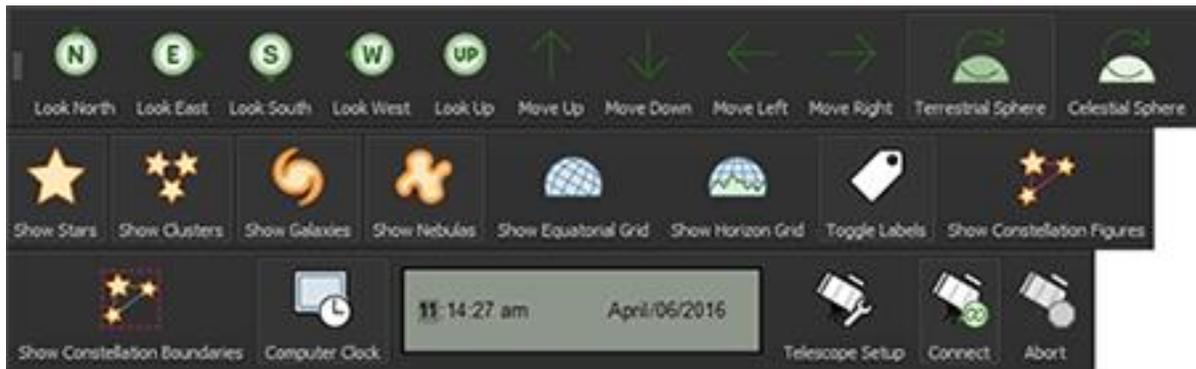


Figure 95: The default Orientation toolbar.

|  |                         |   |
|--|-------------------------|---|
|  | <b>Celestial Sphere</b> | Display the Sky Chart using an equatorial coordinate-based projection with the direction to the celestial pole toward the top of the window (page 151). |
|--|-------------------------|---|

|  |                           |   |
|--|---------------------------|---|
|  | <b>Free Rotation</b>      | In this projection, the Sky Chart can be rotated to any position angle (page 151).<br><br>This option is helpful when aligning photos with the simulated chart. |
|  | <b>Rotate Tool</b>        | Turn on the Rotate Tool to set the Sky Chart's position angle (page 151).   |
|  | <b>Terrestrial Sphere</b> | Display the Sky Chart using a horizon-based projection with the local zenith located at the top of the window (page 150).                                       |

**Small Screen Toolbar**

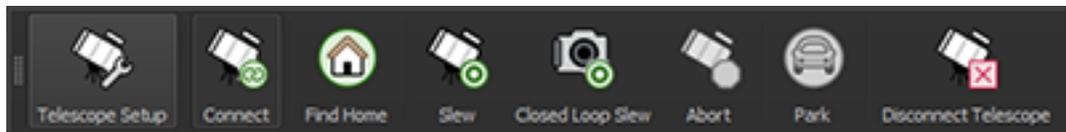


**Figure 96: The default Small Screen toolbar.**

|  |                   |  |
|--|-------------------|--|
|  | <b>Abort</b>      | Stops the current telescope slew (page 393).   |
|  | <b>Connect</b>    | Establishes communication between TheSkyX and the telescope's controller (page 365). |
|  | <b>Look East</b>  | Orient the Sky Chart looking East at a 100-degree field of view.                     |
|  | <b>Look North</b> | Orient the Sky Chart looking East at a 100-degree field of view.                     |

|  |                        |   |
|--|------------------------|---|
|  |                        |   |
|  | <b>Look South</b>      | Orient the Sky Chart looking East at a 100-degree field of view.                  |
|  | <b>Look West</b>       | Orient the Sky Chart looking East at a 100-degree field of view.                  |
|  | <b>Move Down</b>       | Orient the Sky Chart looking East at a 100-degree field of view.                  |
|  | <b>Move Left</b>       | Adjusts the Sky Chart's field of view to simulate looking to the right (page 42). |
|  | <b>Move Right</b>      | Adjusts the Sky Chart's field of view to simulate looking to the left (page 42).  |
|  | <b>Move Up</b>         | Adjusts the Sky Chart's field of view to simulate looking upward (page 42).       |
|  | <b>Telescope Setup</b> | Shows the Telescope Setup window (page 359).                                      |
|  | <b>Time Control</b>    | Shows the date and time for the current Sky Chart (page 142).                     |

**Telescope Toolbar**



**Figure 97: The default Telescope toolbar.**

|  |                  |   |
|--|------------------|---|
|  | <b>Find Home</b> | Slews the telescope to its home position. |
|  | <b>Park</b>      | Slews the telescope to the park position. |
|  | <b>Slew</b>      | Slews the telescope to the target object. |

**Time Toolbar**

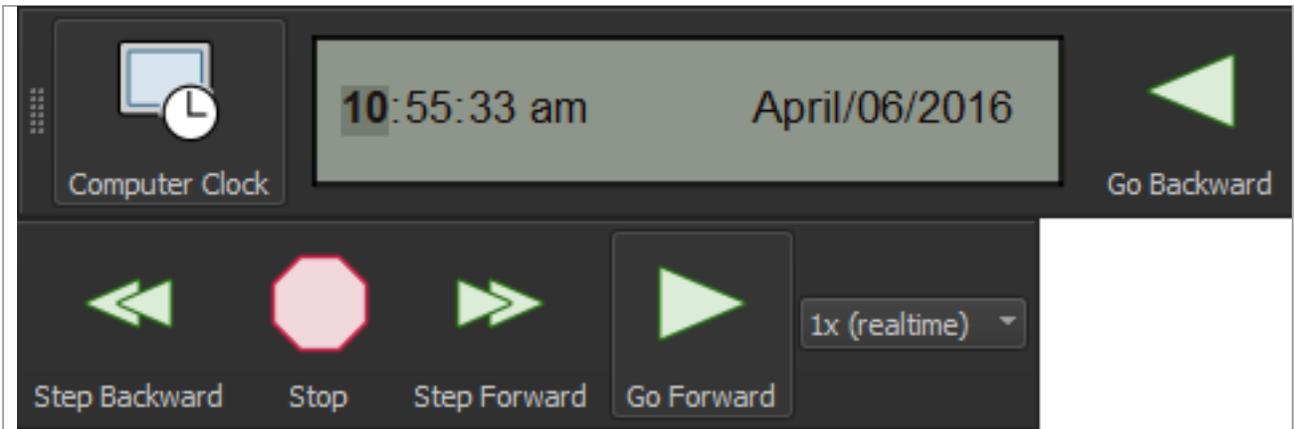


Figure 98: The default Time toolbar.

|                           |                            |  |
|---------------------------|----------------------------|--|
|                           | <b>Computer Clock</b>      | Get the date and time from the computer's clock (page 142).                    |
|                           | <b>Go Backward</b>         | Decrement time continuously at the current rate or skip increment (page 142).  |
|                           | <b>Go Forward</b>          | Increment time continuously at the current rate or skip increment (page 144).  |
|                           | <b>Set Time Flow</b>       | Choose the rate or increment of time to advance or retreat (page 145).         |
|                           | <b>Step Backward</b>       | Decrement time one skip increment each time this button is clicked (page 143). |
|                           | <b>Step Forward</b>        | Increment time one skip increment each time this button is clicked (page 144). |
|                           | <b>Stop</b>                | Freeze time (page 144).  |
|                           | <b>Time Controls</b>       | Shows the date and time for the current Sky Chart (page 142).                  |
| <b>All Other Commands</b> |                            |  |
|                           | <b>Add Pointing Sample</b> | Adds a TPoint pointing calibration sample (page 395).                          |

|  |  |   |
|--|--|---|
|  |  | See the TPoint Add On User Guide for details about modeling telescopes.   |
|  | <b>Add or Edit Observation</b>                 | Creates or edits the observer log for the target object (page 296).   |
|  | <b>Add to List</b>                             | Add the target object to the Observing List.<br><br>You can also press and hold the SHIFT key while clicking an object on the Sky Chart to add it to the Observing List (page 291). |
|  | <b>Angular Separation &amp; Position Angle</b> | Show the Angular Separation and Position Angle tool (page 152).   |
|  | <b>Binocular 50°</b>                           | Change the Sky Chart's field of view to 50°.  |
|  | <b>Calibrate Photo</b>                         | Show the Camera Add On Calibrate Photo window.  |
|  | <b>Center</b>                                  | Center the target object on the Sky Chart.  |
|  | <b>Center Cross Hairs</b>                      | Center the telescope cross hair on the Sky Chart (page 393).  |
|  | <b>Check for Updates</b>                       | Check to see if a newer version is available.   |
|  | <b>Clear Park Position</b>                     | Forgets the current telescope park position (page 375).   |
|  | <b>Connect Telescope</b>                       | Establishes a connection with the currently selected telescope (page 365).  |
|  | <b>Copy Text</b>                               | Copies the selected text to the Clipboard.  |

|  |                                       |   |
|--|---------------------------------------|---|
|  | <b>Cut</b>                            | Cuts or removes the selected text and places it on the Clipboard.   |
|  | <b>Disconnect Telescope</b>           | Terminates the connection with the currently selected telescope (page 365).                               |
|  | <b>Exit/Quit</b>                      | Quits <i>TheSkyX</i> .  |
|  | <b>Finder 10°</b>                     | Change the Sky Chart's field of view to 10°.  |
|  | <b>Frame</b>                          | Frame the current target object (page 63).  |
|  | <b>Full Screen</b>                    | Show the Sky Chart using the entire desktop (page 56).<br><br>Press the ESC key to exit Full Screen mode. |
|  | <b>Highlight Center Constellation</b> | Highlights the constellation that is located near the center of the Sky Chart (page 254).                 |
|  | <b>Lock On</b>                        | Pins a solar system target object to the center of the Sky Chart (page 69).                               |
|  | <b>Maximum</b>                        | Zooms to the maximum field of view for the current projection.  |
|  | <b>Minimum 30"</b>                    | Change the Sky Chart's field of view to 30 arcseconds.  |
|  | <b>Move Down</b>                      | Adjusts the Sky Chart's field of view to simulate looking downward (page 42).                             |
|  | <b>Move Left</b>                      | Adjusts the Sky Chart's field of view to simulate looking to the right (page 42).                         |
|  | <b>Move Right</b>                     | Adjusts the Sky Chart's field of view to simulate looking to the left (page 42).                          |

|  |                                       |  |
|--|---------------------------------------|--|
|  | <b><i>Move Up</i></b>                 | Adjusts the Sky Chart's field of view to simulate looking upward (page 42).                                  |
|  | <b><i>Naked Eye 100°</i></b>          | Change the Sky Chart's field of view to 100°.  |
|  | <b><i>New</i></b>                     | Restores the chart settings to default values (page 57).   |
|  | <b><i>Next</i></b>                    | Show the next photo of the object (page 64).   |
|  | <b><i>Night Vision Setup</i></b>      | Configure screen to preserve dark adaptation (page 344).   |
|  | <b><i>Overlay DSS Photo</i></b>       | Show a Digitized Sky Survey Photo on the Sky Chart (page 103).   |
|  | <b><i>Point to Target</i></b>         | Show a green laser pointer directed at the current target object.  |
|  | <b><i>Previous</i></b>                | Show the next photo of the object (page 64).   |
|  | <b><i>Print Info</i></b>              | Print information about the target object.   |
|  | <b><i>Push Scope To</i></b>           | Show on-screen graphics that help find objects when using a hand-controlled or push to telescope (page 357). |
|  | <b><i>Remove DSS Photos</i></b>       | Hide and remove Digitized Sky Survey Photos from the Sky Chart (page 103).                                   |
|  | <b><i>Remove Satellites</i></b>       | Remove satellite two-line elements from Sky Chart and from auto-download list (page 248).                    |
|  | <b><i>Reset Chart to Defaults</i></b> | Restore the chart settings to default values (page 57).  |
|  | <b><i>Rotate Clockwise</i></b>        | Rotate the Sky Chart counterclockwise.   |
|  | <b><i>Rotate Counterclockwise</i></b> | Rotate the Sky Chart clockwise.  |

|  |                              |  |
|--|------------------------------|--|
|  |                              |  |
|  | <b>Save As</b>               | Save the chart settings with a specific file name.   |
|  | <b>Set Park Position</b>     | Save the current position of the telescope as the park position (page 375).  |
|  | <b>Set Track Rates</b>       | Set the telescope's tracking rates to match the target object (page 394).  |
|  | <b>Show Milky Way</b>        | Show the Milky Way Galaxy on the Sky Chart.  |
|  | <b>Show Photo+</b>           | Show a photo or H-R diagram for the target object (page 64).   |
|  | <b>Show in Constellation</b> | Adjusts the field of view to the approximate size of the constellation surrounding the target object and points the green laser pointer at the object. |
|  | <b>Sleep</b>                 | Minimizes CPU usage by halting all real-time computations.   |
|  | <b>Slew Prior</b>            | Slew the telescope to the last target object, if one is available (page 382).  |
|  | <b>Star Brightness Down</b>  | Decrease star brightness.  |
|  | <b>Star Brightness Up</b>    | Increase star brightness.  |
|  | <b>Star Contrast Down</b>    | Decrease the contrast between brighter and fainter stars.  |
|  | <b>Star Contrast Up</b>      | Increase the contrast between brighter and fainter stars.  |
|  | <b>Suspend Connection</b>    | Temporarily stop sending command to, and receiving commands from, the mount or telescope.  |

|  |                                  |   |
|--|----------------------------------|---|
|  | <b>Sync</b>                      | Synchronize the telescope's position using the coordinates of the target star (page 366). |
|  | <b>TPoint Add On User Guide</b>  | View the TPoint Add On User Guide in PDF format.  |
|  | <b>Telescope 1°</b>              | Change the Sky Chart's field of view to 1°.   |
|  | <b>TheSkyX Help</b>              | View documentation (page 32).   |
|  | <b>TheSkyX User Guide</b>        | View the TheSkyX Professional and Serious Astronomer Edition User Guide in PDF format.    |
|  | <b>Toggle Linked Photo</b>       | Show or hide the Image Link photo (page 312).   |
|  | <b>Track Satellite</b>           | If the target object is a spacecraft, show the Satellite tracking window (page 388).      |
|  | <b>Turn Sidereal Tracking On</b> | Set the mount's tracking rate to the sidereal rate.                                       |
|  | <b>Turn Tracking Off</b>         | Set the mount's tracking rate to zero.  |
|  | <b>Unpark</b>                    | Unpark the mount at the start of the observing session.                                   |
|  | <b>View From</b>                 | Lock on the target planet, comet or asteroid in the 3D Solar System View (page 182).      |
|  | <b>What's Up?</b>                | Show a report of interesting objects that are visible tonight (page 119).                 |
|  | <b>Wide Field 180°</b>           | Change the Sky Chart's field of view to 180°.   |
|  | <b>Zoom In</b>                   | Decrease the Sky Chart's field of view.   |

|                      |   |  |
|----------------------|---|--|
|                      | <b>Zoom Out</b>                             | Decrease the Sky Chart's field of view.  |
|                      | <b>Zoom Tool</b>                            | Show the Zoom Tool on the Sky Chart (page 40).   |
| <b>Other Windows</b> |   |  |
|                      | <b>About TheSkyX</b>                        | Show <i>TheSkyX's</i> About window to reveal the software version, Edition and copyright information.                    |
|                      | <b>Auto Pointing Calibration</b>            | Show the TPoint Add On Auto Pointing Calibration window. See the TPoint Add On User Guide for details.                   |
| <b>PROFESSIONAL</b>  | <b>Bisque TCS</b>                           | Show the Bisque TCS window. See the Paramount MX User Guide for details.   |
|                      | <b>Calendar</b>                             | Show the Calendar window showing the phase of the moon, rise and set times of the sun and moon and other events.         |
|                      | <b>Calibration</b>                          | Show the TPoint Add On Calibration window for collecting pointing samples. See the TPoint Add On User Guide for details. |
|                      | <b>Chart Elements</b>                       | Show the Chart Elements window (page 49).  |
|                      | <b>Conjunction Finder</b>                   | Find astronomical conjunctions (page 197).   |
|                      | <b>Constellation &amp; Asterism Options</b> | Show options for displaying constellations and asterisms.  |
|                      | <b>Create Sky Database</b>                  | Create an auxiliary database from any ASCII text data.   |
| <b>PROFESSIONAL</b>  | <b>Create Tour</b>                          | Create an astronomical tour (page 91).   |
|                      | <b>Database Manager</b>                     | Manage TheSkyX's databases (page 268).   |
|                      | <b>Date and Time</b>                        |  |

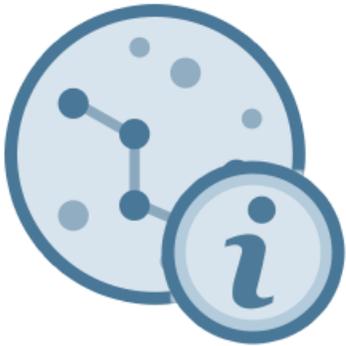
|                     |   |   |
|---------------------|---|---|
|                     | <b>Digital Setting Circles</b>          |   |
|                     | <b>Digitized Sky Survey</b>             |   |
|                     | <b>Edit Chart Elements</b>              |   |
|                     | <b>Export Chart</b>                     |   |
|                     | <b>Horizon &amp; Atmosphere Options</b> |   |
| <b>PROFESSIONAL</b> | <b>Image Link</b>                       | Overlay FITS photos to match cataloged stars and determine the astrometric solution (page 312.) |
|                     | <b>Imaging System Setup</b>             | Configure your imaging hardware.  |
|                     | <b>Iridium Flares</b>                   |   |
|                     | <b>Labels</b>                           |   |
|                     | <b>Location</b>                         |   |
|                     | <b>Manage Observing List</b>            |   |
|                     | <b>Milky Way Options</b>                |   |
|                     | <b>Moon Photo Viewer</b>                |   |
|                     | <b>Mosaic Grid</b>                      |   |
|                     | <b>My Chart Elements</b>                |   |
|                     | <b>Navigate</b>                         |   |
|                     | <b>Non-Stellar Object Options</b>       |   |
|                     | <b>Object Paths</b>                     |   |
|                     | <b>Observing List</b>                   |   |
| <b>PROFESSIONAL</b> | <b>Open FITS</b>                        |   |
| <b>PROFESSIONAL</b> | <b>Place Photo</b>                      |   |
|                     | <b>Preferences</b>                      |   |
|                     | <b>Print Setup</b>                      |   |
|                     | <b>Print</b>                            |   |
|                     | <b>Projections</b>                      |   |
|                     | <b>Reference Lines &amp; Photos</b>     |   |
|                     | <b>Reports</b>                          |   |
|                     | <b>Run Java Script</b>                  |   |
|                     | <b>SGT Align</b>                        |   |
|                     | <b>Satellites</b>                       |   |
|                     | <b>Show DSS FITS Photo</b>              |   |
|                     | <b>Slide Show</b>                       |   |
|                     | <b>Small Solar System Bodies</b>        |   |
|                     | <b>Solar and Lunar Eclipse Viewer</b>   |   |
|                     | <b>Star Search</b>                      |   |
|                     | <b>Star Synchronization</b>             |   |
|                     | <b>TCP Server</b>                       |   |
|                     | <b>TPoint Add On</b>                    |   |
|                     | <b>Telescope Limits</b>                 |   |

|                          |                               |  |
|--------------------------|-------------------------------|--|
|                          | <b>Telescope Window</b>       |  |
| <b>PROFESSIONAL</b>      | <b>Tours</b>                  |  |
|                          | <b>Track Satellite Window</b> |  |
|                          | <b>Verify TheSkyX Time</b>    |  |
| <b>My Chart Elements</b> |                               |  |
|                          | <b>Add Area of Interest</b>   |  |
|                          | <b>Add Arrow</b>              |  |
|                          | <b>Add Chart Scale</b>        |  |
|                          | <b>Add Ellipse</b>            |  |
|                          | <b>Add Graphic</b>            |  |
|                          | <b>Add Label</b>              |  |
|                          | <b>Add Lines</b>              |  |
|                          | <b>Add Object</b>             |  |
|                          | <b>Add Object Label</b>       |  |
|                          | <b>Add Polygons</b>           |  |
|                          | <b>Add Telrad™</b>            |  |

## Status Windows

TheSkyX offers three different status windows that can be configured to show information about the current time, telescope position, and other report attributes.

## Chart Status



The Chart Status window (**Display > Chart Status**) provides helpful information about the sky chart. By default, the current location, date and time are shown, but up to 21 chart status attributes be added.

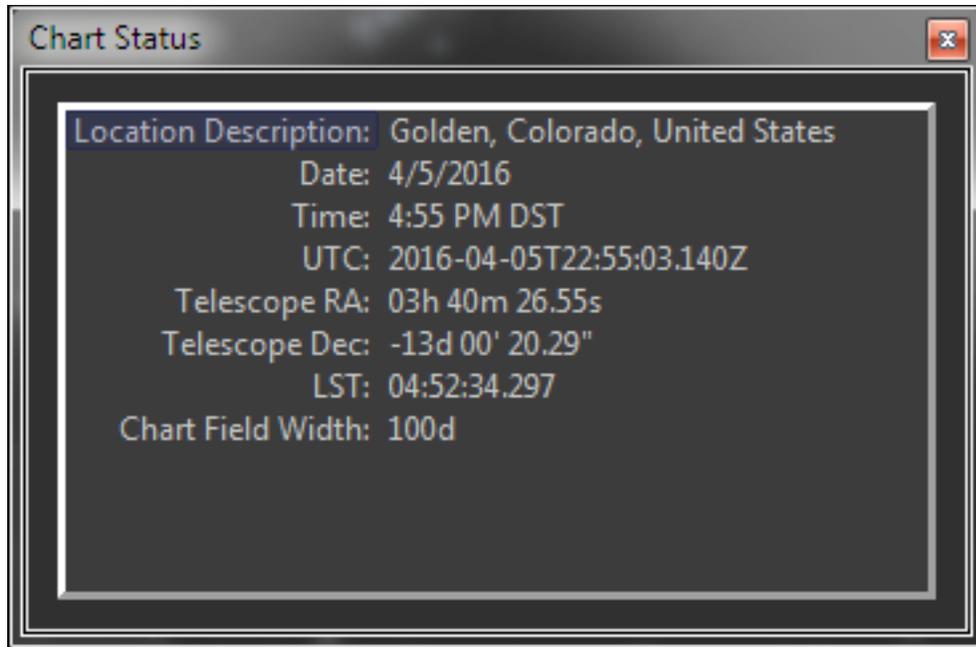


Figure 99: Chart Status window (Display > Chart Status).

To change the contents of the Chart Status report, select the **Preferences** command from *TheSkyX* menu on the Mac (**Edit > Preferences** on Windows) then click the **Status Windows** icon. In the **Status Window** list, select **Sky Chart Status**.

Highlight the items in the **Attribute List** that interest you, then click the right-arrow button.

Note that double-clicking the *left* side of the Sky Chart Status report shows the Sky Chart Status report options on the **Preferences** window. Double-clicking the *right* side of the report shows the attribute-specific window. For example, double-clicking on the Location text reveals the Location window.

#### **Digital Setting Circles and Status Bar**

The contents of the report that appears on the Digital Settings Circles window (page 397) and the Status Bar window can be configured identically as the Chart Status window. Just make sure to select the appropriate option on the **Status Window** list.

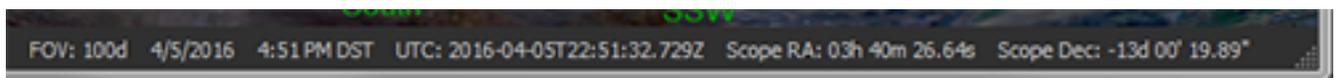


Figure 100: A Status Bar can be shown at the bottom of Sky Chart.

## Report Setup



The object-specific properties (for example, an object's magnitude, or the spectral class of stars or the Moon's ecliptic longitude), that appear in the Object Information Report and Tool Tips Report is configurable to your needs.

- The Object Information Report appears on the **Edit > Find** window.
- The **Tool Tips Report** is the small window that appears when you place the mouse over an object on the Sky Chart.

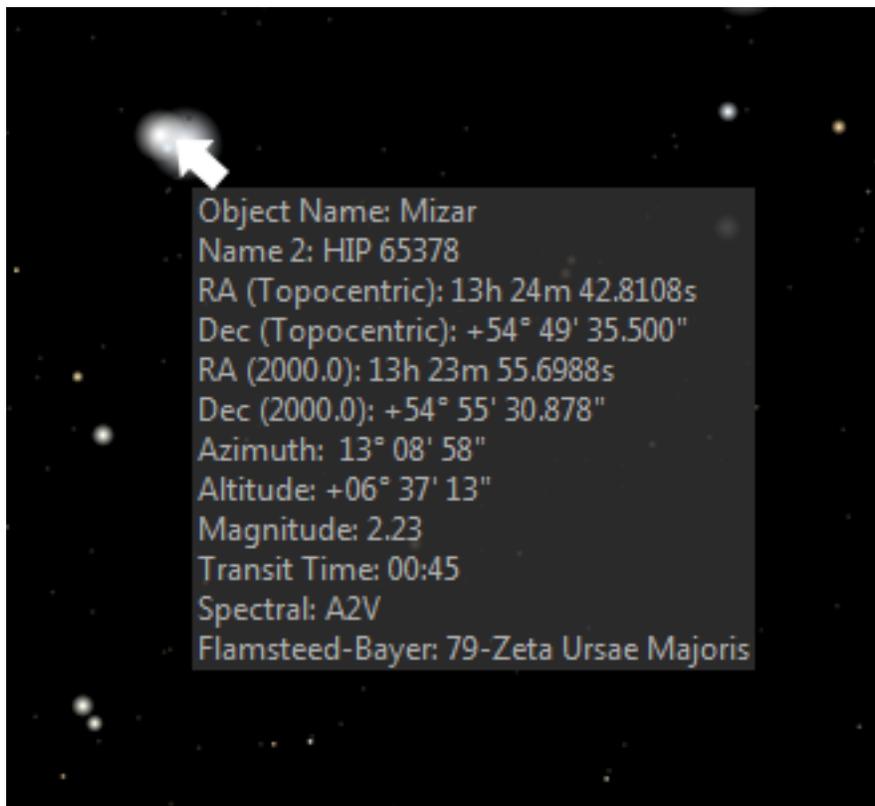


Figure 101: Tool tip on the Sky Chart.

## Date & Time Control

The format of the date and time displayed in the **Date & Time** control (page 140) can be configured to meet your requirements.

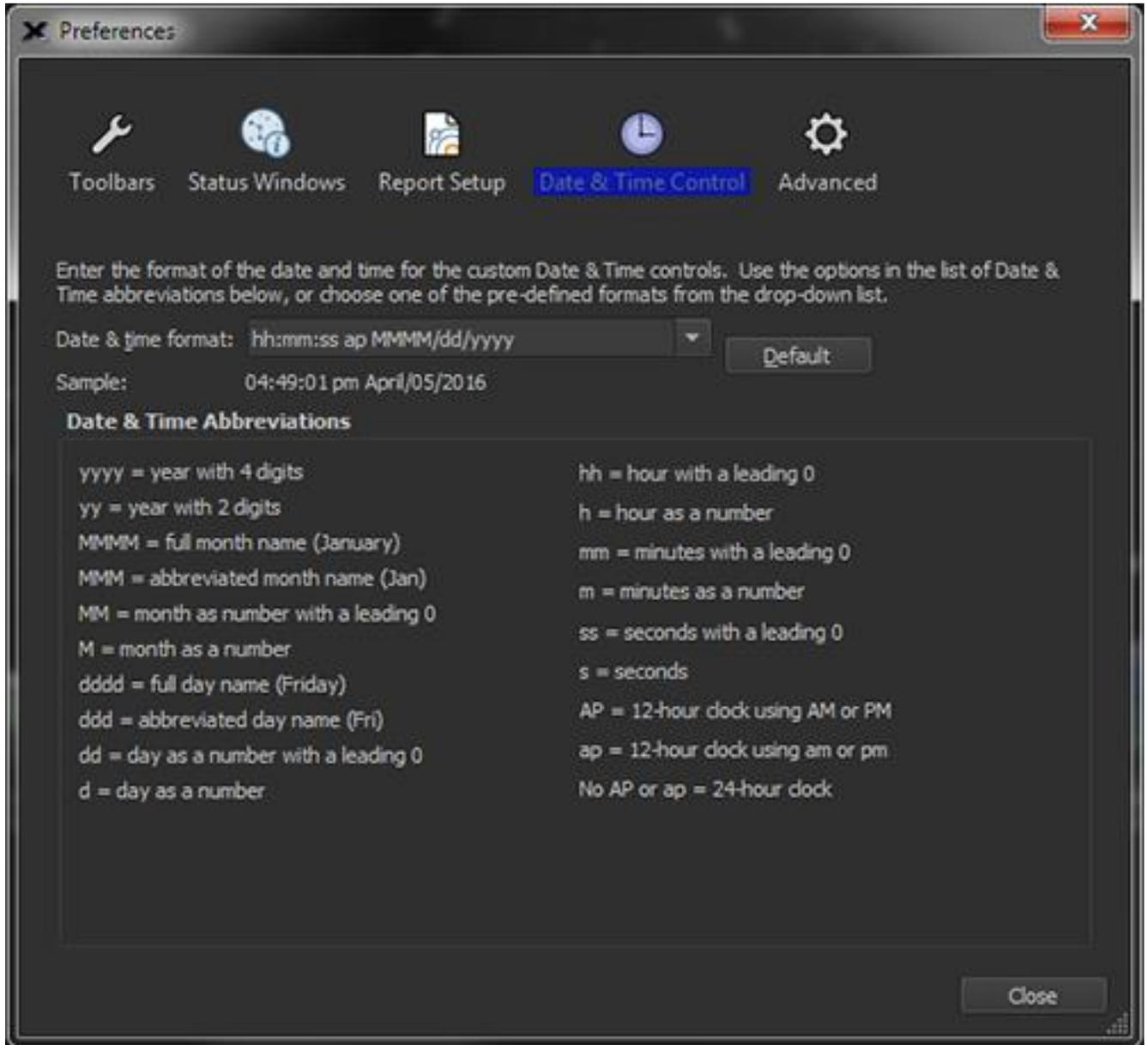


Figure 102: Date & Time Control options on the Preferences window.

To open the Date & Time Control window select the **Preferences** command from *TheSkyX* menu (or **Edit > Preferences** in Windows) then click the **Date & Time Control** icon.

In concept, formatting the date and time is simple. On the **Date & Time Format** text box, just type the format of the date and time that you want, or select one of the predefined formats from

the drop-down list. However, please take a moment to carefully read the text on this window. It should be self-explanatory, but this seemingly simple option is extremely flexible, and it might take you a few tries to get the format just the way you want it.

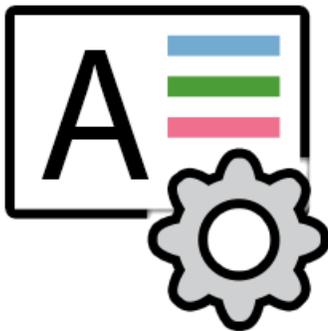
### **Date & Time Format Configuration**

The allowable date and time format abbreviations in the Date and Time format text are shown in the table below.

| <b>Abbreviation</b> | <b>Explanation</b>   |
|---------------------|--|
| <b>AP</b>           | Shows <i>AM</i> or <i>PM</i> in capital letters. Omitting the AP from the format will the time using a 24-hour time, or “military time” instead of the standard time format.                           |
| <b>Ap</b>           | Shows <i>am</i> or <i>pm</i> in lower case letters. Omitting the Ap abbreviation from the format will the time using a 24-hour time, or “military time” instead of the standard time format.           |
| <b>d</b>            | A single lower-case d shows the day as a number from 1 to 31.  |
| <b>dd</b>           | The lower-case letter ‘d’, repeated twice, shows the day as number with a leading zero (01 to 31).   |
| <b>ddd</b>          | The lower-case letter ‘d’, three times in succession, indicates the abbreviated name of the day should be displayed. For example, dd shows the text <i>Fri</i> .                                       |
| <b>dddd</b>         | The lower-case letter ‘d’, four times in succession, indicates the complete name of the current day should be displayed. For example, entering dddd shows the day of the week, such as <i>Friday</i> . |
| <b>h</b>            | A single lower-case ‘h’ shows the hour without a leading zero. For example, 1 a.m. is shown as <i>1</i> .  |
| <b>hh</b>           | The lower-case letter ‘h’, repeated twice, shows the hour with a leading zero when appropriate. For example, 1 a.m. is shown as <i>01</i> .  |
| <b>M</b>            | A single upper-case letter ‘M’ shows the month as a number between 1 and 12.   |
| <b>m</b>            | A single lower-case letter ‘m’ shows the minutes without a leading zero when appropriate. For example, 5 minutes after the hour is shown as <i>5</i> .   |

| Abbreviation       | Explanation   |
|--------------------|---|
| <b><i>mm</i></b>   | The lower-case letter 'm', repeated twice, shows the minutes with a leading zero. For example, 5 minutes after the hour is shown as <i>05</i> .                         |
| <b><i>MM</i></b>   | The upper-case letter 'M', repeated twice, indicate the abbreviated name of the current month should be displayed. For example, <i>MM</i> shows <i>Jan</i> for January. |
| <b><i>MMM</i></b>  | The upper-case letter 'M', three times in succession, shows the abbreviated localized month name (for example, 'Jan' to 'Dec' for English).                             |
| <b><i>MMMM</i></b> | The upper-case letter 'M', four times in succession, shows the complete name of the current month should be displayed. For example, <i>MMMM</i> shows <i>January</i> .  |
| <b><i>s</i></b>    | A single lower-case letter 's' shows the seconds without a leading zero when appropriate. For example, 5 seconds after the minute is shown as <i>5</i> .                |
| <b><i>ss</i></b>   | The lower-case 's', repeated twice, shows the seconds with a leading zero. For example, 5 seconds after the minute is shown as <i>05</i> .                              |
| <b><i>yy</i></b>   | The lower-case letter 'y', repeated twice, shows the decade and year. For example, <i>yy</i> shows <i>15</i> .  |
| <b><i>yyyy</i></b> | The lower-case letter 'y', repeated twice, shows the year using four digits. For example, <i>yyyy</i> shows <i>2018</i> .   |

## Advanced Preferences



Click the **Advanced** icon to show the *application-wide* options that normally do not need to be modified. We recommend leaving the options alone unless you are an advanced user, or you've contacted technical support and have been instructed to alter one or more settings.

The exceptions to this rule are:

- Turning on/off the chart scroll bars
- Showing the target frame rate (the frequency at which the Sky Chart is updated)
- Turning on/off the status bar
- Setting the **Target Frame Rate** (to conserve power on battery operated computers)
- Turning on/off the zoom tool
- Playing the startup sound
- Showing the splash screen at startup

The table below describes the advanced preferences.

| Option                             | Description  |
|------------------------------------|--|
| <b>Registration</b>                |  |
| <b>Name</b>                        | Shows the user's name that was entered when <i>TheSkyX</i> was first launched. This name is not, <i>necessarily</i> , your Software Bisque account sign in name.   |
| <b>TheSkyX Serial Number</b>       | Shows the serial number that was entered when <i>TheSkyX</i> was first launched.<br><br>The serial number is stored in the <i>appsettings.ini</i> text file located in the "Application Support Files" folder (page 26). |
| <b>TPoint Add On Serial Number</b> | Shows the serial number that was entered for the <i>TPoint Add On</i> .<br><br>The serial number is stored in the <i>appsettings.ini</i> text file located in the "Application Support Files" folder (page 26).          |
| <b>Dome Add On Serial Number</b>   | Shows the serial number that was entered for the <i>Dome Add On</i> .<br><br>The serial number is stored in the <i>appsettings.ini</i> text file located in the "Application Support Files" folder (page 26).            |
| <b>Edition</b>                     | Lists the current Edition of <i>TheSkyX</i> that is installed.   |
| <b>Sky Chart</b>                   |  |

| Option  | Description  |
|---|--|
| <p><b>Graphics Rendering Mode (Restart Required)</b></p>    | <p>Select the graphics rendering mode used by <i>TheSkyX</i>. See “Hardware Acceleration” on page <b>Error! Bookmark not defined.</b> and “Running TheSkyX without Acceleration” on page 14 for a complete discussion on this setting.</p> <p><b>Automatic</b> determines whether or not hardware acceleration is available and sets the rendering mode accordingly.</p> <p><b>Hardware Acceleration</b> forces <i>TheSkyX</i> to use hardware acceleration.</p> <p><b>No Hardware Acceleration</b> forces <i>TheSkyX</i> to use non-hardware accelerated graphics.</p> <p>The default setting is <b>Automatic</b>.</p> <p><i>TheSkyX</i> must be restarted for changes to this option to take effect.</p> |
| <p><b>FOV Mask Transparency</b></p>                         | <p>Set the transparency (a value between 0 and 255) for a field of view indicator’s “masked” region (page 122).</p> <p>The default value is <b>0.00</b>.</p> <p>Maximum value = 255.0.</p> <p>Minimum value = 0.0.</p>   |
| <p><b>Automatically Save Chart Settings Upon Exit</b></p>   | <p>Turn this checkbox on so that <i>TheSkyX</i>’s settings are automatically saved each time the application is closed.</p> <p>The default setting is <b>True</b>.</p>   |
| <p><b>Prompt to Save Modified Chart Settings</b></p>        | <p>Turn this checkbox on to be prompted to save changes when <i>TheSkyX</i> is closed.</p> <p>The default setting is <b>False</b>.</p>   |
| <p><b>Auto Update Satellite TLEs Older Than (Hours)</b></p> | <p>Enter the number of hours that must pass before satellite TLEs are considered “out of date.” TLEs older than this value are automatically updated from the web when <i>TheSkyX</i> is launched.</p> <p>The default value is <b>20</b> hours.</p> <p>Maximum value = 1200.</p> <p>Minimum value = 1.0.</p>   |

| Option                                    | Description   |
|---|---|
| <b>Zoom In/Out Percentage</b>             | <p>Enter the relative amount of change to the field of view of the Sky Chart when zooming in or out, as a percentage of the current field of view.</p> <p>The default value is <b>3.00</b>.<br/>Maximum value = 100.0.<br/>Minimum value = 0.0.</p>   |
| <b>Move Left/Right/Up/Down Percentage</b> | <p>Enter the relative amount of change in the position of the center of the screen while scrolling left, right, up, as a percentage of the current field of view.</p> <p>The default value is <b>2.50</b>.<br/>Maximum value = 100.0.<br/>Minimum value = 0.0.</p>                                    |
| <b>Fade Transition Time</b>               | <p>Enter the length of time, in seconds, to transition or fade between Sky Charts when the position of the chart is changing.</p> <p>The default value is <b>0.35</b> seconds.<br/>Maximum value = 3.0.<br/>Minimum value = 0.0.</p>  |
| <b>Show Frame Rate</b>                    | <p>Show the frequency, in frames per second, at which the Sky Chart is updated. This value appears on the bottom left of the Sky Chart.</p> <p>Default value is <b>False</b>.</p>   |
| <b>Target Frame Rate</b>                  | <p>Specify the “steady state” frame rate frequency at which to update the Sky Chart. The higher the frame rate, the more CPU and GPU processor cycles required to display the Sky Chart.</p> <p>The default value is <b>30</b> frames per second.<br/>Maximum value = 200.<br/>Minimum value = 0.</p> |
| <b>Show Chart Scroll Bars</b>             | <p>Show or hide scroll bars on the Sky Chart.</p> <p>The default setting is <b>False</b>.</p>   |
| <b>Show Status Bar</b>                    | <p>Show or hide a small window on the bottom of the Sky Chart that provides Sky Chart status.</p>   |

| Option   | Description  |
|--|--|
|  | <p>The default setting is <b>False</b>.</p>  |
| <b>Show Zoom Tool</b>                                  | <p>Show or hide the Sky Chart Zoom Tool (page 40) on the upper left side of the Sky Chart to adjust the chart's field of view.</p> <p>The default setting is <b>True</b>.</p>  |
| <b>Copy Sample Files to Application Support Folder</b> | <p>Turn this checkbox on to copy all user-configurable files to the "Application Support Files" folder (page 26) when the application is launched.</p> <p>The default value is <b>True</b>.</p>  |
| <b>Play Startup Sound</b>                              | <p>Play <i>TheSkyX</i>'s introduction "jingle" each time the application launched.</p> <p>The default setting is <b>True</b>.</p>  |
| <b>Show Startup Splash Screen</b>                      | <p>Shows an introduction graphic and status messages while <i>TheSkyX</i> is being initialized.</p> <p>The default setting is <b>True</b>.</p>   |
| <b>Bad Pointing Sample Criterion (Degrees)</b>         | <p>When a calibration point is added during a TPoint Add On pointing calibration run, the <b>Bad Pointing Sample Criterion</b> specifies the maximum angular separation allowed between the telescope's position and the actual coordinates of the calibration point. If the angular separation between the equatorial coordinates (RA/Dec) of the calibration point and the telescope's position exceeds this value, an error message is displayed, and the point is not added to the calibration data.</p> <p>The default value is <b>0.50</b> degrees.<br/>                     Maximum value = 50.0.<br/>                     Minimum value = 0.0.</p> |
| <b>Sleep on Minimize (Windows Only)</b>                | <p>Turn this checkbox on so that <i>TheSkyX</i> will not perform any operations might affect the CPU usage, including screen updates, downloads, etc.</p> <ul style="list-style-type: none"> <li>This option applies to the Windows operating system only.</li> </ul>  |

| Option  | Description  |
|---|--|
|   | <ul style="list-style-type: none"> <li>The default setting is <b>True</b>.</li> </ul>  |
| <b>Legacy, External Pulse Focuser Control Small Size</b>      | <p>This deprecated setting is used for pulse focuser control during CCDSoft @Focus automated focusing.</p> <p>The default value is <b>50</b>.<br/>Maximum value = 0.<br/>Minimum value = 5000.</p>   |
| <b>Legacy, External Pulse Focuser Control Large Size</b>      | <p>This deprecated setting is used for pulse focuser control during CCDSoft @Focus automated focusing.</p> <p>The default value is <b>1000</b>.<br/>Maximum value = 0.<br/>Minimum value = 5000.</p>   |
| <b>Maximum Objects in Observing List (Restart Required)</b>   | <p>For a given database query, enter the maximum number of objects that can appear in the Observing List at one time.</p> <p>The default value is <b>2000</b> objects.<br/>Upper limit = 20,000.<br/>Lower limit = 100.</p> <p><i>TheSkyX</i> must be restarted for changes to this option to take effect.</p>   |
| <b>Log ccdsoftCamera and sky6RASCOMTele Methods</b>           | <p>Turn this checkbox on to create a log file named LogISN.txt (where “N” is the current imaging system, starting at 0) of the ccdsoftCamera and sky6RASCOMTele methods that have been called via TheSkyX’s automation model (page 657).</p>   |
| <b>Black Box Recorder (Windows OS Only; Restart Required)</b> | <p><i>TheSkyX</i> can optionally record, and optionally transmit Windows crash log reports to Software Bisque. This information in crash log reports can help find the cause of the crash more quickly and enabling this feature will not affect the software’s performance.</p> <ul style="list-style-type: none"> <li>The default setting is <b>Off</b></li> <li>Choose the <b>Save to Disk</b> option to save crash log reports in the folder named <b>Black Box Recorder Data</b> of the Application Support Files folder (page 26). Please attach this report in an email to <a href="mailto:ForumsAdmin@bisque.com">ForumsAdmin@bisque.com</a></li> <li>Choose the <b>Send to Software Bisque</b> to automatically upload crash log reports to a Software Bisque server when crashes occur.</li> </ul> |

| Option  | Description   |
|---|---|
|   | <ul style="list-style-type: none"> <li>This option applies to the Windows operating system only.</li> <li>TheSkyX Professional Edition must be restarted before this option takes effect.</li> </ul>  |
| <b>TCP Responses Close Socket</b>                                       | Always close the TCP socket when TheSkyX receives a response.   |
| <b>Accurate Polar Alignment Auto Finishes In-Progress Pointing Runs</b> | <p>If a TPoint session has not been finished, performing an Accurate Polar Alignment (see the TPoint Add On User Guide for details) finishes the TPoint session which prevents additional pointing calibration samples.</p> <p>The default value is <b>False</b>.</p>                                   |
| <b>Enable Dark Theme</b>  | <p>When this checkbox is turned on and TheSkyX is restarted, windows and other elements use a dark gray background color as opposed to a light-gray color.</p> <p>The default value is <b>True</b>.</p>   |
| <b>Minor Planet Center URLs</b>   |   |
| <b>Observable Comets</b>  | <p>The web address (or URL) for retrieving the list of observable comets from the Minor Planet Center.</p> <p>Default URL:<br/> <a href="http://www.minorplanetcenter.net/iau/Ephemerides/Comets/Soft06Cmt.txt">http://www.minorplanetcenter.net/iau/Ephemerides/Comets/Soft06Cmt.txt</a></p>           |
| <b>Comets and Asteroids By Name</b>                                     | <p>The web address (or URL) for retrieving the list of comets and asteroids by name from the Minor Planet Center.</p> <p>Default URL:<br/> <a href="http://scully.cfa.harvard.edu/cgi-bin/mpeph2.cgi">http://scully.cfa.harvard.edu/cgi-bin/mpeph2.cgi</a></p>  |
| <b>Distant Asteroids</b>  | <p>The web address (or URL) for retrieving the list of distant asteroids from the Minor Planet Center.</p> <p>Default URL:<br/> <a href="http://www.minorplanetcenter.net/iau/Ephemerides/Distant/Soft06Distant.txt">http://www.minorplanetcenter.net/iau/Ephemerides/Distant/Soft06Distant.txt</a></p> |
| <b>Critical Asteroids</b>   | The web address (or URL) for retrieving the list of critical asteroids from the Minor Planet Center.  |

| Option  | Description   |
|---|---|
|   | Default URL:<br><a href="http://www.minorplanetcenter.net/iau/Ephemerides/CritList/Soft06CritList.txt">http://www.minorplanetcenter.net/iau/Ephemerides/CritList/Soft06CritList.txt</a>   |
| <b>Unusual Asteroids</b>                              | The web address (or URL) for retrieving the list of unusual asteroids from the Minor Planet Center.<br><br>Default URL:<br><a href="http://www.minorplanetcenter.net/iau/Ephemerides/Unusual/Soft06Unusual.txt">http://www.minorplanetcenter.net/iau/Ephemerides/Unusual/Soft06Unusual.txt</a>                    |
| <b>Bright Asteroids at Opposition</b>                 | The web address (or URL) for retrieving the list of bright asteroids at opposition from the Minor Planet Center.<br><br>Default URL:<br><a href="http://www.minorplanetcenter.net/iau/Ephemerides/Bright/2011/Soft06Bright.txt">http://www.minorplanetcenter.net/iau/Ephemerides/Bright/2011/Soft06Bright.txt</a> |
| <b>Theater Screens (TheSkyX Theater Edition only)</b> |   |
| <b>Screen Number for Theater Controls</b>             | Enter the screen number of the multiple screen display that shows the Theater Edition control center.<br><br>The default value is <b>0</b> .  |
| <b>Screen Number for Theater Graphical Chart</b>      | Enter the screen number of the multiple screen display that shows the Theater Edition's Sky Chart.<br><br>The default value is <b>1</b> .   |
| <b>Satellite Tracking</b>                             |   |
| <b>Maximum Declination (Degrees)</b>                  | Enter the highest permissible declination to track a satellite. Tracking is stopped automatically when the declination of the satellite exceeds this value.<br><br>The default value is <b>85</b> degrees.<br>Maximum value = 0.<br>Minimum value = 90.   |

| Option  | Description  |
|---|--|
| <b>Lost Track Factor (of Track Box)</b>                               | <p>This value represents the maximum allowable average tracking error (as a percentage of the size of the current tracking box size) for the “state” of the mount to be considered “tracking”. When the average tracking error exceeds this value, tracking is automatically stopped.</p> <p>The default value is <b>9</b>.<br/>                     Maximum value = 0.<br/>                     Minimum value = 10.</p> |
| <b>Minimum Altitude (Degrees)</b>                                     | <p>Enter the lowest permissible altitude to track a satellite. Tracking will not begin until the altitude of the satellite reaches this value, likewise, tracking is stopped when the altitude of the satellite falls below this value.</p> <p>The default value is <b>5</b> degrees.<br/>                     Minimum value = 0.<br/>                     Maximum value = 89.</p>                                       |
| <b>Track Box Size (Arcminutes)</b>                                    | <p>Sets the size of the satellite track box, in arcminutes (page 392).</p>   |
| <b>Offset Bump Size (Arcseconds)</b>                                  | <p>Displays the amount of adjustment or “bump size”, in arcseconds, to move the telescope when the bump up, down, left, right buttons are clicked. This option is available in the Advanced Satellite Tracking Add On only.</p>  |
| <b>Camera (Camera Add On Only)</b>                                    |  |
| <b>Record Autoguider Graph History (Minutes)</b>                      | <p>Enter the number of minutes of historical autoguiding data to graph.</p>  |
| <b>Advanced Camera User Interface (Restart Required)</b>              | <p>Turn this checkbox on and restart <i>TheSkyX Professional Edition</i> to allow autoguiding with the imaging camera, and imaging with the autoguiding camera in the Camera Add On. This checkbox is turned off by default.</p>   |
| <b>Separate Interface for Autoguider’s Devices (Restart Required)</b> | <p>Turn this checkbox on and restart <i>TheSkyX Professional Edition</i> if the imaging system’s autoguider uses a different focuser, filter wheel, or rotator than the imaging detector so that each device can be operated independent of the imager’s hardware.</p>   |

| Option  | Description  |
|---|--|
| <b>Camera Warm Up/Cool Down Time Out (mins)</b>                     | Enter the number of minutes to allow the camera to cool to the temperature set point, or warm up, before issuing a communication time out error. |
| <b>Camera Connect Automatically Connects the Filter Wheel</b>       | When this checkbox is turned on, connecting to the camera automatically connects to the selected filter wheel.                                   |
| <b>Camera Connect Automatically Connects the Focuser</b>            | When this checkbox is turned on, connecting to the camera automatically connects to the selected focuser.  |
| <b>Camera Connect Automatically Connects the Rotator</b>            | When this checkbox is turned on, connecting to the camera automatically connects to the selected rotator.  |
| <b>Camera Disconnect Automatically Disconnects the Filter Wheel</b> | When this checkbox is turned on, disconnecting from the camera automatically disconnect the selected filter wheel.                               |
| <b>Camera Disconnect Automatically Disconnects the Focuser</b>      | When this checkbox is turned on, disconnecting from the camera automatically disconnect the selected focuser.                                    |
| <b>Camera Disconnect Automatically Disconnects the Rotator</b>      | When this checkbox is turned on, disconnecting from the camera automatically disconnect the selected rotator.                                    |
| <b>Mirror Cover Open/Close Timeout (secs)</b>                       | Enter the number of seconds to wait for the mirror covers to open or close before issuing a communication time out error.                        |
| <b>TCP Responses Close Socket</b>                                   | Turn this checkbox on to force the Camera Add On to close open sockets when a TCP response is received by the client.                            |

### All Sky Image Link Crop Settings

#### PROFESSIONAL

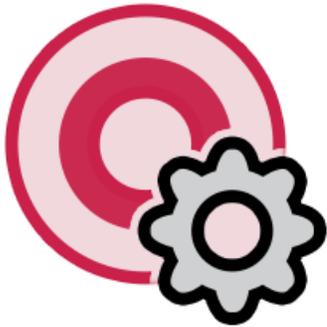
Large photos generally have a large number of stars (light sources) and require more CPU cycles to process, which slows the All Sky Image Link process. Rather than use the entire photo for an Image Link, cropping and using the central portion can significantly decrease All Sky Image Link solution times. Once an All Sky Image Link is located for the cropped region, the original photo can be restored and displayed on the Sky Chart.

| Option   | Description   |
|--|---|
| <p>The options below let you specify the height and width of the photo that will trigger this “behind the scenes” All Sky Image Link optimization process.</p> <p> Photos are cropped when the <b>Blind</b> All Sky Image Link option is selected (page 334). All other options use the photo’s full frame.</p> |   |
| <p><b>When the Height or Width of the Photo is Greater than (Pixels)</b></p>   | <p>Photographs that have a height or width greater than this value will be automatically cropped (by the amount specified immediately below) when performing All Sky Image Links.</p>   |
| <p><b>Use a Portion of the Photo by Cropping Dimensions (Percentage)</b></p>   | <p>Enter the size of the cropped photo, as a percentage of the original size, to use for the All Sky Image Link.</p> <p>For example, for a 2400 x 2400-pixel photo, entering 25 means that the height and width of the photo used as the source for the All Sky Image Link will be 600 x 600 pixels, and is cropped from the center of the original photo.</p> <div> <p>The diagram illustrates a large blue square representing the 'Original Photo' with dimensions of 2400 pixels by 2400 pixels. Centered within this square is a smaller white square representing the 'Cropped region' with dimensions of 600 pixels by 600 pixels. Dimension lines with arrows indicate the 2400 width and height for the original photo, and the 600 width and height for the cropped region.</p> </div> <p><b>Figure 103: The cropped region is 16 times smaller than the original photo.</b></p> |

## Customizing Chart Elements

There are over ninety different chart elements that can be displayed in the *TheSkyX*. The universe is made up of vast emptiness, punctuated by an infinite variety of objects with an infinite variety of form. From stars, nebulae, and galaxies, to ecliptic lines, coordinate grids, and reference lines, they are all here. What follows is an introduction to each chart element. To toggle any chart element on or off in the Sky Chart, simply check the box next to its name in the window.

### **Editing Chart Element Attributes**



Before we continue to discuss chart elements, it would be prudent to say a word about their customizability. The attributes of most Chart Elements are configurable, giving you the ultimate flexibility in customizing the Sky Chart.

Items such as the color, transparency and graphic used to display an object, the font style for chart labels, the thickness, color and type of reference lines are all editable.

Simply double-click on any object in the **Chart Elements** tab, and the **Edit Chart Element Attributes** window opens. Here, you can change fonts, line attributes, object fill color, and symbol options. Also, for objects that have them, you can adjust the **magnitude limits**, and **angular size limits** by selecting the appropriate tab in the same window. Experimentation is perhaps the best teacher when exploring the customizable item attributes for chart elements.



Not every attribute of every chart element is editable, as many are not applicable. Controls to select these attributes are disabled.

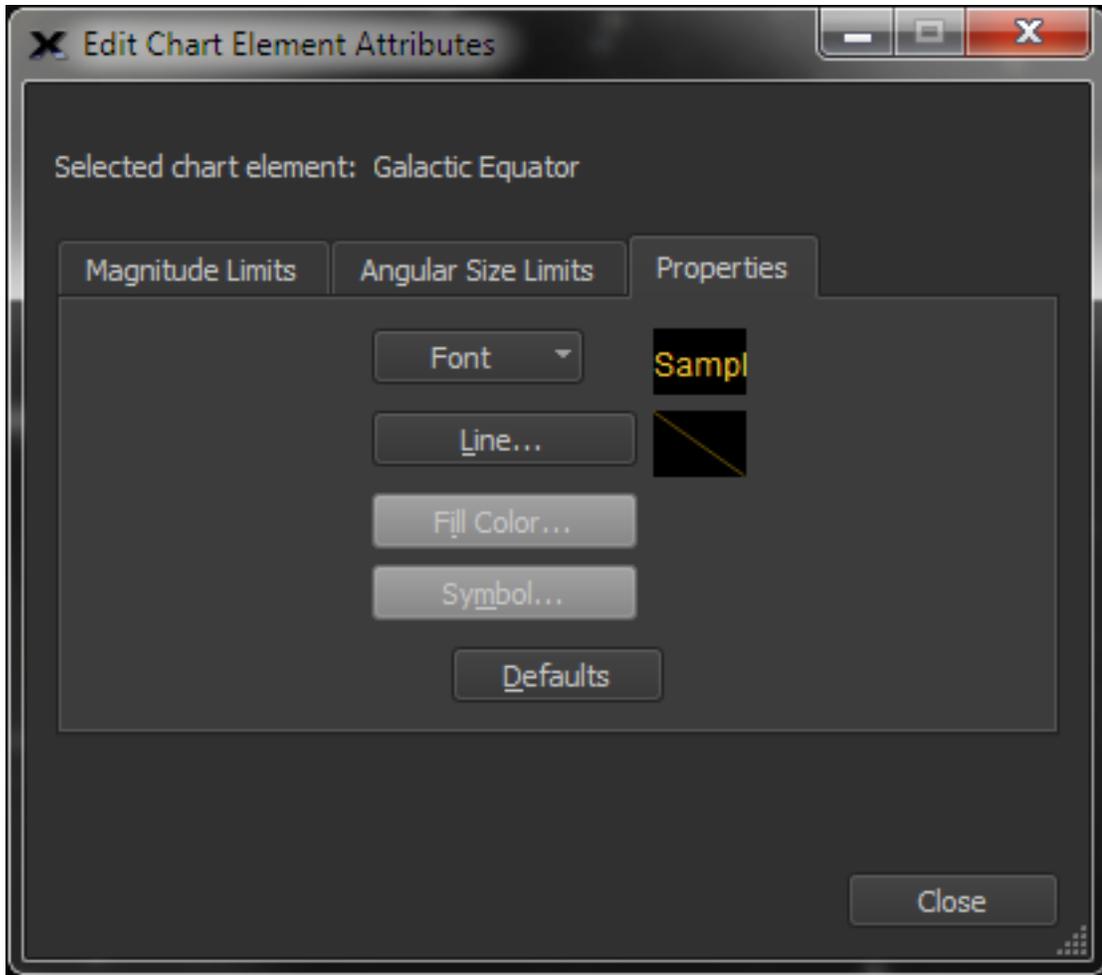


Figure 104: Properties tab on the Edit Chart Element Attributes for the Galactic Equator.

In Figure 104, the **Properties** tab for the **Galactic Equator** chart element is shown. Notice that the **Fill Color** and **Symbol** buttons are grayed because the galactic equator chart element is a line and therefore does not have an associated fill color or symbol.

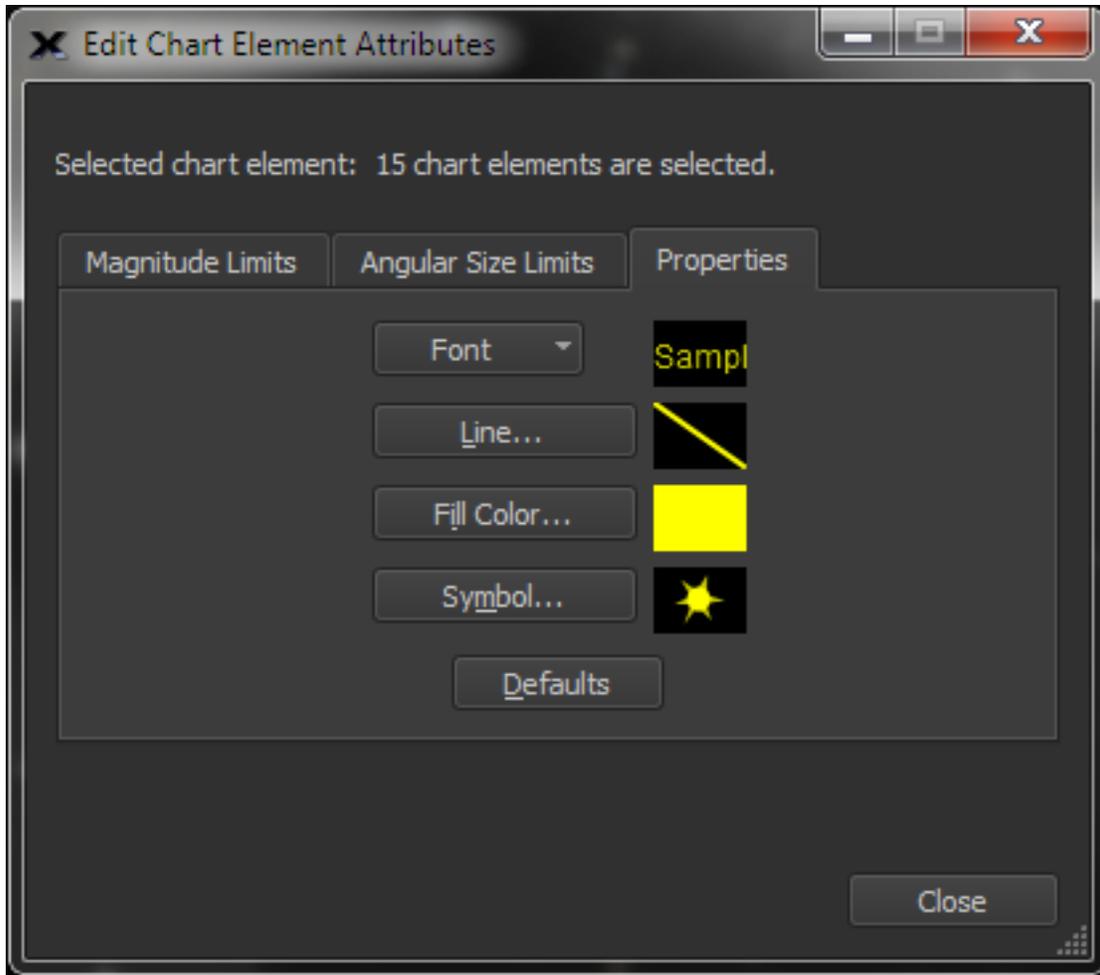


Figure 105: Properties tab on the Edit Chart Element Attributes when more than one element is highlighted.

The **Edit Chart Elements** window can be used to set the magnitude limits, angular size limits and properties of multiple object types, too. For example, on the Chart Elements window, highlight the **Galaxies** text under the **Non-Stellar Objects** node of the **Celestial Objects** group and then click the **Edit Attributes** button.

The **Selected Chart Element** text shows that seven different chart elements (that is, all the different classifications of galaxies) have been selected. Any attribute changes will now be applied to each object type.

As another example, you could limit magnitude of *every object on the Sky Chart* to only those between magnitude 8 and 10 by selecting the **Celestial Objects** group, then setting the **Hide Fainter Than** number input to 10 and the **Hide Brighter Than** to 8.

## Editing Attributes by Right Clicking

The attributes of a chart element can also be edited by right-clicking the mouse (⌘+click on the Mac) over the element on the Sky Chart, and then clicking the **Edit <Chart Element> Attributes** where <Chart Element> is the element beneath the cursor.

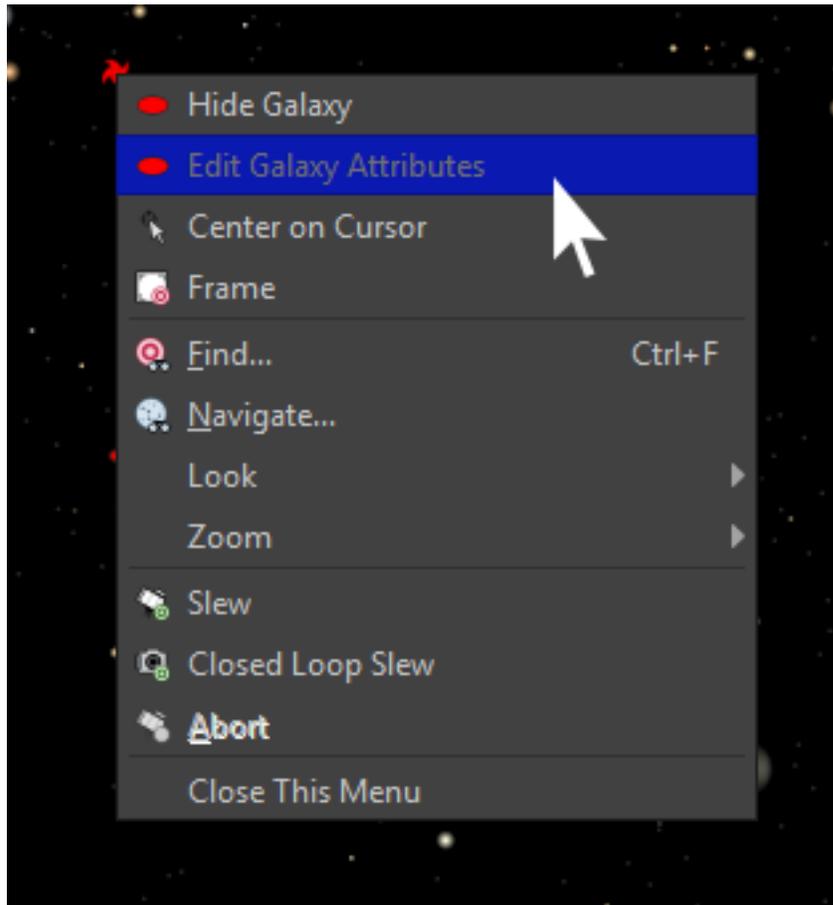


Figure 106: Right-clicking on a constellation line shows a context pop-up menu.

## Celestial Objects

Here, you will find all the real objects of the universe that are included in *TheSkyX's* database.

### Non-stellar Objects

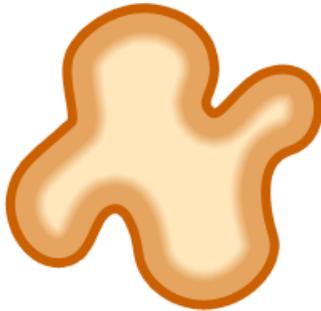
Celestial objects other than individual stars and the objects of our solar system, such as galaxies, nebulae, and star clusters, can be found under the heading **Non-Stellar Objects**.

### Galaxies

Galaxies, sometimes called “island universes,” are the largest building blocks of the observable universe. Galaxies are classified according to their shape. You can choose among galaxy types

that you wish to display in the Sky Chart. You can choose to show Type C, elliptical, lenticular, spiral, and irregular galaxies, as well as galaxy clusters. Under **Non-Stellar Objects > Galaxies**, the list of checkboxes will allow you to toggle on or off galaxies based upon their type. Notice that there are several different graphical points indicating galaxy type; these allow for quick identification in the Sky Chart.

## Nebulas



There are many kinds of clouds of gas and dust in the sky, such a cloud is known as a nebula. Each of the different kinds of nebulae can be selected for display in the Sky Chart.

### **Bright Nebula**

Bright nebulae are nebulae that emit or reflect light visible to the naked eye and appear as glowing clouds in the night sky. In some bright nebulae, called *emission nebulae*, the radiation from nearby stars ionizes the gas in these nebulae, and causes it to glow. A well-known emission nebula is the Orion Nebula in the sword of Orion, the Hunter. In still others, the light from stars bounces off dust particles in the nebula, thereby illuminating it; these nebulae as known as *reflection nebulae*. A famous reflection nebula is that around the Pleiades.

### **Dark Nebula**

Not all nebulae emit light. Sometimes they are dark and are only visible by being amongst or in front of regions of ionized gas (bright nebulae). A famous dark nebula is the Horsehead Nebula, also known as Barnard 33, in the constellation of Orion, the Hunter. A dark nebula is a region of cold, dense dust and gas. They are so dense as to block the light from background stars or from a nearby emission nebula. Star formation occurs within the dark nebulae, but such formation has not yet reached a level great enough for nebular ionization to occur. The Great Rift of the Milky Way is a dark nebula that is visible to the naked eye from a dark sky site.

### **Planetary Nebula**

Planetary nebulae are special kinds of nebulae occurring near a dying star or white dwarf. When stars about the eight times the mass of our Sun or smaller begin to decline, they swell and contract, throwing off the outer layers in the process, and eventually leaving a white dwarf at the center. The white dwarf's radiation causes the cloud of gas to glow. These objects are called

planetary nebulae because they looked like planets in the telescopes of astronomers during the 18<sup>th</sup> and 19<sup>th</sup> centuries. They do not have anything to do with the planets of our solar system, though. They are all quite far away. An interesting fact is that our Sun will end up as a planetary nebula in some 5 billion years from now.

## **Star Clusters**



Visible in the sky are several clusters of stars. These are stars which formed together in the same region of space at about the same time. Star Clusters come in two varieties, open and globular.

### ***Open Clusters***

An open star cluster is a group of a few hundred stars up to a few thousand stars. These stars all formed from the same nebula, or cloud of gas and dust. These stars still interact with each other gravitationally, albeit loosely. Some open clusters, such as the Pleiades, in Taurus, the Bull, are still surrounded by remnants of the cloud from which the component stars formed. Others, such as the Hyades, also in Taurus, do not reveal distinct nebulosity.

### ***Globular Clusters***

Globular clusters are ancient, high density clusters of stars existing beyond the plane of the Milky Way or other galaxies. They are so-called because they look like globes in the sky. Some people have described them as looking, in telescopes, very much like salt spilled onto a black table cloth. These clusters orbit the galactic core in the region beyond the disk, known as the halo. Globulars are composed of old stars, and are remarkably free of gas and dust, presumably because that material was long ago turned into stars. Some globulars are visible to the naked eye, such as Omega Centauri and M13 in Hercules, though M13 requires very dark skies and good vision.

### ***Cluster + Nebulosity***

Some clusters contain nebulosity, either reflection nebulae caused by light from the component stars bouncing off of dust and gas surrounding them, or emission nebulae, which glow due to ionization of the cloud by the component stars' radiation. Use this item to toggle such clusters on or off.

## Other Sources

### **Quasar**

Quasars, *quasi-stellar* radio sources, are among the oldest known objects in the universe. They are all very far away, lying hundreds of millions or even billions of light years away from Earth. The first quasars were discovered in the late 1950's by radio astronomers. For years, the debate raged as to their nature. Today, it is believed that they are supermassive black holes. Tremendous energy emits from such a black hole region rising from the tremendous turmoil of the material orbiting and flowing into the black hole, in what is known as the accretion disk. It is possible that such objects are the precursors to modern galaxies, and would therefore account for the presence of the supermassive black holes found at many galactic cores.

### **X-ray Source**

Many high-energy objects in the universe emit x-rays, such as stars, nebulae, and galaxies. Unusually strong x-ray emissions indicate a very high energy situation, such as a black hole's accretion disk. In fact, it was by observing strong x-ray sources, such as Cygnus X-1, that black holes were eventually brought from the realm of the theoretical to that of the real. Other powerful x-ray sources include quasars, certain double stars, such as those with a neutron star or white dwarf component, and some galaxy clusters.

### **Radio Source**

Some objects emit large quantities of radio waves, these are known as radio sources. *Pulsars* (short for pulsating star) are perhaps the most well-known examples of astronomical radio sources. Pulsars are rapidly rotating neutron stars with a beam of radio radiation that sweeps by Earth like the beam from a lighthouse. The result is a pulsing radio signal detectable in radio telescopes. The first pulsar was discovered by Jocelyn Bell and Antony Hewish in 1967.

Radio astronomy is a complete subfield of astronomy that has its roots in the 1930s, when the radio emissions of the Milky Way were first discovered. Radio astronomy really took off after World War II. In the 1950s, Cambridge's Ryle and Hewish created important radio maps of the sky. Other milestones occurred in the 1960s with the research of Frank Drake at Green Bank, West Virginia, and the ground-breaking discovery of the cosmic microwave background by Penzias and Wilson in New Jersey.

### **NGC Probable Star**

These are objects that are listed in the New General Catalogue (NGC) as being probable stellar objects. Probable objects are those predicted mathematically or through a combination of mathematics and observations.

### **Other NGC**

*NGC* stands for *New General Catalogue*, a catalog of astronomical objects most notable for its size and the fact that it includes all types of deep-sky objects. It was first compiled in the 1880s on commission of the Royal Astronomical Society by J.L.E. Dreyer, using William and John

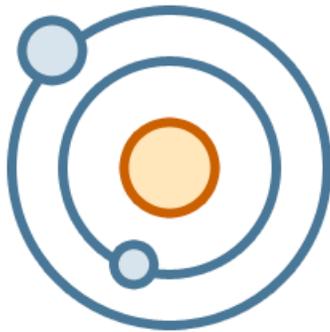
Herschel's observations. Since then, it has continued to grow in size and has been thoroughly revised twice.

Turn the **Other NGC** checkbox on or off to toggle those objects belonging to the NGC and not specifically to any other object group.

### **Mixed Deep Sky**

To toggle those objects that do not fall into any other category of non-stellar object, choose the **Mixed Deep Sky** checkbox. *TheSkyX* classifies objects in the famous Messier catalog as a mixed-deep sky.

## **Solar System Objects**



The many objects of our solar system are discreetly displayable in *TheSkyX*. Choosing which to show in the Sky Chart is as simple as clicking a checkbox.

### **Moon, Sun, Planets**

Here, you will be able to toggle the Moon and the eight classical planets, (including Earth), a host of small solar system bodies (comets, asteroids), satellites, and the Sun. You will notice that each of the naked eye planets, plus the Moon and Sun, each has a unique graphic point style to instantly distinguish them in the sky chart.

Here, you can select from any of the solar system objects. By clicking the tree arrow next to **Solar System Objects**, you will see that you can choose among the Moon, the eight classical planets, small solar system objects (you'll find Pluto here), satellites, and the Sun.

## Small Solar System Bodies



Under **Small Solar System Bodies**, you will find a button with the same label. Clicking this button (or, clicking the **Small Solar System Bodies** command from the **Input** menu) will open a window allowing you to import small solar system bodies, such as comets and asteroids, into *TheSkyX* by using either an existing file, or by downloading orbital data from the internet.

### Comets

Getting comet data imported into *TheSkyX*, follow these four, simple steps.

1. With the Solar System window open, click **Input > Small Solar System Bodies**. A new window appears with three tabs at the top, **Comets**, **Asteroids (Small Database)**, and **Asteroids (Large Database)**. Select the **Comets** tab.
2. A window opens labeled **Comets Available for Display**. Here, you will see the total number of comets available for display, as well as a list of their names with check-boxes. It is with these check-boxes that you can toggle comets on or off in the Sky Chart or in the solar system simulator.
3. You have three options for importing comet data into *TheSkyX*. You can import them from an existing file, or you may download comet data directly in *TheSkyX* using internet databases. You may download individual comet data by name, or you can download all the data for all observable comets at once. For our example, let's download all observable comets at once. To do this, simply click **Observable**.
4. The data will then download, and the observable comets will now appear in the list above, on the Sky Chart, and in the solar system simulator.

Note: Be sure that your computer is connected to an active internet connection when attempting to download comet data.

### Asteroids

The process is very similar as comet data when downloading asteroid data from the **Asteroids (Small Database)** tab. There, you can choose to import asteroid data from an existing file, by orbital characteristic, such as distant, critical, or unusual, or you may import by asteroid name.

Should you decide to import asteroids from the **Asteroids (Large Database)** tab, you will have to visit one of the websites provided and download a file with the desired data. You can then select the file with the **Choose** button to reveal the asteroids in the Sky Chart and solar system simulator. Additionally, the check-boxes you see under the **Asteroids (Large Database)** tab toggle important display options such as computing asteroid positions at start-up and 24-hour object paths for imported asteroids.

### ***Small Database vs. Large Database Asteroids***

There are *lots* of asteroids out there; to date, about 750,000, and counting.

The sheer number of them presents problems for charting programs. If you want to show them all, there's no easy way to continually update their positions without *really* slowing down the computer. And, if you want to show the path of *one asteroid*, "wading through" them all to find the one you want can be difficult.

For optimal functionality, *TheSkyX* breaks asteroids into separate databases, *Small* and *Large*.

### ***Small Database Asteroids***

- Limited to 1000 total on Sky Chart.
- Can be imported by name, orbital characteristic, a text file or by entering the individual orbital elements.
- Can create Object Paths (page 129) for any or all of them.
- Sky Chart coordinates are updated continually.

### ***Large Database Asteroids***

- A virtually unlimited number can be shown on the Sky Chart.
- Can be imported from standard IAU text files.
- Cannot create Object Paths (page 129).
- Can show the 24-hour path vector.

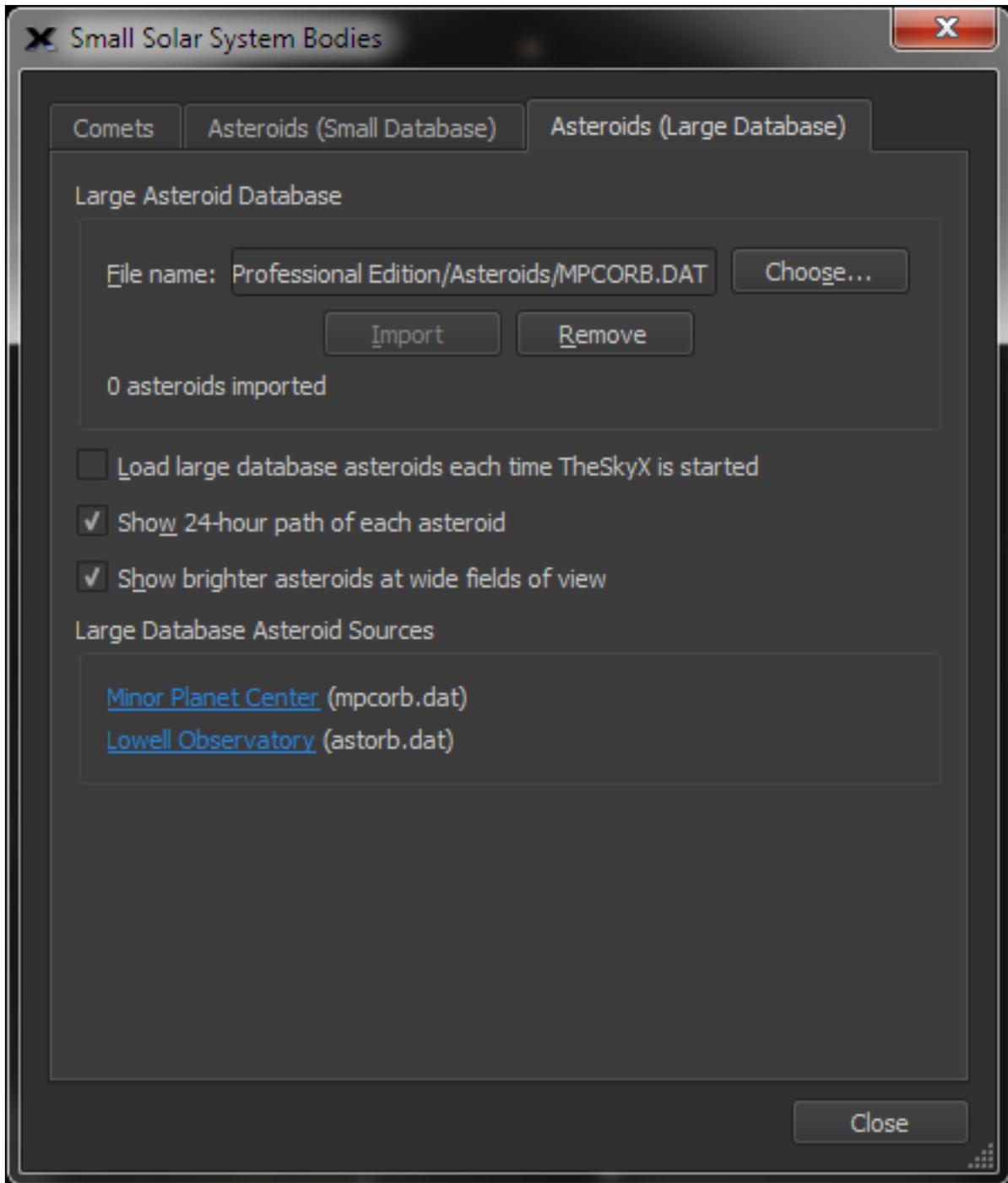


Figure 107: The *Asteroids (Large Database)* pane on the Small Solar System Bodies window.

### **Large Database Asteroid Controls**

The Minor Planet Center and the Lowell Observatory each maintain comprehensive asteroid databases, and both can be imported directly into *TheSkyX*. Web-based links to these web sites are located at the bottom of the ***Asteroids (Large Databases)*** pane, click on the desired asteroid

database, either mpcord.dat or astorb.dat to download it to your computer, then let *TheSkyX* where to find this file.

### ***Choose Button***

Click the ***Choose*** button to display the ***Open Large Database Asteroid*** window, then navigate to the folder that holds the asteroid database. From there, select the database file name, and click the ***Open*** button.

### ***File Name***

The name of the selected asteroid database is displayed in this text box.

### ***Load Large Database Asteroids Each Time TheSkyX is Started***

When this checkbox is on, large database asteroids are automatically loaded each time *TheSkyX* is started. There are over 730,000 known asteroids; importing them all can take a minute or so.

### ***Show 24-Hour Path of each Asteroid***

When this checkbox is on, each asteroid on the Sky Chart shows an arrow that indicates the direction, and length of the asteroid's path for the next 24 hours.

### ***Show Brighter Asteroids at Wide Fields of View***

By default, large database asteroids are shown on the Sky Chart when the field of view is 60 degrees or less. When this checkbox is on, the brighter (lower magnitude) asteroids are shown at fields of view greater than 60 degrees.

When you click on an asteroid to identify it, its elements are numerically integrated to update them to the current equinox. The coordinates in the Object Information report are computed to an accuracy of  $\pm 1$  arcsecond.

### ***Asteroid Paths***

The position and 24-hour path of any asteroid, over any time period, and for any number of selected small database asteroids, or for all asteroids.

#### ***To View a 24-hour path for all Large Database Asteroids***

1. Click the ***Small Solar System Bodies*** command on the ***Input*** menu.
2. Click the ***Asteroids (Large Database)*** tab.
3. Turn on the ***Draw a line for each asteroid showing its path for the next 24 hours*** checkbox.

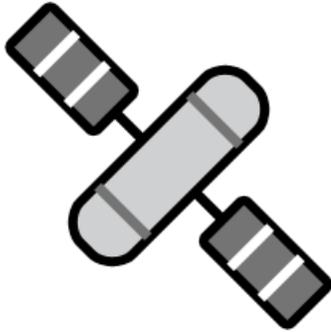
#### ***To Create the 24-hour path for a Small Database Asteroid***

1. Click ***Input > Small Solar System Bodies***.
2. Click the ***Asteroids (Small Database)*** tab.
3. Load the desired asteroids and click ***Close***.
4. Click ***Tools > Object Paths***.

5. Select the asteroids in the **Asteroids** list.
6. On the **Create Paths** tab, enter **1 hour** (or any other increment).
7. On the **Count** text box, enter **24 hours** or any other number of increments.
8. Click the **Create Path** button.

A path for the selected asteroids for the select time increment is drawn on the Sky Chart.

## Satellites



Artificial satellites can be viewed on the Sky Chart as they appear from your backyard, or from a position above Earth.

From the **Chart Elements** window, click the **Satellites** button, or select the **Satellites** command from the **Input** menu, to open the **Satellites** window. In this window, you can import satellite or Iridium flare data from an existing file or from the internet. Checkboxes allow you to toggle the satellites and orbital paths in the Sky Chart. The **Brightness** slider allows you to control the brightness of satellites, making them easier to spot against a starry background.

### **Viewing Satellites and their Orbits**

To observe satellite orbits, select **Tools > Satellites from Above Earth**. If this is your first time using the satellites tool, there will not be any satellites listed, and you will have to download some satellite two-line elements (TLEs) before any satellite data can be shown. You can think of a TLE as a set of numbers that describes a satellite's orbit.

To obtain TLE data, click the **Satellites** button, or select **Satellites** from the **Input** menu. The **Satellites** window appears. From here, you can choose to import satellite data from the web or an existing file. Later, you can also choose to clear all satellite data by clicking **Remove All**.

Note: Ensure that TheSkyX's date is set to within 45 days of the current date to avoid date rejection when downloading satellite for import.

Let's start by downloading some satellite TLEs from the web. To do this, click the **Import From Web...** button. You can then choose the satellite category or categories you wish to download

from the internet database, Celestrak. After you have selected the desired satellite categories, click **Download**.

Return to the **Satellites From Above Earth** window, and you will see the satellites plotted as points around the Earth globe. Also, note that the satellites are also viewable in the Sky Chart.

On the **Satellites From Above Earth** window, a list featuring your newly downloaded satellites appears on the left. By selecting a satellite(s) from this list and by clicking **Show Selected Orbits**. The satellite orbits will appear in the viewer. Sliding the **Viewing Distance** slider will change the view from a distance of 1 Earth radius up to 50 Earth radii. If your mouse is equipped with a scroll wheel, you can use it to adjust the viewing distance, too. If need be, the lower right corner of the window can be dragged to resize it.

By clicking **Update Chart**, the Sky Chart is updated to show the recent satellite data from a ground-based perspective. Now you will be able to amaze your friends and neighbors with your uncanny ability to “predict” satellite appearances in the heavens!

### **Viewing Iridium Flares**

Some satellites become incredibly bright for short periods of time. This phenomenon is due to the fact that their orbit brings them into precise alignment as to reflect a large quantity of sunlight down to Earth in a precise location. This is most commonly observed with the Iridium communication satellites, and is therefore referred to as an Iridium Flare.

*TheSkyX* can predict and display Iridium Flares using the satellite function.

1. Select **Input > Satellites**, or, if the **Satellites from Above Earth** window is open, click the **Satellites** button.
2. Choose the **Iridium Flares** tab.
3. You can search for all flares, or limit your search to just daytime, nighttime, or dawn/dusk flares. For this example, choose **All flares**.
4. Leave the next few menus at their default settings.
5. Click **Find Flares**, and *TheSkyX* will connect to an internet database to retrieve Iridium Flare data. Be sure that your computer is connected to the internet for this.
6. Once the upcoming flares appear in the list, click the **Watch Flare** button, and the flare will appear in the Sky Chart, along with a pointer directing you to the flare’s position.

Now you know just where to look when it’s time for the next Iridium Flare.

The **Satellites** window also features a button labeled **Satellites From Above Earth**, clicking this button opens the tool of the same name. For more on using viewing satellites, please see the section **Satellites From Above Earth**.

## Stellar Objects

From the **Chart Elements** window, under the **Stellar Objects** heading, you will see the stellar objects displayable by *TheSkyX*; stars, double stars, suspected variables, supernovae, and variable stars. Any of these are selectable via the checkboxes.

## Stars

Immense luminous spheres occurring in the night sky, stars make up the better part of the mass of the universe observable to the naked eye. They generate their light from nuclear reactions in their cores. These nuclear reactions fuse hydrogen and helium to form elements up to atomic number 26: iron. Stars occur in a variety of sizes and colors. The color of a star is due to its temperature; red stars are relatively much cooler blue stars. Our Sun is a middle-sized star. The sizes of star points in the Sky Chart does not reflect actual size, but is an expression of relative apparent brightness, with larger points representing stars of greater apparent brightness.

### Star Options



You will also see a button labeled **Star Options**. Clicking this button opens a useful window that contains controls allowing you to adjust the **Appearance** of stars as well as options for their **Proper Motion**. Tabs at the top of this window allow you to select between the two.

Clicking the **Appearance Tab** brings up several sliders. The **Fainter/Brighter** slider adjusts the apparent brightness of the stars in the Sky Chart. The **Contrast** slider adjusts the contrast of the Sky Chart image. Less contrast can be useful those learning to identify constellations. The **More Fuzzy/More Solid** slider lets you change the star points from fuzzy, nebulous orbs, to solid balls, and many points in between. You can adjust the number of stars appearing in the Sky Chart by using the **Less/More Stars** slider. Additionally, the halos seen around the star points can be controlled by the **No/Bright Halos** slider.

### Star Color

Star color can be adjusted here in terms of the saturation of the spectral color of stars. Also, the stars may be colored according to the selected 'Star' attribute color via a checkbox.

If you would like the stars to appear red in **Night Vision Mode**, check the checkbox labeled **Red in Night Vision Mode**.

### **Map Like vs. Photo Like Display**

You may also choose between a Map Like chart, where the Sky Chart appears like a traditional printed chart, or a Photo Like chart, where the Sky Chart appears as photo-realistic view of the sky, by choosing the radio button at the bottom of the window.

### **Proper Motion**

TheSkyX continually calculates stars' proper motion, that is their *actual* motion in the heavens, not just the rising and setting, called *apparent motion*. To access the proper motion options from the **Star Options** window, click the **Proper Motion** tab. From here, you can turn off proper motion at any time by un-checking **Compute Proper Motion**. You can also choose to **Show Proper Motion Vectors** by checking the box labeled as such. Using the field labeled **Proper motion vector length**, you can enter a value between 0 and 99 years.

## **Suspected Variable**

Many stars in the heavens are not steady in their energy output. Such stars are known as *variable stars*. There are many different types of variable star. (Please see **Variable Stars** for more information.) Choose **Suspected Variable** to toggle on or off those stars which appear, based upon best observations, to exhibit variable star tendencies, but are not yet confirmed.

## **Supernova**

Perhaps the most energetic single event in the cosmos, the supernova is a relentless stellar explosion, whose effects are felt across vast expanses of space and time. There are a few different types of supernovae, all with the same effect: an exploded star. These events release incredible amounts of energy, much more than the Sun will release over its entire lifetime! In addition to an enormous emission of light, there is also a shock wave emanating from the star. Material in this shock wave reaches incredible speed, and matter is slammed together hard enough for it to fuse into heavier elements and to emit light. It is this fusion that is thought by some scientists to produce all elements heavier than iron in the Universe.

## Variable Star



A variable star is a star whose energy output is not constant, but varies in a regular pattern. Some variable stars are useful in determining cosmic distances. There are many different types of variables, but two main types of variable star, eclipsing binaries and Cepheids, make up most variables in the night sky.

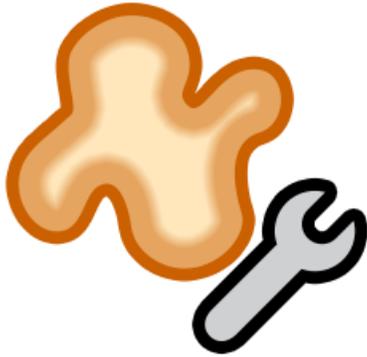
An eclipsing binary is a binary star with two component stars of unequal brightness. When the brighter one is in “front” as viewed from Earth, the star appears to be brighter, and it appears dimmer when the dimmer one is in “front.” A notable eclipsing binary is Algol in the constellation of Perseus.

A Cepheid variable is a star whose energy output varies because the star swells and shrinks at regular intervals. It is believed that these stars do this because of their internal structure and rotation causing a harmonic resonance. The prototype Cepheid variable is  $\delta$  (delta) Cephei. Cepheids are useful because they can be used to determine distances. Their variation periods are directly related to their brightness. Using this information, an observed Cepheid’s apparent brightness can be compared with its brightness as determined by observing its period to calculate its distance. An historic use of this principle was when Edwin Hubble proved that the spiral nebulae were distant, separate galaxies in 1922 by observing Cepheid variables within them.

## Non-Stellar Objects

Just as with stars, *TheSkyX* offers several options for displaying non-stellar objects. Select **Display > Non-Stellar object options** to bring up the **Non-Stellar Object Options** window. You can also access this window from the **Chart Elements** tab, under **Non-Stellar Objects**.

## Non-Stellar Object Options



Many of these options are designed to reduce computer resources while rendering the Sky Chart. Others are designed to reduce the number of non-stellar objects rendered to help you to hone in on just the objects you wish to observe.

### ***Non-Stellar Object Density***

The top two sliders are used to adjust the non-stellar object density in fields of view greater than 60° (top slider) and less than 60° (bottom slider). Simply click and drag the slider to the left or right for less or greater object density.

You can also choose to plot objects whose entries overlap in various catalogs, such as NGC, IC, and PGC. Turn on the ***Plot overlapping catalog entries*** checkbox to use the option.

TheSkyX plots small galaxies as either filled ellipses or as a galaxy symbol. If you prefer a symbol, select the ***Plot small galaxies as a “galaxy symbol…”*** checkbox. For more on galaxy symbols, see the ***Galaxies*** section in the ***Chart Elements*** tab.

### ***Non-Stellar Object Drawings***

The style and appearance of non-stellar object drawings can be set with the drop-down and slider here. Choose either ***Filled*** or ***Hollow*** from the drop-down menu to set the non-stellar object drawing style. The slider below the drop-down menu morphs the drawings between ***More fuzzy*** and ***More solid*** appearance.

### ***In Place Photos***

TheSkyX can show NGC, IC, and PGC non-stellar objects as in place photos from the Digitized Sky Survey. It can also clip the photos to the catalogued shape of the object, if you so choose. Select the appropriate checkboxes in this section to turn on these options.

You can also set the ***Default frame size when object size is unknown*** with this section’s value field. The default setting is 10.00 arc-minutes, but you can change that value to suit your needs by using the up/down arrows or by directly entering a value in the field.

### **Solar System Options**

If you want the Sun and Moon to appear as **transparent ellipses**, select the first checkbox in this section.

You can also choose to **Show Earth's shadow** by selecting this checkbox.

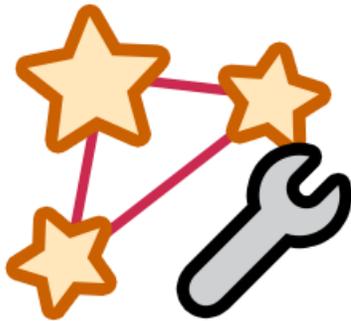
To exaggerate the angular size of the Sun and Moon in fields of view 90° and wider, set the desired value in the bottom-most field in the Non-Stellar Object Options window. You can choose values between 1.0 and 10.0 times.

When you are satisfied with the non-stellar object options settings, click **Close** to return to the Sky Chart.

### **Reference Lines and Photos**

The Sky Chart can optionally show reference lines that reveal celestial coordinates, the meridian, ecliptic, galactic equator and others to help you find your way.

### **Constellation and Asterism Options**



Click the **Constellation & Asterism Options** button (or the **Constellation & Asterism Options** command from the **Display** menu) to configure items such as asterisms, constellation drawings, constellation boundaries, constellation figures and constellation labels.

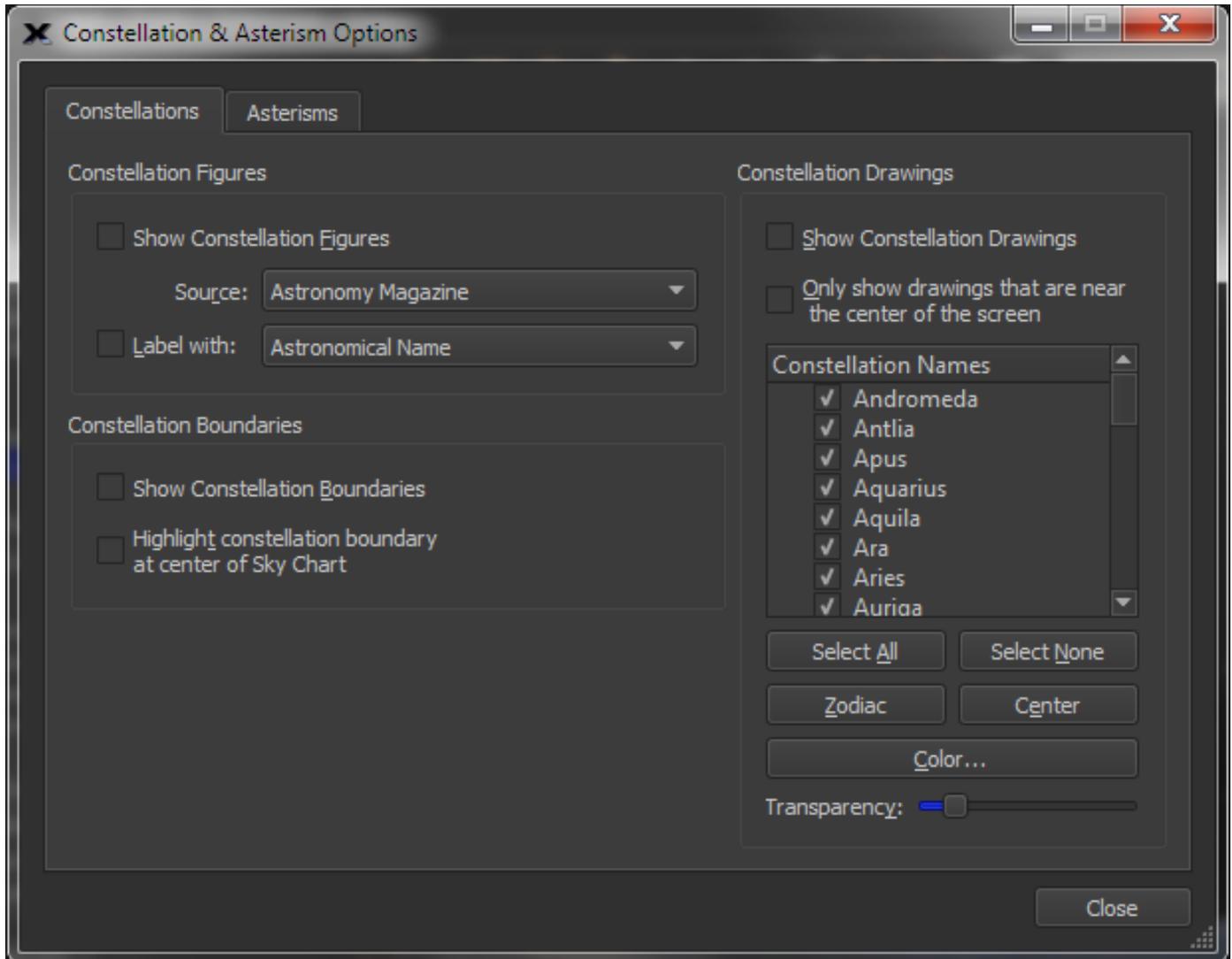


Figure 108: The Constellation & Asterism Options window.

Each of the above items can be toggled, and there are several options available to you by clicking **Constellation & Asterism Options**. Doing so opens a window of the same name. Two tabs, labeled **Constellations** and **Asterisms** appear at the top. Under the **Constellations** tab, note that there are sections each for constellation figures, boundaries, and drawings, with many customizable options for each.

## Asterisms

Click the **Asterisms** tab, and you will see a list of available asterisms, along with a checkbox enabling asterism labels to be shown in the Sky Chart. To show an asterism, locate it in the list and ensure that it is checked. The chosen asterism will then appear in the Sky Chart.

Also, you can choose all asterisms at once by clicking the **Show All** button, or no asterisms by clicking the **Show None** button.

Highlighting an asterism from the list and clicking the **Center** button is a handy way to locate and learn asterisms; they will be centered in the Sky Chart once the button is clicked. *TheSkyX* probably contains more asterisms than you have come across before, so spend some time and have some fun discovering new ones.

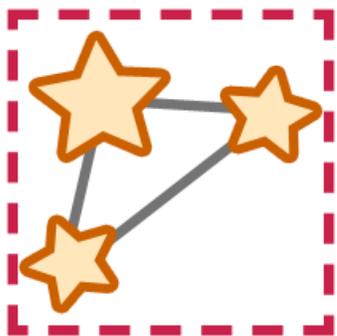
## Constellation Drawings

To display beautiful constellation drawings from Johannes Bayer's *Uranometria*, check the box labeled **Show Constellation Drawings**. Additionally, if you would like to see only the drawings for constellations currently at the center of the screen, click the **Only show constellations that are near the center of the screen**.

Below that is a list of the 88 constellations with checkboxes, along with buttons for selecting **All**, **None**, the **Zodiac** constellations, and those constellations at the **Center** of the screen. You can select exactly which constellations appear by utilizing the corresponding checkbox (check **Andromeda** to display the Andromeda drawing).

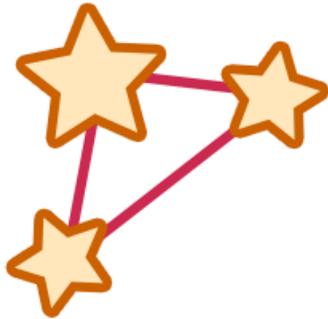
Click the button with the color above the **Transparency** slider to change the color of the constellation drawing overlay. You can pick from a list of colors, or you can choose your own color from the color wheel by clicking the color square in the lower right (the one with the three black dots). The transparency of the constellation drawing overlay is controlled by the **Transparency** slider: move it to the right for increased transparency, and left for increased opacity.

## Constellation Boundaries



Astronomers use the constellations to map out the sky. But, instead of using just the drawings themselves, astronomers have laid out the entire sky in 88 sections, each attributed to a constellation found within that section. To view these sections, or constellation boundaries, check **Show Constellation Boundaries**. If you would like to highlight the central constellation region in the Sky Chart, simply click **Highlight constellation boundary at center of Sky Chart**.

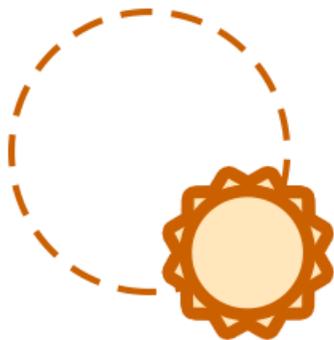
## Constellation Figures



Click the **Show Constellation Figures** checkbox: dot-to-dot figures appear in the Sky Chart. Today, there are a number of conventions for drawing the constellation figures, such as those from *Astronomy* and *Sky & Telescope* magazines, as well as those from H.A. Rey, and *TheSkyX*'s own. Choosing between the many styles is as easy as using the pop-up menu.

You can also choose to label the constellations, and you can customize that label among many options. This is especially useful, as there is much confusion about constellation pronunciation, especially the genitive forms, such as Cephei or Aurigae. Checking the box labeled **Label with:** brings up the labels, and the pop-up menu lets you pick from a number of label options, including pronunciation for the constellation name and the genitive forms (used for describing objects that “belong” to a constellation, such as the star Epsilon Eridani).

## Ecliptic

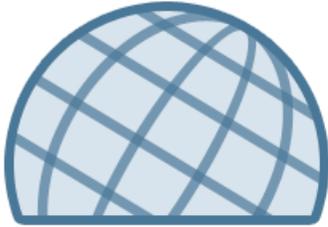


The ecliptic is the apparent path of the Sun through the sky throughout the year. This path also represents the general plane of the solar system, and it is because of this that the Moon and the planets can be found on or very near this line in the sky. That is a handy fact, as it greatly limits the possible areas for planets to appear, therefore making them more easily found.

To turn the ecliptic line on in *TheSkyX*, click the **Ecliptic** checkbox in the Chart Elements window. Likewise, the ecliptic can be turned off by clicking the **Ecliptic** checkbox again. The ecliptic, like

most chart elements, is customizable by double-clicking on **Ecliptic** in the chart elements window, or by right-clicking on the ecliptic in the Sky Chart.

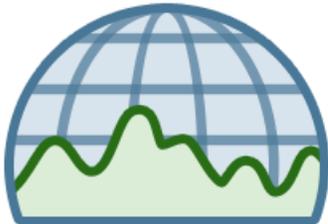
## Equatorial Grid



An equatorial grid can be plotted onto the Sky Chart by turning on the **Equatorial Grid** checkbox. This spherical grid is based upon Earth's equator projected into space, or the *celestial equator*. The grid also displays coordinates of right ascension and declination overlaid onto the Sky Chart.

The grid's attributes are fully customizable (see "Customizing Chart Elements" on page 236).

## Horizon Grid



A grid that is based on the local theoretical horizon can be shown by turning on **Horizon Grid** checkbox. This grid displays coordinates of azimuth and altitude overlaid onto the Sky Chart.

The grid's attributes are fully customizable (see "Customizing Chart Elements" on page 236).

## Horizon

Turning on the **Show Horizon** checkbox displays a photograph or shaded region that represents the *local horizon*. The default local horizon is drawn as a featureless line at 0° altitude. You can redefine the line so it represents the horizon at your viewing site (see "Horizon and Atmosphere"

on page 259). Adding natural objects and obstructions to the horizon gives a better idea of what is and isn't visible, and the approximate times at which objects rise or set.

## Horizon and Atmosphere Options



To best approximate your observing site, *TheSkyX* allows you to show custom horizons and simulate atmospheric conditions including showing clouds, the Sun and Moon's glow and displaying simulated meteor showers.

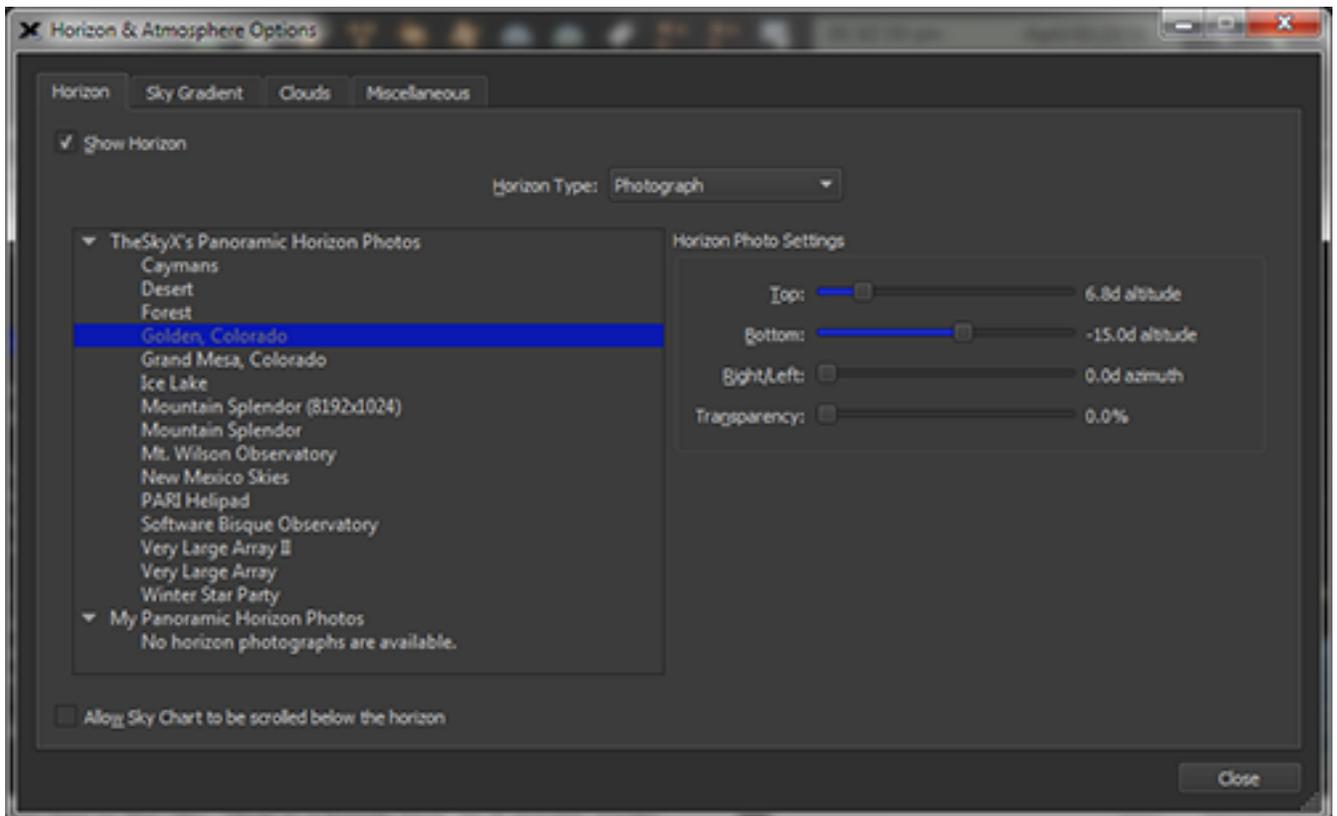


Figure 109: The Horizon tab on the Horizon and Atmosphere Options window.

### **Horizon and Atmosphere Options**

Under this section, you can choose to display the horizon as a panoramic photograph or a custom drawn horizon, as well as show clouds, meteor radiants and other options.

In the Horizon & Atmosphere Options window, you will notice four tabs at the top: Horizon, Sky Gradient, Clouds, and Miscellaneous.

Under the **Horizon** tab, you can toggle the horizon and change it to one of several available virtual observing spots by choosing from the list at the left.

Using the sliders on the right, under **Horizon Photo Position**, you can fine-tune the positioning of the horizon photos to best simulate each observing location. You can also adjust the transparency of the horizon photo.

If you would like to be able to scroll the sky chart below the horizon, click the **Allow Sky Chart to be scrolled below the local horizon** checkbox.

### **Custom Drawn Horizons**

Near the center of the **Horizon & Atmosphere** window is a pop-up menu labeled **Horizon Type**. This is set to **Photograph** by default, but by changing it to **Custom Drawn**, you can use the mouse to draw a horizon outline that is based on your observing location.

Left to right on the gray-blue-black shaded graphic represents the azimuth of your location. Due north, or zero degrees azimuth is on the left, azimuth increases to the right through east (90°), south (180°), west (270°) and then back to north. The vertical axis represents the altitude of the local horizon, starting at zero degrees or horizontal on the bottom, increasing up to 90 degrees, or “straight up” at the top of the graphic. Note that the default size of the **Horizon & Atmosphere Options** window shows the sky up to 60 degrees altitude or so. If you need to draw portions of your local horizon higher than this, just make the window larger so that the graphic shows the entire region above the horizon.

Click and drag in the blue shaded region along the correct coordinates to draw the custom horizon mask.

Click the **Apply** button to update the Sky Chart’s horizon. This also saves the custom horizon to the Application Support Files folder as an ASCII text file named `Custom Horizon.hrz`. This text file has the following format:

```
360
 5.88
 5.75
 5.62
 5.17
 4.40
 4.14
```

3.88  
3.43  
3.05  
2.47  
.  
.  
.  
4.72  
4.40  
4.14  
4.34  
4.59  
5.56

The number 360 appears in the first line, and represents the number of entries in the horizon text file, one line for each degree of azimuth. Each subsequent line contains four spaces, followed by a number that is the altitude of the horizon line at that azimuth. In the example above, the first line represents 5.88 degrees altitude at 1 degree of azimuth (through east), 5.75 degrees altitude at 2 degrees azimuth, and so on to the end of the file.

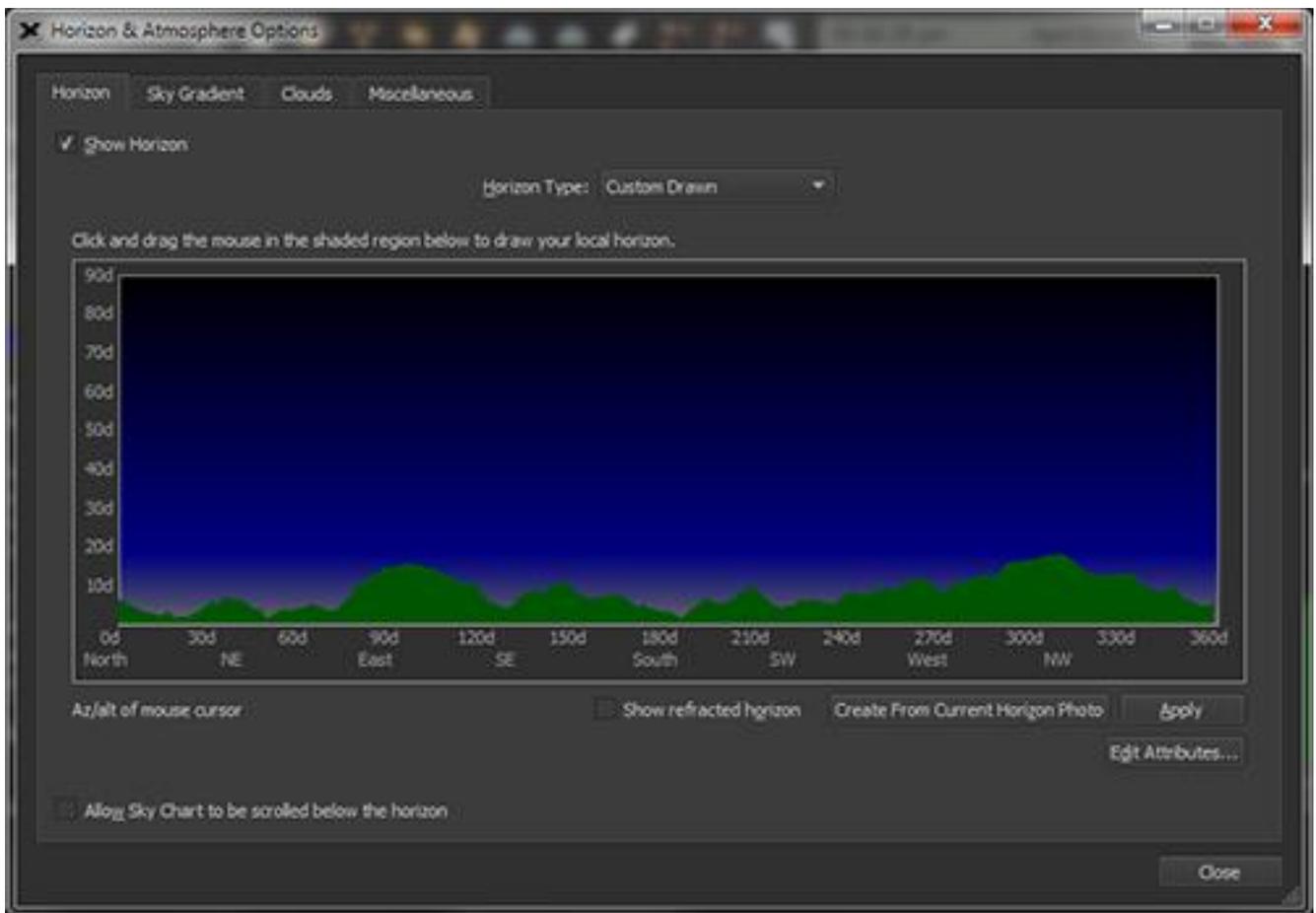


Figure 110: The Custom Drawn horizon options window.

Turning on the **Show Refracted Horizon** checkbox will draw a line on the refracted sky that corresponds to the observer's horizontal. Near the horizon, the atmosphere refracts (bends) the light so much that objects below the "physical" horizon are visible.

Clicking the **Create From Current Horizon Photo** button generates a horizon mask based upon the photo selected when the **Photograph** horizon type is selected. Once you are satisfied with your custom drawn horizon mask, click **Apply**.

Click the **Edit Attributes** button to configure:

- the custom horizon fill color
- the transparency (Windows) or opacity (Mac) of the horizon fill color
- the style and color of the line that is drawn on the horizon's boundary
- the font used to show the N, S, E, W and related directions text

See "Customizing Chart Elements" on page 236 for more information about changing the attributes of chart elements.

### ***Creating and Using Your Own Panoramic Horizon***

If you own a digital camera and popular image processing software, you can create your own horizon panorama by stitching together a sequence of photos that spans 360 degrees. Once this photo is created, copy it to the **Horizons** Application Support folder (see "Application Support Files" on page 26 for more information). It will automatically appear under the **My Panoramic Horizon Photos** node in the Photos tree.

### ***Collecting the Photos***

If you wish to create a panoramic horizon, the following hardware and software is *recommended*:

- A digital camera
- A tripod
- Panorama or "stitching" software that supports the PNG file format (PhotoShop Elements™, PhotoShop CS4™ or The Panorama Factory™, or Microsoft's Image Composite Editor, for example).
- Image processing software to make the "sky" portion of the photo transparent (PhotoShop Elements™ or PhotoShop CS4™, for example).

### ***Photo Taking Tips***

- Early morning, late evening, or an overcast day works best for even light distribution.
- Use the widest field settings for your camera or telephoto lens. Don't zoom or magnify the photo.
- If you use a tripod, make sure it is level so that the "ends" of the panorama match. Modern stitching software can account for errors here.

- For best results, expert photographers recommend using up to a *fifty to eighty percent overlap* for adjacent photos.



**Figure 111: Panorama before transparency is added.**



**Figure 112: Panorama after the transparent sky layer is added.**

### ***Tips for Creating Panorama Photos***

- Both the *width* and the *height* of the panorama must be a multiple of 512 pixels. If the width is not a multiple of 512 pixels, a portion of the photograph may be truncated or missing when it is displayed on the Sky Chart. The supplied panoramic photos are 4096 x 512 pixels or 8192 x 512 pixels, for example.
- The photo must be 4 channel RGB (8 bits per channel) format.
- Use your favorite stitching software to combine the individual images. Search the web for a list of software that can perform this operation. [The Panorama Factory](#) software works well.
- After stitching the adjacent photos together, the panorama must have a transparent region that identifies the “sky”. Use your favorite image processing software to create an “alpha channel” or “transparency” layer to define a mask of the transparent regions, and then save this as a PNG photo. Your image processing software should have detailed information about how to accomplish this.
- Larger images consume more computer *and* video RAM. Generally, the smaller the panorama, the better.
- Consider opening one of the horizon photos that come with *TheSkyX* in your image processing software to use as a “template” for creating your own panorama.

There are many web sites dedicated to creating photographic panoramas. Search for “panorama” and “panorama tools” or “image stitching”.

### ***Selecting the Panorama Photo***

When you have completed and saved the final panorama, copy it to the *Horizons* folder. The location of this folder depends on your operating system.

## Mac

On the Mac, custom horizon photos should be saved in the **Horizons** folder that is in the *TheSkyX's Application Support Files* folder (page 26):

```
~/Library/Application Support/Software Bisque/TheSkyX <Edition Name Here>/Horizons
```

The “~” represents the location of your home directory (technically, `/Users/<username>` or the `$HOME` folder). Look for the little icon of a house under **Places** in Finder's Sidebar to find it.

## Windows

On Windows, custom horizon photos should be copied to the **Horizons** folder located in *TheSkyX's Documents* folder:

```
< Documents>\Software Bisque\TheSkyX <Edition Name Here>\Horizons
```

Where `<root>\Users\<username>` for Windows 7 and Windows 8; `<Edition Name Here>` is either *TheSkyX Professional Edition* or *TheSkyX Serious Astronomer Edition*.

The horizon photo tree on the **Horizon** tab of the **Horizon & Atmosphere Options** window detects that a new photo is available and updates the list. Select its name, to update the Sky Chart. You'll need to adjust the **Horizon Photo Position** settings to get things “just right” for your panorama.

## Sky Gradient

*TheSkyX* even lets you adjust the color of the sky. While this is best used to match sky conditions at your real-life observing location, you can always use it for fun, too. Click the **Sky Gradient** tab to see how.

Hint: Sky Gradients only apply when the **Show Daylight** command (page 57) is turned on.

On the left, you will see a list of different sky color gradients corresponding to different times of day and sky conditions.

On the right, you will see the controls for editing the sky color gradient. Under **Edit Sky Gradient**, you will see the name of the selected sky gradient, the selected cloud tint (if any), a color preview of the selected sky gradient, as well as various buttons used to adjust the sky gradient.

Let's make a change to the default daytime sky gradient to represent a pale-sky day.

1. Click the **Show Daylight** command from the **Display** menu to turn on daylight simulation.
2. Click the **Horizon & Atmosphere Options** command on the **Display** menu.
3. After the new window opens, click on the **Sky Gradient** tab.
4. In the drop-down menu, **Sky Gradient Type**, choose **Selected Sky Gradient**.

5. Select a sky gradient form the list to edit, this time let's choose **Daytime**. This gradient simulates the color of the sky during sunlight hours. If you would like, you may change the **Description** by editing the text in the field to the right.
6. Now, on the right you will see the daytime sky color gradient in a sample box. On the far right, you will also see little gray triangles that correspond to start points for the gradient colors. Double-click the top-most triangle.
7. The color wheel opens, allowing you to select a new color. Choose any color you like from the wheel and click **OK**. Do this for the remaining triangles until you are satisfied with the sky color gradient in the sample box. If you would like to remove a gradient point, click **Remove Point**. You can also click **Paste Photo** to import a sky photograph.
8. Once you have the sky gradient set to your liking, you can fine-tune it with the **Darker/Lighter** slider, located below the sample box.
9. To save your new gradient, click **Save Gradients**. This action will save all changes made to gradients during the current session. To return to default settings, you can always click **Defaults**, even after saving changes.
10. Once you have saved and selected your new sky color gradient, it appears in the Sky Chart.

## Clouds

Select the **Clouds** tab in the **Horizon & Atmosphere** window to bring up options for cloud images, position, and transparency. Handily, these options will update live in the Sky Chart as you choose them.

### **Cloud images**

On the top left, notice the checkbox marked **Show Clouds**. Selecting this option will turn the clouds on or off completely.

Choose a cloud image from those listed in the box to the left labeled **Cloud Photo Name**. Click the **Apply** button or double-click on the cloud photo you want to use to apply it to the Sky Chart. You can also see a preview of your cloud choice to the right of the window.

### **Cloud Transparency**

Maybe you have hazy, thin clouds at your observing site and you would like *TheSkyX* to model similar clouds in the Sky Chart. Simply click and drag the **Transparency** slider to achieve the level of transparency you desire. The exact transparency percentage appears to the right of the slider.

### **Cloud Photo Position**

You have complete control over the position and orientation of cloud images in *TheSkyX*. Choose a top and bottom limit for your cloud image by using the sliders to the right. You can also spin the cloud image around your point of view by using the **Right/Left** slider. Note that your selections for each slider are marked in degrees or either altitude (**Top/Bottom**) or azimuth (**Right/Left**).

## Miscellaneous

Options for the Sun's halo, the Moon's halo, and meteors appear under the **Miscellaneous Tab** in the Horizon & Atmosphere window.

### **Sun's Halo**

Turn on this checkbox to show the simulated Sun's halo on the Sky Chart. You can also stipulate an angular size (in degrees) for the solar halo. The Sun's halo is The default size is 10.00°.

### **Moon's Halo**

This checkbox controls the simulated halo that appears around the Moon at night. Turn it on to have the Moon's halo appear on the Sky Chart under the following conditions:

- In the evening, after astronomical twilight's end, through morning, when astronomical twilight begins. (The angular size of the Moon's glow increases slowly as twilight approaches, and is displayed at the maximum size afterward.)
- The Moon is less than five degrees below the horizon, or astronomical twilight is in effect, whichever is earlier.
- The Sky Chart's field of view is greater than 10 degrees.

The halo's default angular size is 50.00°, but you can change it to whatever you wish using the **Size** box (0.00°-99.99°).

### **Meteors**

Several options exist for displaying sporadic meteors and meteor showers.

Checking the **Show Meteor Shower Radiants** checkbox will show the radiant points for upcoming meteor showers in the Sky Chart. You can select how far into the future you want *TheSkyX* to look in plotting upcoming meteor shower radiants by entering a value in the **Show only those during the next:** field. The default value is one week (7 days), but you can change it to whatever you wish. This feature is particularly useful when planning to observe a meteor shower.

You can also choose to show random, or sporadic, meteors in the Sky Chart by selecting the **Show meteors (randomly)** checkbox, and then choosing an hourly rate. These sporadic meteors will not be based on actual forecasts, but are a great way to add extra realism to the Sky Chart. In the real sky, you can expect to see anywhere from five to 15 sporadic meteors per hour.

## Milky Way Options



The Milky Way may be toggled by clicking the **Milky Way** checkbox in the Chart Elements window. There are a number of options for Milky Way display available by clicking the **Milky Way Options** button.

Once you have clicked the **Milky Way Options** button, the corresponding window will open. With the central drop-down menu, you may choose either **Photograph** or **Isophotes** as your Milky Way type. Choosing **Photograph** will display a photo-realistic depiction of the Milky Way in the Sky Chart. Alternately, choosing **Isophotes** will give you a view reflecting areas of equal brightness.

## Celestial Pole Arrow

If you would like to have a handy guide orienting you toward the celestial pole, turn on the **Celestial North Arrow** checkbox in the **Chart Elements** window. A red indicator will appear in the upper left-hand corner of the Sky Chart, pointing North and East to help you stay oriented.

## Reference Objects

There are a number of markers for various reference objects available in *TheSkyX*. Many are self-explanatory, but here is a short description of those with a more technical aspect. Remember that each chart element is editable by double-clicking on its name in the list.

### **Area of Interest, Arrow, Chart Scale**

See the “My Chart Elements” on page 283 for an explanation of these object types.

### **Dome Slit**

The graphic that is displayed when *TheSkyX* is coupled to, and positioning an astronomical dome.

### **Meteor Shower Radiants**

This marks the radiant point (or point of apparent origin) of a meteor shower.

***Mosaic Grid***

This is the grid produced when setting up to take a photo mosaic of a region in the sky. This grid represents each component frame of the mosaic.

***Reference Line***

A user-drawn line of reference.

***Reference Point***

A user-generated reference point.

***Telescope Limit***

This is a reference line that marks the slewing limit of the telescope currently set up in *TheSkyX*.

***Target Object***

This object marks the set target of your telescope or the object otherwise currently selected in the Sky Chart.

***Telrad***

If you have a telescope setup, the field of view of your Telrad™ viewfinder will appear on the Sky Chart with this option turned on.

***Telescope Cross Hairs***

With a telescope set up, these cross hairs show where it points in the Sky Chart.

***Pointing Sample***

A position on the celestial sphere that has been used by TPoint to calibrate the telescope and improve the telescope's pointing.

***Tour Title***

When viewing a tour, this object toggles the title of the tour on or off in the Sky Chart.

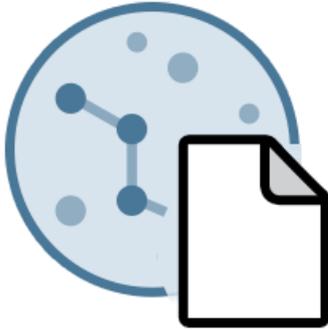
***Zoom Box***

This option is a place holder so that the zoom box attributes can be edited (see "Editing Chart Element Attributes" on page 236). To show or hide a zoom box, press and hold down the SHIFT key while dragging the mouse (see "Zoom Box" on page 41).

## **Managing Databases**

*TheSkyX* includes a host of standard astronomical databases (see "Appendix A: Databases and Cross References" for a complete list). *TheSkyX* can also be used to create custom databases from text-based data (see "Custom Databases"). The Database Manager on the ***Input*** menu provides a means to turn on and off these databases, depending on your needs.

## Using the Database Manager



To access the database manager, choose the **Database Manager** command from the **Input** menu. On the **Database Manager** window, you will see an expandable tree list of databases to the left; to the right are tabs for **General** information, database **Items**, **Advanced** options, and **Replaced Objects**.

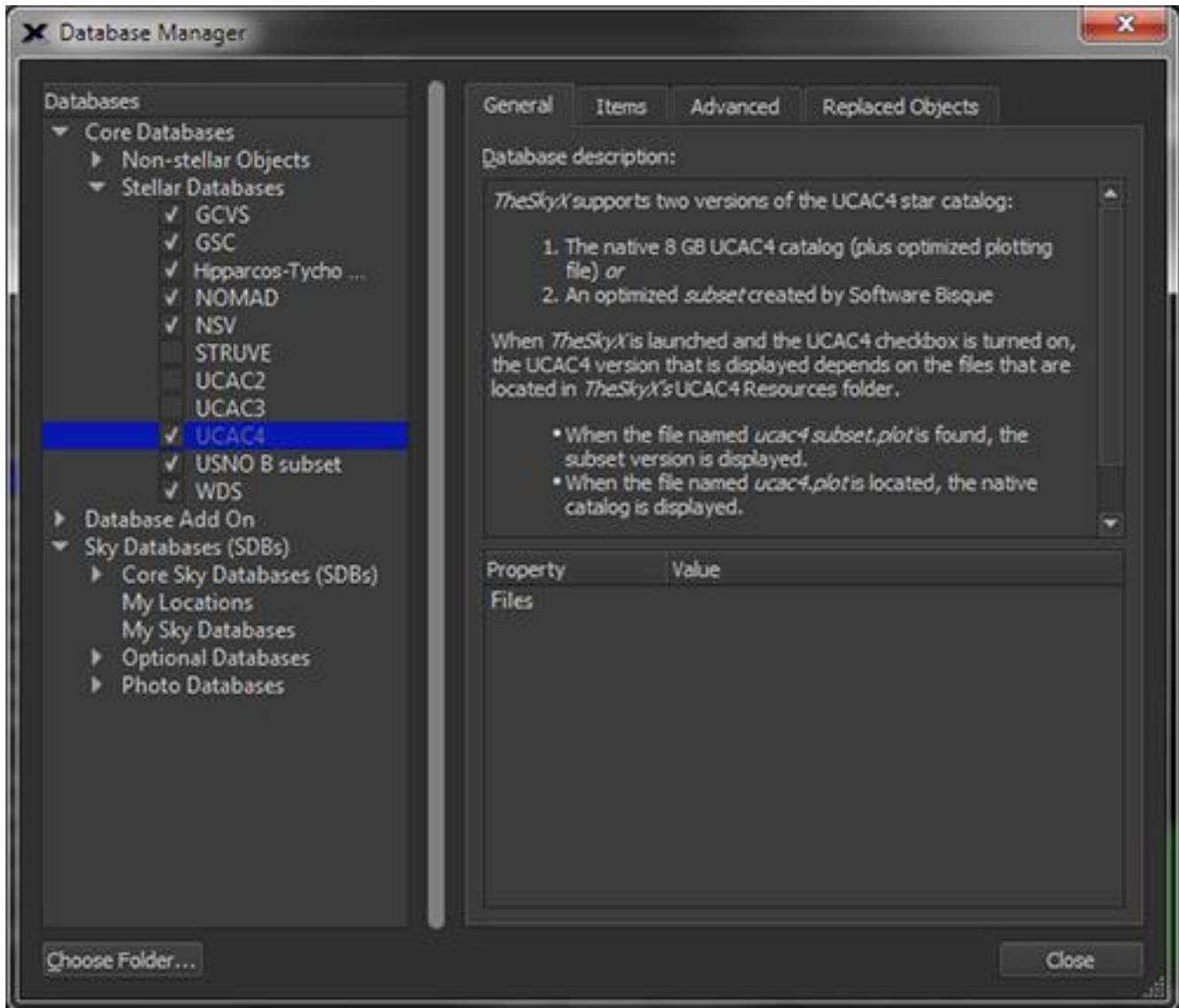


Figure 113: The Database Manager window (General tab).

To show objects in a database on the Sky Chart, turn on the checkbox next to its name in the **Databases** list.

### General Tab

Selecting this tab (see Figure 113) will let you view the general information about the selected database. When a core database is selected in the **Databases** list, a description and the location of the database files are displayed. When a Sky Databases is selected, information such as the source text file, object types contained within the database, and the file path are listed.

## Items Tab

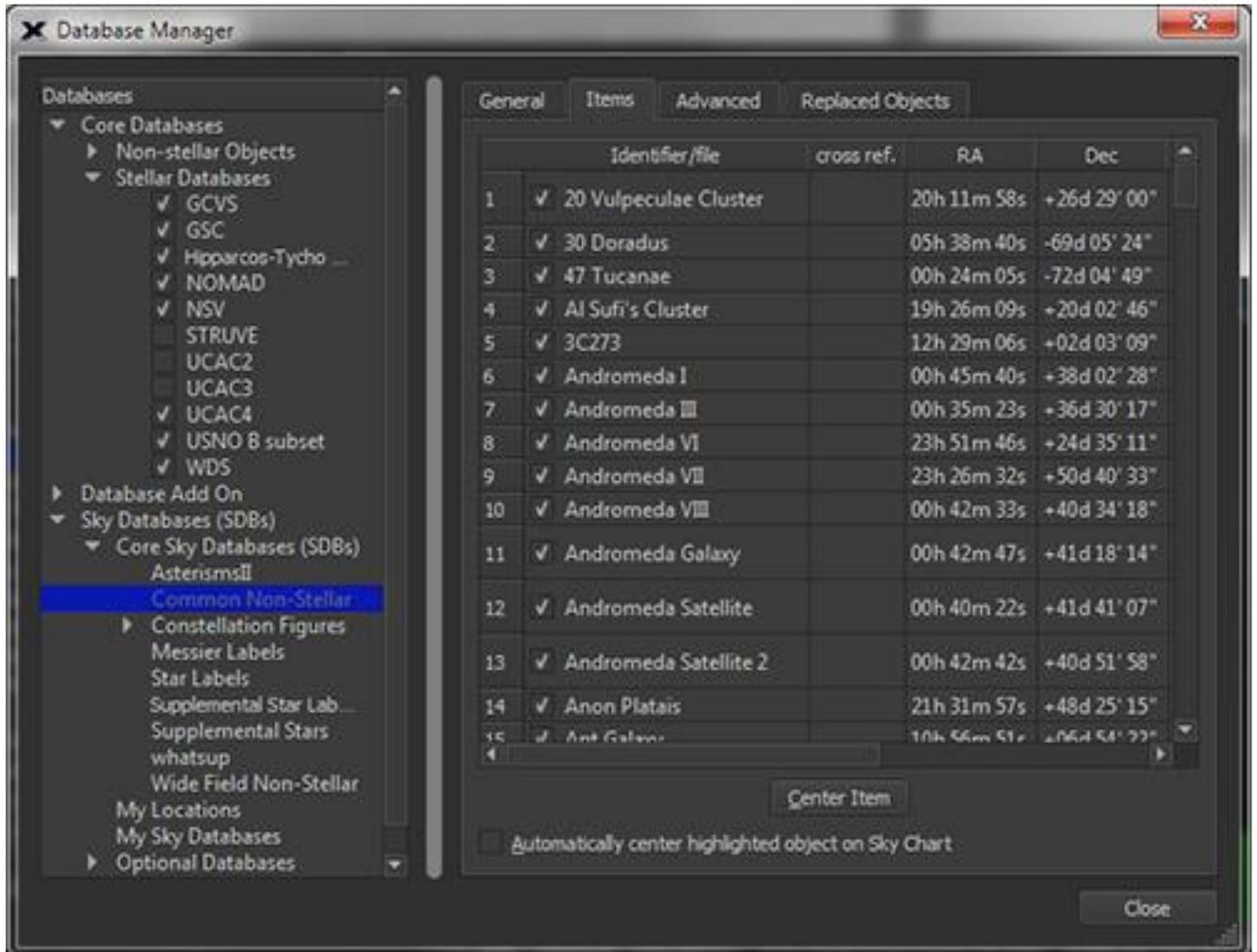


Figure 114: The Items tab on the Database Manager window.

The table lists all the objects in the database, by row, and the fields in the database, by column. Clicking the **Center Item** button will center the highlighted object in the Sky Chart. Alternately, you can automatically center a selected item by turning on the **Automatically Center Highlighted Object on Sky Char** checkbox.

## Advanced Tab

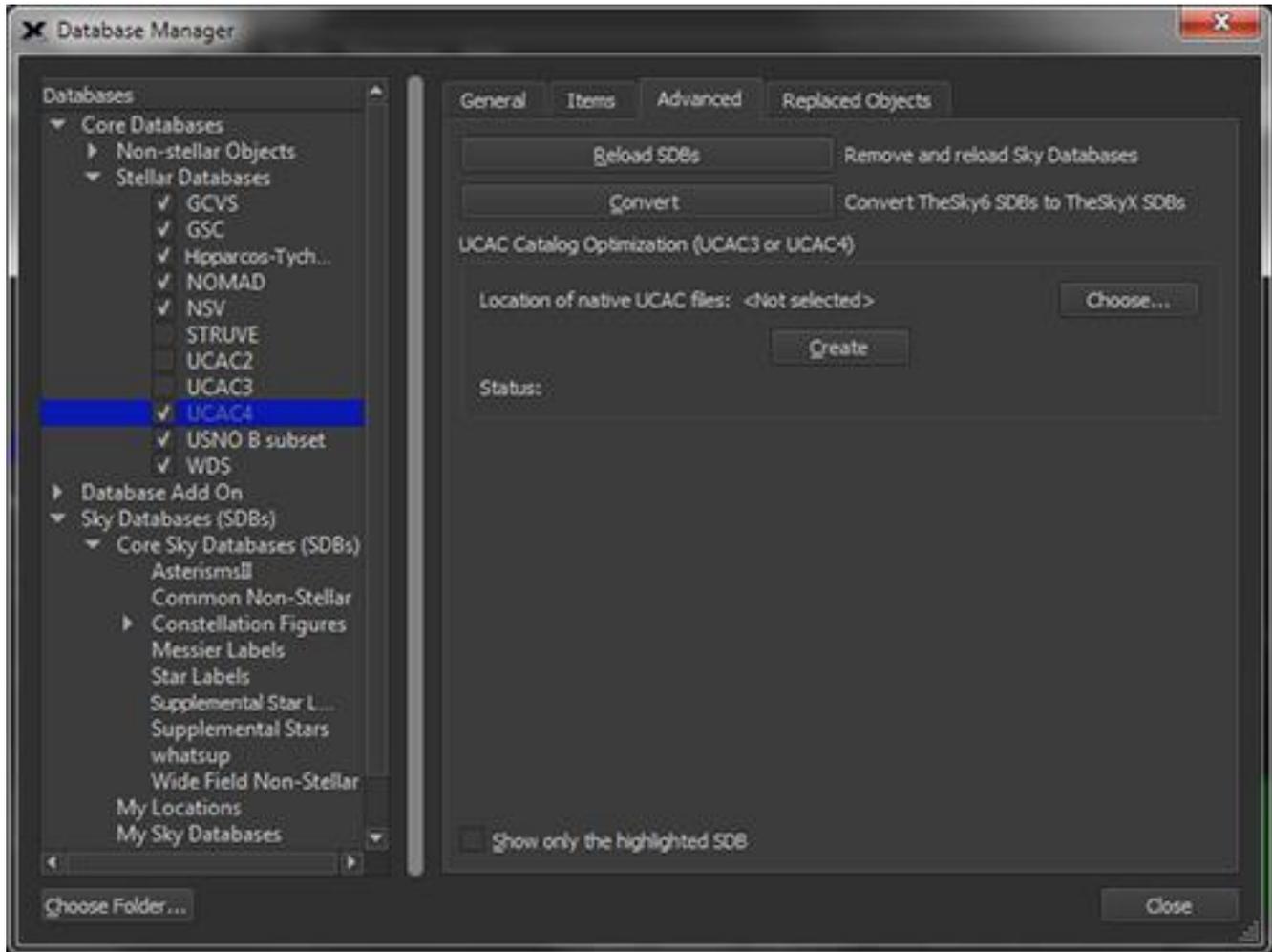


Figure 115: The Advanced tab on the Database Manager window.

Here, you can remove, then reload the Sky Databases (SDBs) by clicking the **Reload SDBs** button. You can also convert existing *TheSky6* SDBs to *TheSkyX*-compatible SDBX format by clicking the **Convert** button.

1. Copy your *TheSky6* Sky Database (.sdb) and text (.txt) files into *TheSkyX*'s **SDBs** folder (see "Application Support Files" on page 26 for details about these files).
2. Click the **Convert** button, select the folder that holds your existing SDBs and associated text data (only).
3. Click the **Open** button to begin the conversion process.

The converted Sky Databases will appear on the **Database Manager** window's list of **Databases** under **My Sky Databases**.

### Optimized UCAC3/UCAC4 Catalogs

TheSkyX Professional Edition can show stars from the native UCAC3 and/or the native UCAC4 star catalogs. Before it can do so, you must first create a *TheSkyX Pro*-specific database file as described below.



#### Important notes:

- *TheSkyX Pro Database Add On* already includes the optimized UCAC3 and UCAC4 plot files and these files *need not be generated separately* as describe below. If you own the Database Add On, see “Accessing TheSkyX Pro Database Add On Catalogs” on page 640 for more information.
- Clicking a UCAC star from the Sky Chart retrieves extended information about that star directly from the text-based UCAC database. The optimized plot file is used to quickly display the position and magnitude of UCAC objects when panning and scrolling the Sky Chart.

#### Choose

Click this button to specify the location of the native UCAC3 or UCAC4 databases.

#### Create

Click this button to create an optimized TheSkyX-specific UCAC3 or UCAC4 database file:

- *UCAC3.plot* for the native UCAC3 database.
- *UCAC4.plot* for the native UCAC4 database.

Optimized “plot” files are used by *TheSkyX Pro* to efficiently display objects and retrieve information from text-based databases. Make sure that the UCAC3 or UCAC4 folder has “write access” so that the *UCAC3.plot* or *UCAC4.plot* file, respectively, can be saved in this folder.

Creating the optimized plot files from the native databases takes several hours. To configure *TheSkyX Pro* to use this optimized database, select either **UCAC3** or **UCAC4** in the **Stellar Databases** section of the **Databases** list, then click the **Choose Folder** button and choose the folder that holds the appropriate file.

#### Show Only the Highlighted SDB

When this check mark is turned on, and a **Sky Database (SDB)** is highlighted in the **Databases** list, the *only* the highlighted database is displayed on the Sky Chart (whether the checkbox next to the database is turned on or whether other Sky Databases are turned on). This option allows you to individually display Sky Databases on the Sky Chart using the up/down arrows on the keyboard. This can be helpful when trying to locate an SDB, or to troubleshoot whether or not your custom SDBs were compiled and are being displayed properly.

## Replaced Objects Tab

To view replaced objects, click this tab. Clicking **Refresh** will update the list.

## Custom Databases

Creating your own database of celestial objects can be a useful thing to do if you choose to carefully document your observations. *TheSkyX* lets you do this with a great amount of freedom. Let's take an overview look at the **Create Sky Database** command.

### Creating a Sky Database



To see the **Create Sky Database** window, select the **Create Sky Database** command from the **Input** menu. A tabbed window then opens, with options for defining fields, behaviors, advanced operations, and compilation operation.

#### **Define Fields Tab**

From the **Define Fields** tab, you can select values for a number of items. If you wish to open a file containing field data, simply click **Choose Source Text File**. If you would like to open it in Unicode, be sure to select the **Open text file in Unicode** checkbox.

To enter value ranges for field items, highlight a field in the window to the left. You will see its current column start and end points, if any. To enter values, you may either enter them in the **Starting column** and **Ending column** fields below, or you can click on the starting point on the graph and drag to the desired ending point. When dragging, the selected values appear to the right of the **Set Columns** button. You can always change the values by clicking and dragging again. Once you have entered the desired values, click the **Set Columns** button. The column will then be set on the graph, and a label featuring its description appears in blue.

Clicking **Clear All** will clear all data from the graph.

### Behavior Tab

This tab includes options that define control the how the database interacts with the Sky Chart.

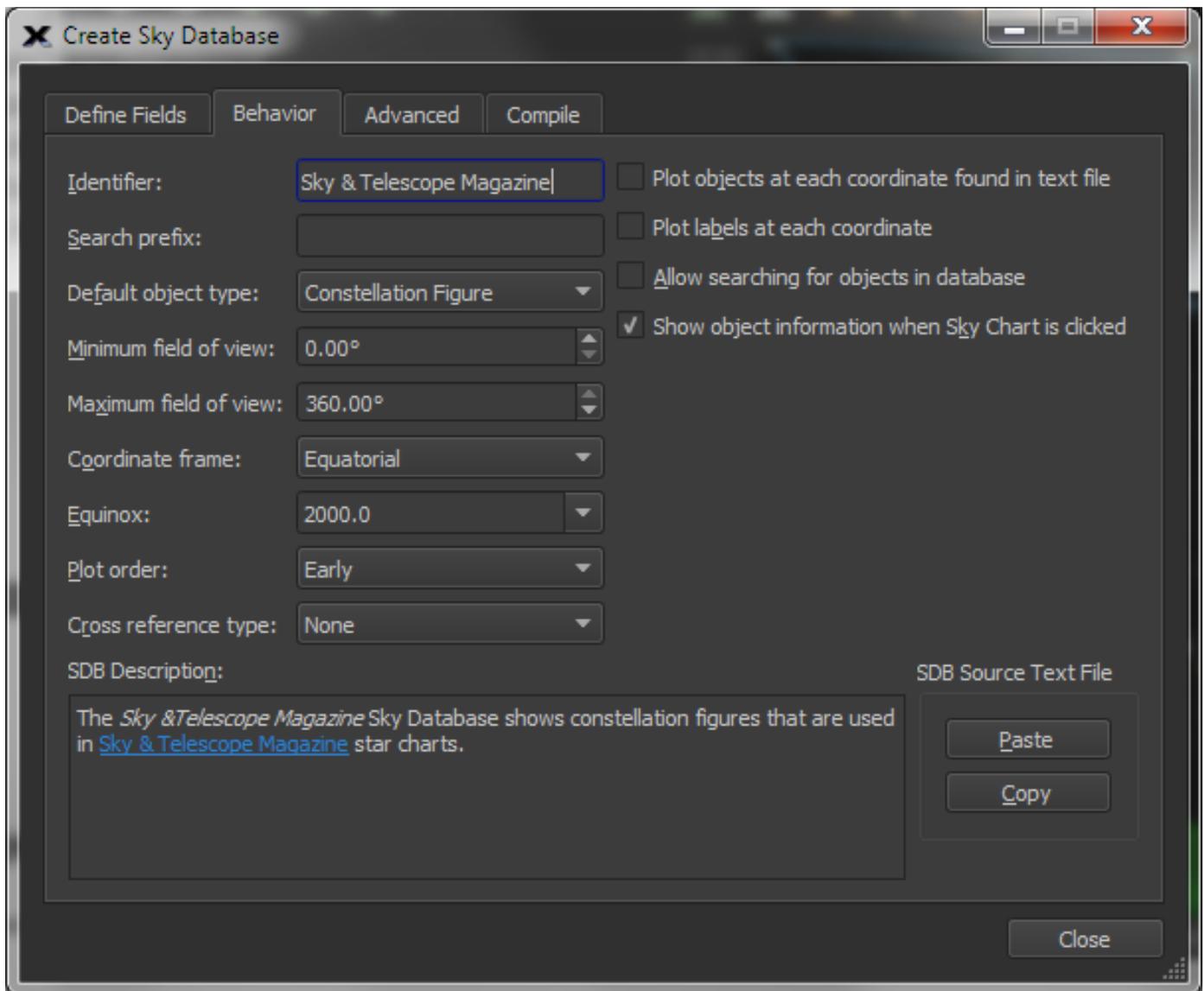


Figure 116: Behavior tab on the Create Sky Database window (*Create Sky Database* command, *Input* menu).

#### **Sky Database Identifier (Identifier)**

Enter text that uniquely defines the database you are creating.

#### **Search Prefix**

Enter the text prefix that can be used to locate objects in the SDB when finding objects (page 59).

#### **Default Object Type**

Select the type of object (star, open cluster, etc.) that is in the source text file from this list.

### **Minimum Field of View**

Enter a number for the smallest (narrowest) field of view on the Sky Chart to show the objects in this database.

### **Maximum Field of View**

Enter a number for the largest (widest) field of view on the Sky Chart to show the objects in this database.

### **Coordinate Frame**

Select the coordinate system of the objects in the source text file.

- **Equatorial:** Coordinates are in right ascension and declination format. Make sure to specify the correct equinox for equatorial coordinates.
- **Horizon:** Coordinates are in azimuth and altitude format.
- **Topocentric:** Coordinates are relative to the current location on the surface of Earth.

### **Equinox**

Enter the equinox of the coordinates in the source text file.

### **Plot Order**

When displaying databases, you may want a specific object to should appear “on top of” other objects. The Plot Order allows you to select when, relative to objects in the core database, this database will be drawn on the sky chart.

- **Early:** Show objects in the Sky Database before stars. Stars will overlay objects in the database.
- **Middle:** Show objects in the Sky Database after stars. Objects in the database will overlay stars.
- **Late:** Show objects in the Sky Database on top of all other objects.

### **Cross Reference Type**

Select how objects in the source text file are cross referenced with objects in the core databases.

- **None:** Objects in the text file do not contain cross references to objects other databases.
- **Database:** Objects in the text file contain cross references to objects in *TheSkyX's* core databases, or other SDBs.
- **Pure:** Objects in the text file reference existing object names or catalog numbers.
- **Common Name:** Objects in the text file reference existing common object names.

### **SDB Description**

Enter a text description for the Sky Database. The **SDB Description** text editor accepts text that is formatted with hypertext markup language (HTML), so that, for example, links to external web sites can be included with the header.

Please note that the **SDB Description** text input is a simple *text editor*, not a *web browser*. This means, for example, when HTML is pasted into the **SDB Description** text box, a link to an external web page may be formatted as a hyperlink (that is, underlined in blue), but clicking on the underlined text *will not show the external link in a web browser*.

Once the SDB is compiled (see “Compile Tab” on page 278), the web links in the description can be accessed from the Description on General tab of the **Database Manager** (see “Managing Databases” on page 268).

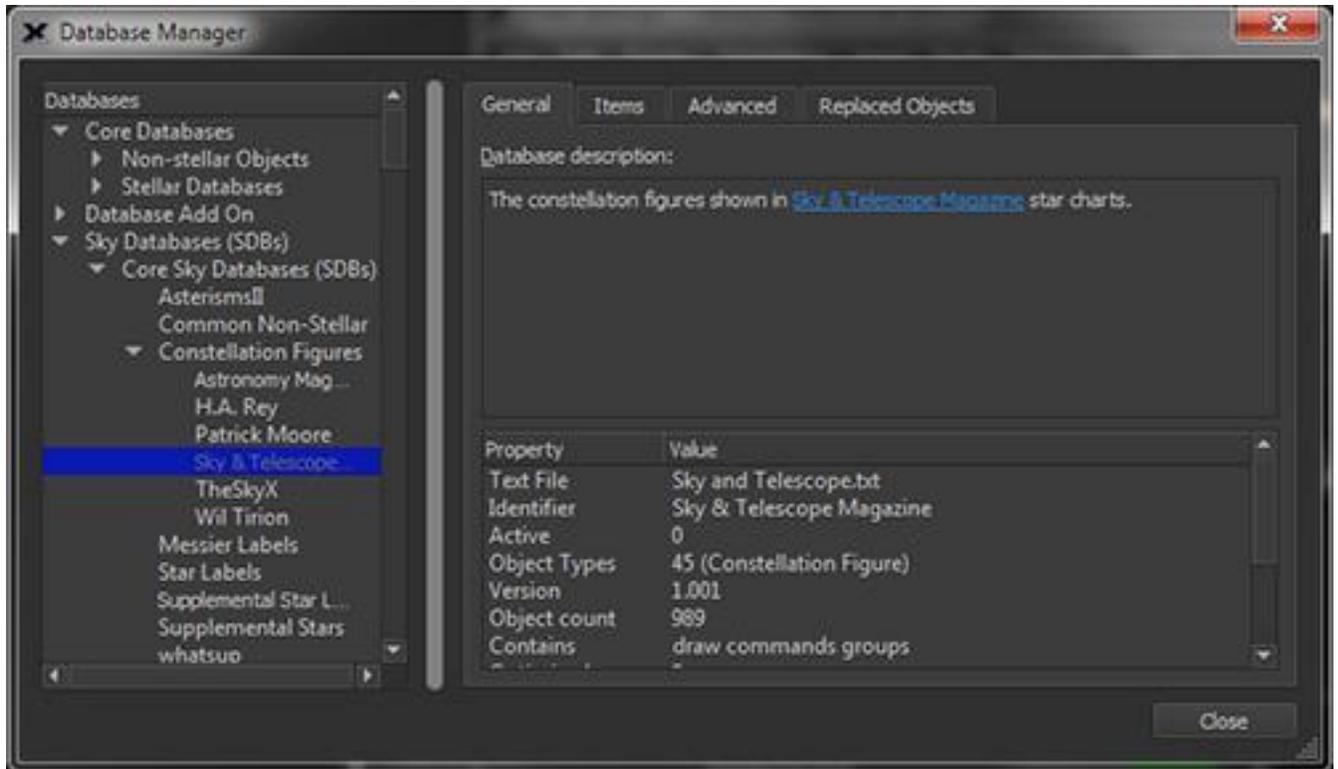


Figure 117: The General tab of the Database Manager window (page 268) showing web accessible hyperlinks in the Sky Database Description field.

Additionally, there are options that control plotting, searching, and how object information is shown in the database and/or Sky Chart.

### **Advanced Tab**

Under **Advanced**, you will find operators to translate text to object type, multipliers for various measurements and coordinates, folder options, and Unicode control.

To the left is the **Translate Text to Object Type** section. Simply type text into the fields, and select the desired object type from the drop-down menu.

**Multipliers** for right ascension, declination, magnitude, major and minor axes, and position angle may be entered into the fields to the upper right.

Under **Folder Operations**, you can choose to **compile** a new folder from existing text files, or you may choose to **convert** a folder of TheSky6 database files for use in *TheSkyX*.

Additionally, you can convert a text file to Unicode and select from a list of codecs to use in the **To Unicode** section to the lower right.

### **Compile Tab**

This is where you can finally compile your database, once all the criteria are set. Clicking the **Compile** button compiles the database, revealing the corresponding text file in the field with a star chart above. You can add a header by checking the **Add header to text file** box.

Once you are finished, click the **Close** button.

## **Defining Search Fields in Sky Databases**

Most text-based celestial object databases include catalog numbers or other identifiers to uniquely identify each object.

*TheSkyX* can use these identifiers to generate a “searchable” Sky Database (SDB). Objects in these databases can be located by typing the SDB *Search Identifier*, followed by the object’s unique identifier in the **Search For** text box on the Find window.

Searchable Sky Databases and the objects they contain, are also listed in the **Advanced** tab of the **Find** window.

The following procedure describes how to configure the Sky Database parameters so that once the SDB is created, the objects in the database can be located using the **Find** command on the **Edit** menu.

1. Select the **Create Sky Database** command from the **Input** menu.
2. On the **Define Fields** tab, click the **Choose** button near the top to the window.
3. Select the file that contains the space separated text-based celestial object database and click **Open**. The contents of the text file appear on the right side of the **Define Fields** tab.
4. Specify the beginning and ending columns that hold the **RA Hours, RA Minutes, RA Seconds, Dec Sign, Dec Degrees, Dec Minutes** and **Magnitude**. These are the minimum required fields for an SDB.

For example, suppose in columns 66-74 contain right ascension in decimal format. To define **RA Hours**, select this text on the left side of the window, then enter 66 in the **Starting Column** text input and 74 in the **Ending Column** text input and then click the **Set Columns** button. The text file shows RA Hours in blue above these columns. (You can also drag the mouse to highlight the desired columns in the text file on the right.)

Repeat this process for each required field.

1. On the **Behavior** tab, click
2. Turn on the Allow Searching for Objects in Database checkbox on the Behavior tab of the Create Sky Database window.

### **Search Prefix**

Some astronomical databases do not require a prefix to search for objects that are present in a database. For example, if the database contains common names of objects like “Polaris” or “Andromeda Galaxy”, a catalog prefix is not required.

Other catalogs identify each item by a single, unique number. For example, the NGC catalog has 7,840 items and they are numbered from 1 to 7,840. For this catalog, a *prefix* and a *number* are required to uniquely identify and locate each object in the catalog (for example, NGC 555).

In the example below, the ARP catalog of galaxies requires a Search Prefix because the search field contains only numbers from 1 to 338. Entering just the number “338” would not provide enough information to uniquely identify ARP 338.

### **Search Prefix Hints**

- For convenience when searching, limit prefixes to about 3-5 characters.
- Do not use existing prefixes such as NGC, IC, PGC or SAO.
- If a Search Prefix is defined in an SDB, then the prefix is *required* when searching for objects in that SDB. For example, if the Search Prefix is defined as **ARP-PG** then the only way to locate objects in the Arp Peculiar Galaxies SDB is to enter **ARP-PG 338**.

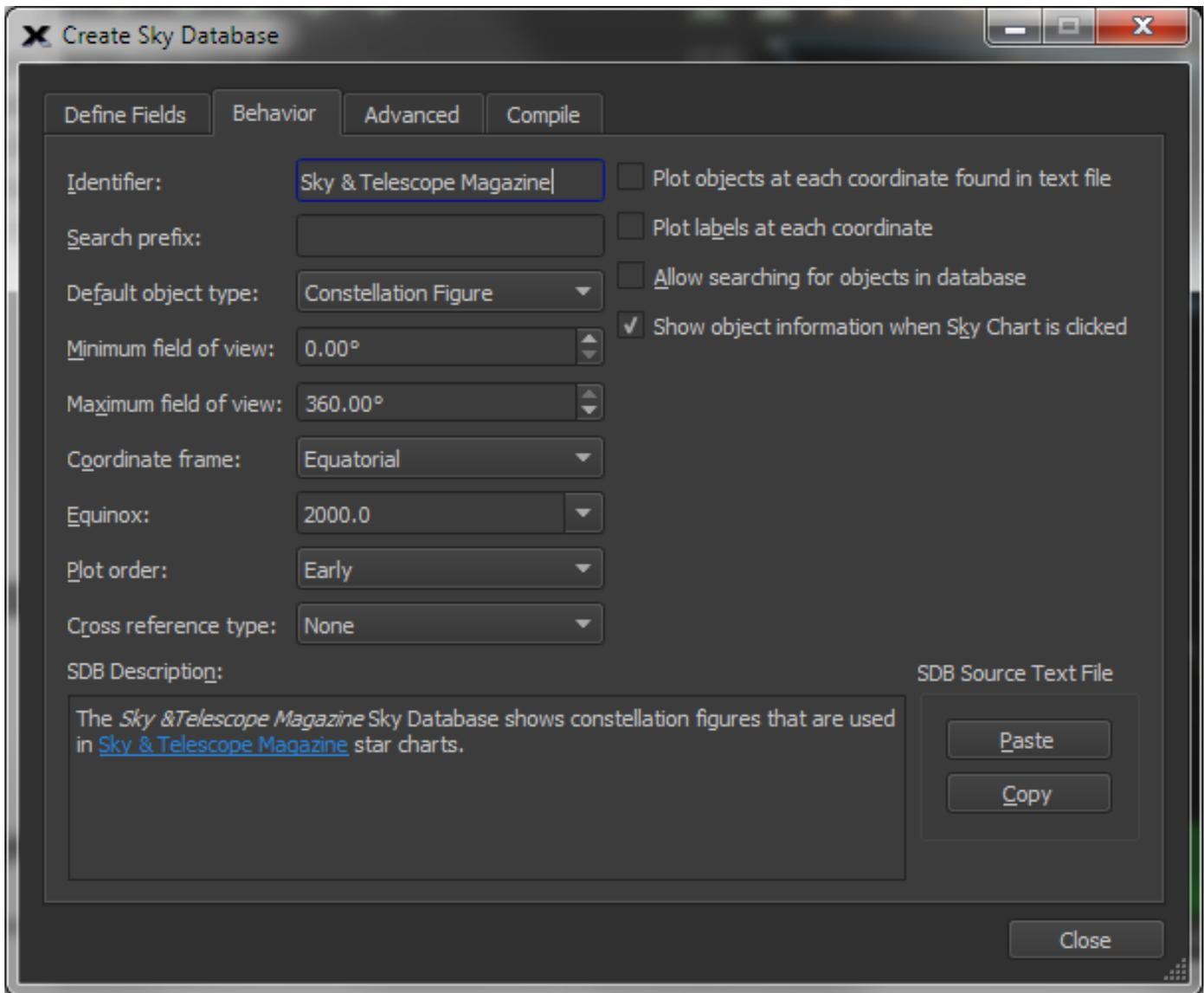


Figure 118: The Behavior tab on the Sky Database window (Sky Database command from the Input menu).

Just like other fields on the Define Fields window, the **Label/Search** field is specified by dragging over the columns (in this example, columns 1 through 3) then clicking the **Set columns** button. Alternatively, you can drag the columns then double-click on the **Label/Search** field.

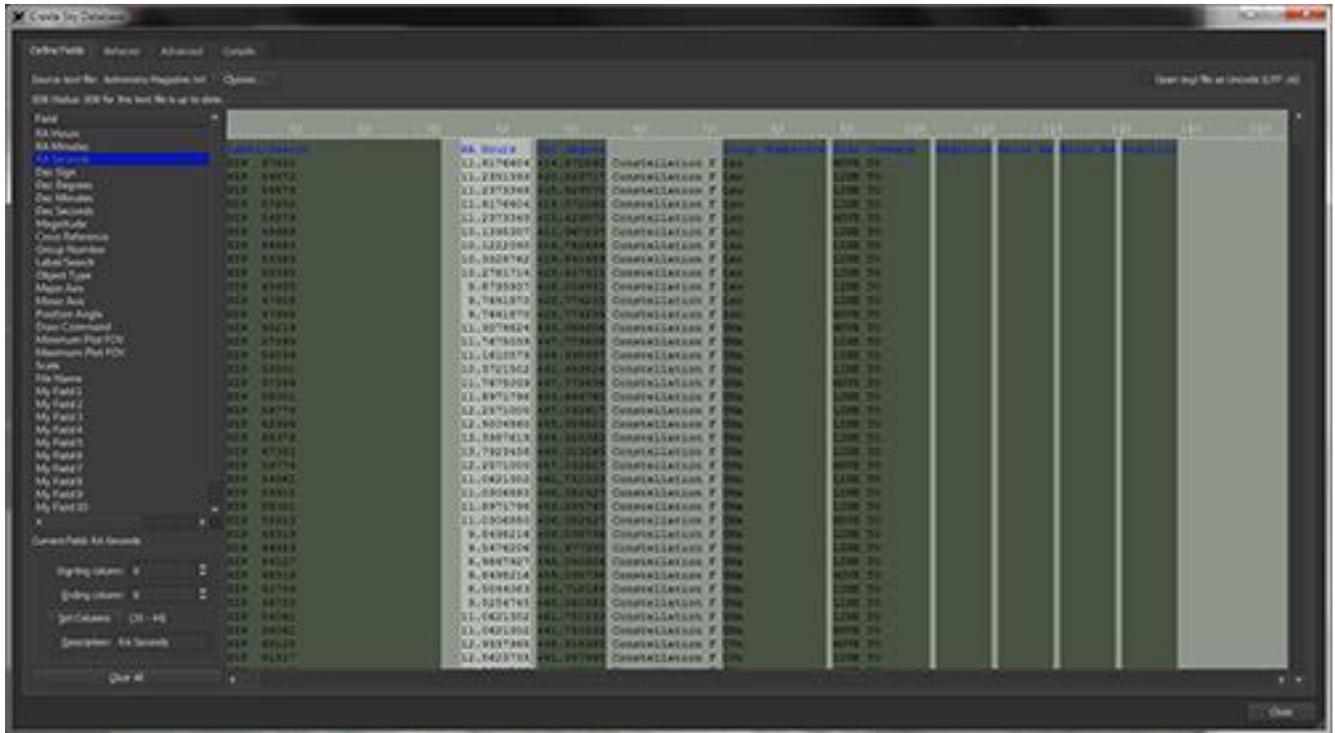


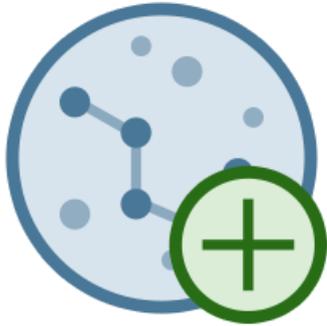
Figure 119: The Define Fields tab on the Sky Database window (Sky Database command from the Input menu).

In the **Advanced** tab of the **Find** window, when the database is expanded the Search Prefix will be added to the search field.



Figure 120: The Advanced tab on the Find window (choose the Find command on the Edit menu).

## My Chart Elements



*TheSkyX* allows you to add your own chart elements to the Sky Chart. In so doing, *TheSkyX* gives you the best of convenience from both electronic and paper star charts.

## Adding Chart Elements

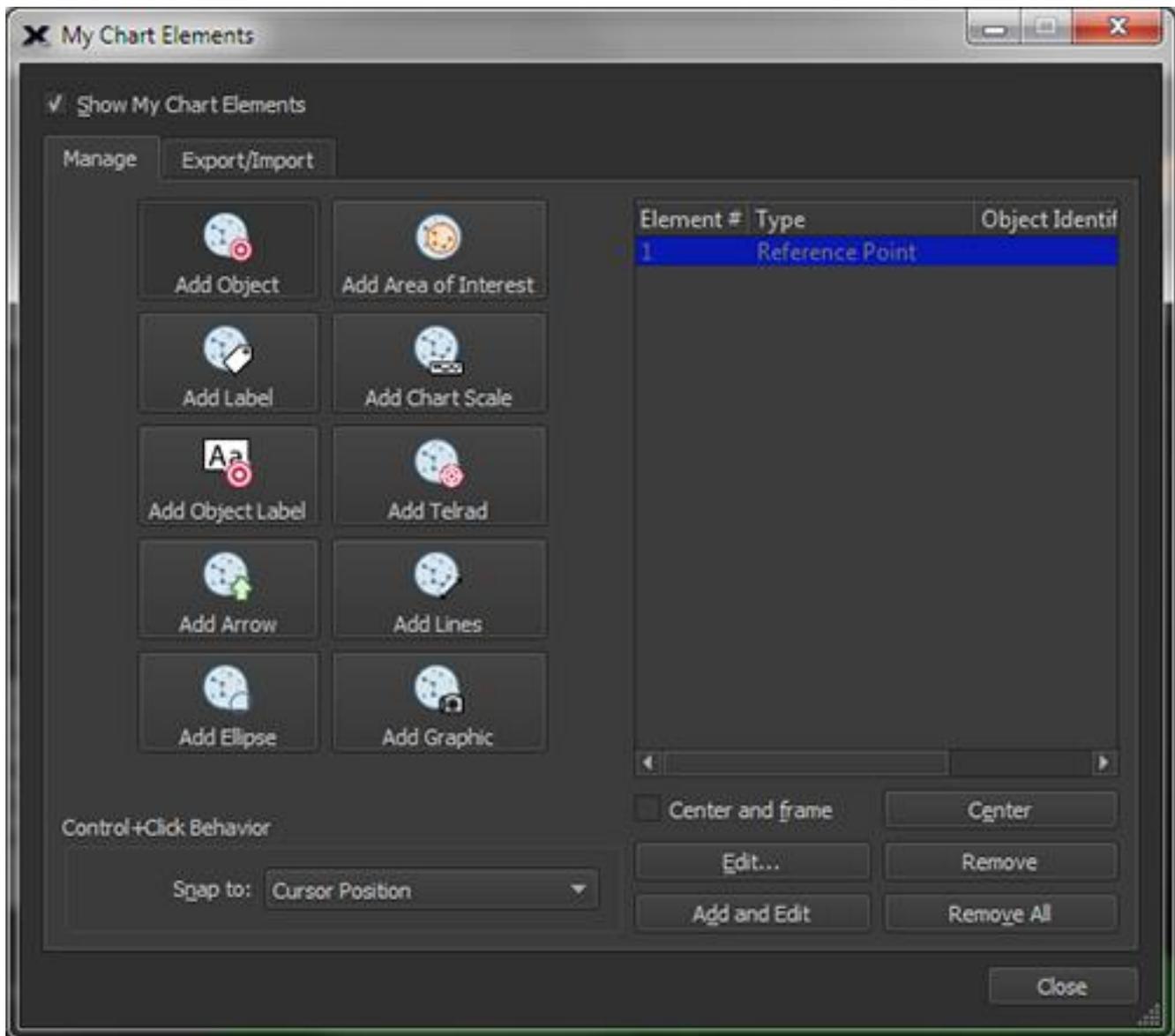


Figure 121: The *My Chart Elements* window (Input menu).

The easiest method to add a chart element to the Sky Chart:

1. Select the **My Chart Elements** command from the **Input** menu. The **My Chart Elements** window opens. At the top left is a checkbox, **Show My Chart Elements**. Once you have added your own elements, turning this option on will reveal them on the Sky Chart. Notice that there are two tabs in this window, **Manage** and **Import/Export**.
2. On the **Manage** tab, select which element to add by clicking one of the buttons on the left side of the window:
  - Add Object – Adds an object to the Sky Chart. The object can be of any type (star, cluster, galaxy, etc.) or one of your own object types (My Object Type).

- **Add Label** – Adds a text label to the Sky Chart. The **Enter Label** window will appear so that you can specify the label's text.
  - **Add Object Label** – Adds a custom label to an existing object.
  - **Add Arrow** – Add a reference arrow to the Sky Chart to highlight a particular object or region.
  - **Add Ellipse** – Adds an ellipse to the Sky Chart.
  - **Add Area of Interest** – Adds a shaded rectangular region to the Sky Chart for emphasis.
  - **Add Chart Scale** – Adds a small graphic that shows the angular scale for the chart.
  - **Add Telrad** – Adds a Telrad™ Finder to the Sky Chart.
  - **Add Graphic** – Adds a photograph or Scalable Vector Graphic to the Sky Chart.
3. Position the mouse cursor over the Sky Chart, then CTRL+left-click (Windows) or ⌘+left-click (Mac) to add the Chart Element at that position.

Or, click the **Add and Edit** button on the My Chart Elements window. This opens a new window where you can input the necessary information about the element.

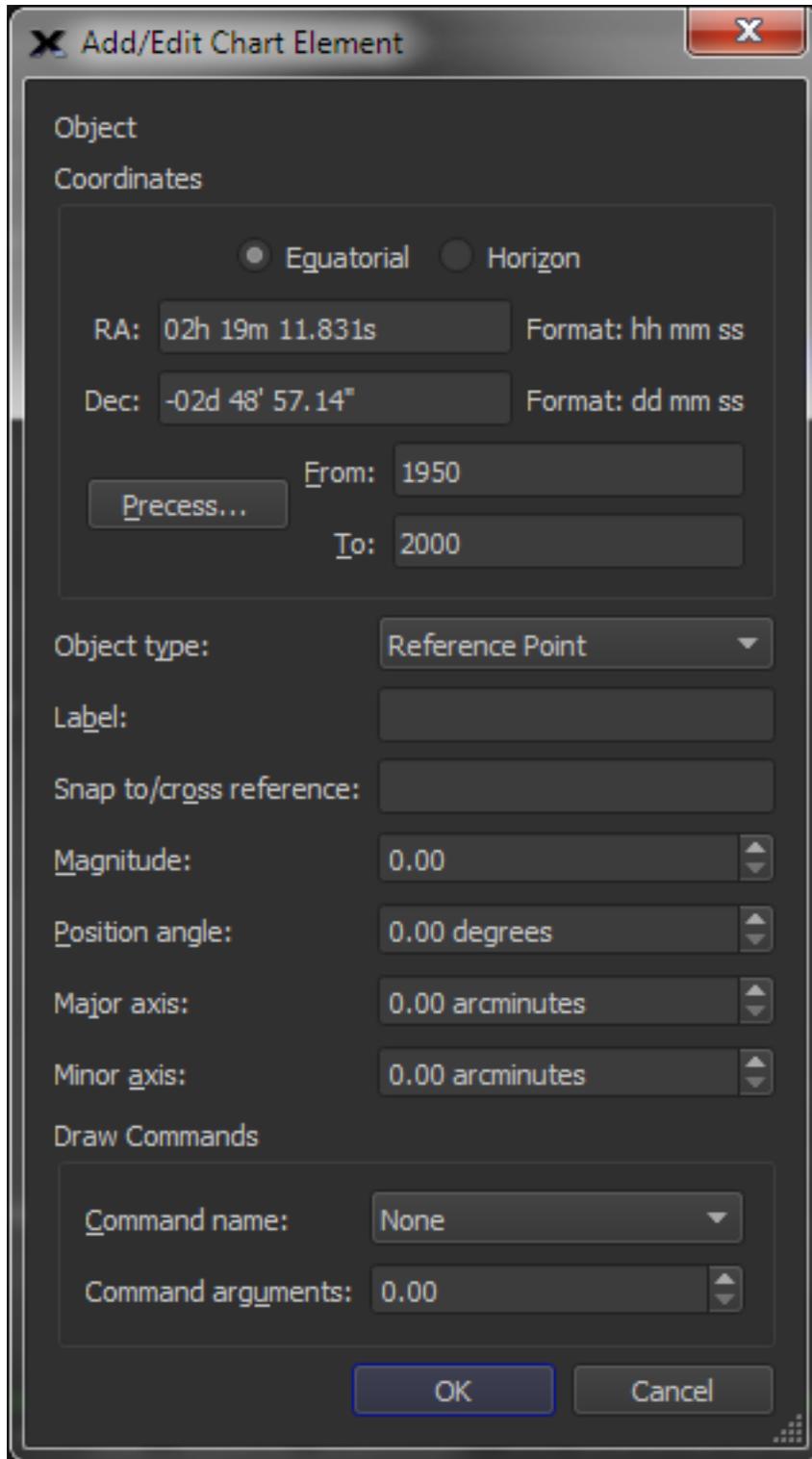


Figure 122: Add/Edit Chart Element window.

Near the top of the **Add/Edit Chart Element** window, you will see the coordinates section. You can choose between **Equatorial** or **Horizon** (azimuth-altitude) coordinates. Also, you can choose to precess the coordinates from one equinox to the current one to update old data. To do this,

simply input equinox dates in the fields **To** and **From**, and then click **Precess**. The new coordinates will then appear in the coordinate fields above.

**Note: This function works forward or backward.** If you would like to precess current coordinates to a past time, you can do that too.

Once you have your coordinates entered, it is time to choose the object type. Using the pop-up menu, choose the object type for your new chart element. Remember that each of these objects can be toggled from various places in the Chart Elements window.

You can then enter **Label** text, and a **Snap to/cross reference** point in the appropriate fields.

The next four fields control the actual appearance of your object in the Sky Chart. **Magnitude**, just like the magnitude of a star, controls the apparent brightness of the object in the Sky Chart (remember that the bigger the number, the dimmer the object). **Position Angle** controls the angular offset in degrees of your new object and the reference object, relative to the north celestial pole. Imagining your object as an ellipse, input the major and minor axis measurements in arc minutes. Remember that circles are special types of ellipses whose major and minor axes are equal.

Near the bottom of the window are the DRAW commands. You can choose the type of draw command you wish to use from the drop-down menu. You can then enter a command argument into the field below, or use the arrows to choose an appropriate argument value.

Once you click **OK**, you will be brought back to the **My Chart Elements** window, and your new custom chart element appears in the object list to the right.

You can always edit the element data by clicking **Edit**.

To center the object in the Sky Chart, click **Center**.

Clicking **Remove All** will remove all My Chart Elements.

To change the CTRL+left click (Windows) or ⌘+left-click (Mac) behavior, use the drop-down menu to the lower left. You can choose to snap to the **Cursor Position**, **Nearest Star**, or the **Nearest Non-Stellar Object**.

When you are finished managing My Chart Elements, click **Close**.

## **Export/Import My Chart Elements**

Choose the **Export/Import** tab at the top of the **My Chart Elements** window. Here, you will be able to export your created chart elements, or you can import other chart elements from a text file.

## Exporting Chart Elements

Follow these easy steps to export your chart elements in Sky Database (SDB) format.

1. To export a chart element, choose **Export/Import** tab at the top of the My Chart Elements window. The top portion of the window now shows export options.
2. Choose an appropriate identifier and enter it into the first field.
3. Then, from the **Default Object Type** drop-down menu, choose the desired object type. You can choose from any of the object types used in *TheSkyX*.
4. Choose the desired maximum and minimum values for the FOV (Field of View).
5. **Coordinate Frame** lets you choose between equatorial or horizon (Azm/Alt) coordinate systems.
6. Choose the appropriate equinox, plot order, and cross reference type.
7. Before exporting, be sure to take note of the checkboxes to the top right of the **export** section. These boxes let you toggle options for plotting objects and their labels, make these objects searchable, and to enable click identify for them.
8. Once you are ready, click the **Export to File...** button to export your data to a Sky Database file. Simply choose the file's destination, and click **Save**.

Note: You can also save these data to the clipboard for later pasting.

## Importing My Chart Elements

You can import any chart element(s) from a text file by using the bottom portion of the **My Chart Elements** window, **Export/Import** tab. Simply click the **From File** button to import an existing file. If you have chart element data copied to the clipboard, you can paste those data into *TheSkyX* by clicking the button labeled **From Clipboard**. Additionally, you can change the working directory by clicking the **Choose** button.

## Observing Lists

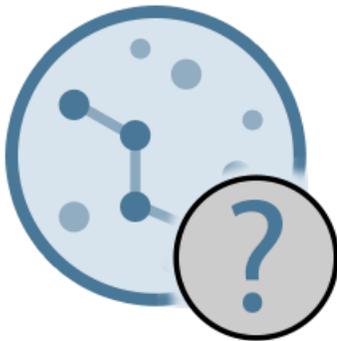


The **Manage Observing List** command in the **Tools** menu can be used to perform advanced searches or database queries to generate observing lists. The **Advanced Query** tab offers much more detail regarding your query of celestial objects than the simplified options on the **What's Up Setup** tab.

The normal procedure for creating an observing list is to define the type of objects you're after, and specify the astronomical databases to search (in the **Object Types & Databases** tab). Next, you can create custom filters based the *attributes* of the object types in the **Filters** tab. The **Constellations** tab allows you to refine the location further.

Once you've defined the parameters for your query, clicking the **Run Advanced Query** button generates an observing list on the **Observing List** window (**Display** menu).

## **Advanced Query Setup**



Defining an advanced query is as simple as clicking the **Advanced Query** tab to the left of the **What's Up Setup** tab. You will notice that the query setup area changes to a multi-tabbed window that lets you **Open/Save Query**, choose **Object Types & Databases**, set **Filters**, and select **Constellations** and **Other** criteria for your query. The following is a brief discussion of each tab and the information contained there.

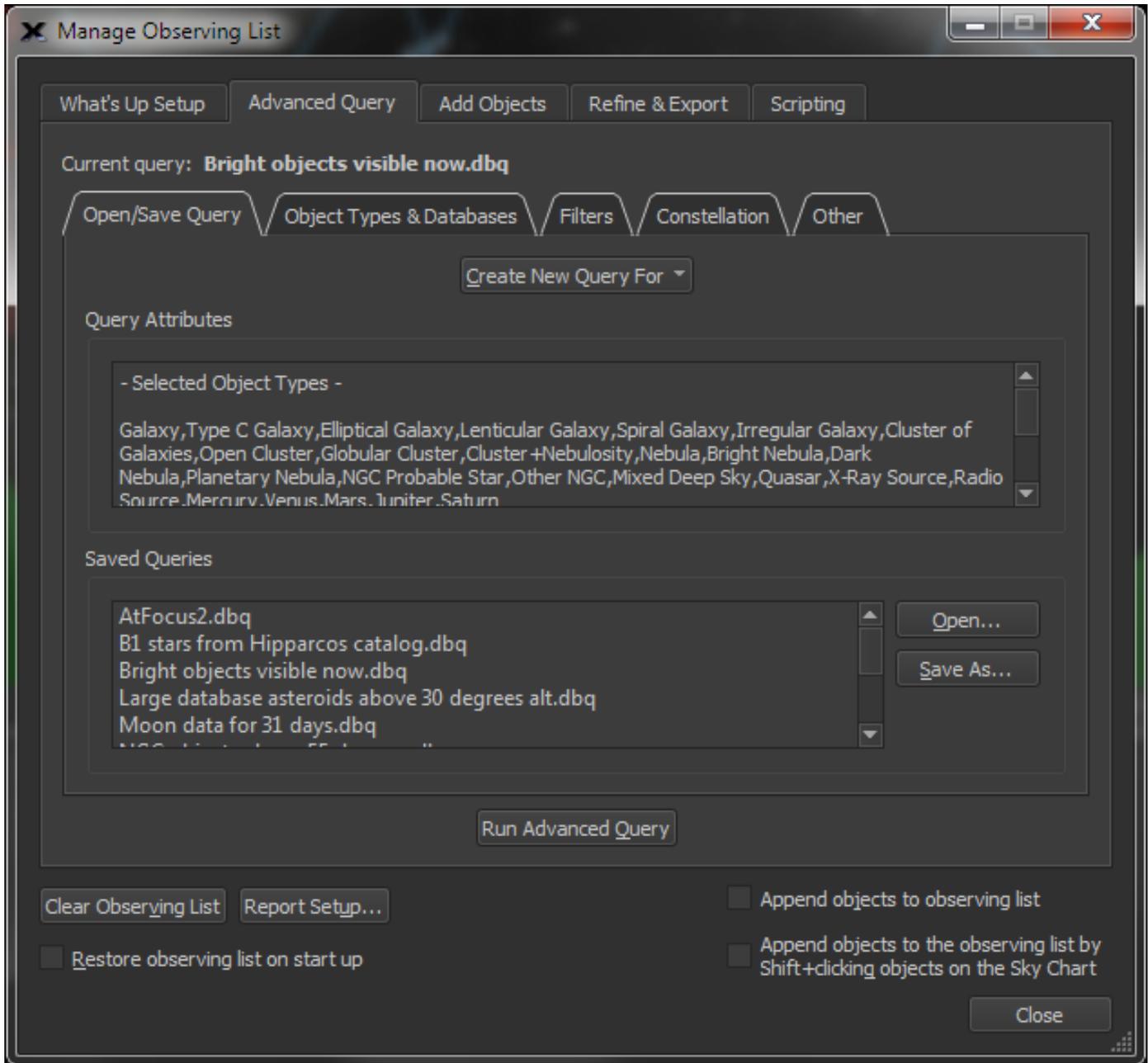


Figure 123: Advanced Query pane on the Manage Observing List window (*Manage Observing List* command, *Tools* menu).

**Run Advanced Query**

Click this button to begin searching for objects based on the specified query attributes.

**Clear Observing List**

Click the **Clear Observing List** button to remove all objects from the current observing list.

### **Report Setup**

Click the **Report Setup** button to define the object parameters that appear in an observing list. For example, the list might contain only object names, or it can include as many additional properties as desired.

### **Append Objects to the Observing List**

Turn on this checkbox to generate an observing list from multiple queries. The results of each successive query are added to the end of the current observing list.

### **Append Objects to the Observing List by SHIFT+Clicking Objects on the Sky Chart**

When this checkbox is turned on, objects can be added to the observing list by holding down the Shift key and then clicking objects on the Sky Chart.

### **Open/Save Query Tab**

Here, you will see advanced (or **Saved**) queries available to you. You can open queries by double-clicking on the query name in the **Saved Queries** list (the **Current Query** shows the name of the currently loaded query settings file), save current query settings by clicking the **Save As** button, or create new ones by clicking one of the options in the **Create New Query For** pop-up menu.

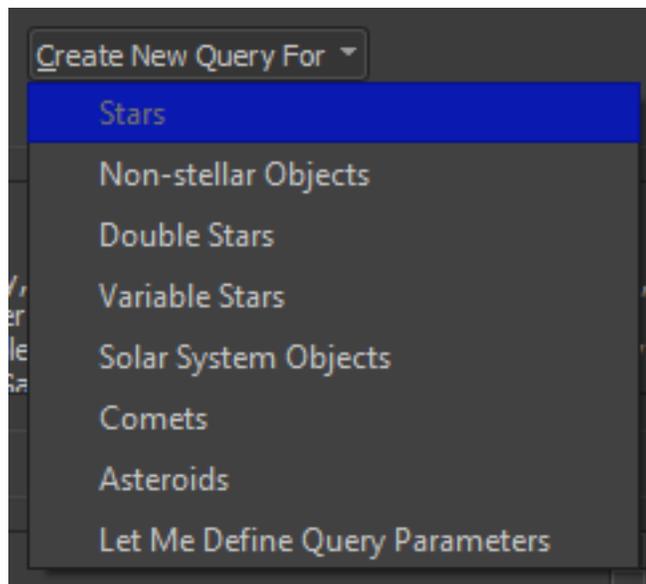


Figure 124: The **Create New Query For** pop-up menu.

### **To Create a New Query**

Click the Create New Query pop-up menu.

Select from one of the pre-defined queries to setup a query for that object type. Or click the **Let Me Define Query Parameters** command to clear any existing query settings and start from scratch.

### **Query Attributes**

The **Query Attributes** report shows the selected object types, databases filters that will be used for the current query.

### **Saved Queries**

The **Saved Queries** list shows supplied queries (files that have the database query or *.dbq* file extension) and the queries that you have generated and saved. To open a query, double-click its name in the list, or click the **Open** button and then select it from the **Open Database Query** window.

### **Saving Queries (Save As)**

Click the **Save As** button to name a query.

## **Object Types & Databases Tab**

Here is where you select which types of objects you wish to include in your query, along with from which databases you would like to search.

It's best not to mix object types in your query. For example, it's not a good idea to create a single query for asteroids *and* spiral galaxies. These object types are distinct and need separate queries.

### **Filters Tab**

Under this tab, you can select from a thoroughly customizable list of filter options to narrow your query parameters. All current filters can be edited or removed at any time by using the corresponding buttons found in the **Current Filters** section.

### **Constellations Tab**

This tab allows you to specify a specific constellation, or group of constellations, to search.

### **Other Tab**

This tab includes miscellaneous options that allow you to provide a text description of the query, choose among search criteria related to the Sky Chart, set queries to run automatically at given times, and to determine imaging availability of objects sorted by the query.

## **Observing List Example**

Let's go through the steps involved in running an advanced query. Suppose you want to create an observing list that contains all the *double stars* from the *Washington Catalog of Double Stars* that have a *spectral type* of G5 in *Orion*.

*TheSkyX* makes generating an observing list from this complex query relative simple.

1. Select the **Manage Observing List** command in the **Tools** menu.
2. Click the **Advanced Query** tab.
3. On the **Advanced Query** tab, click the **Create New Query For** pop-up menu.
4. Select the **Double Stars** command. Double stars from the WDS (Washington Catalog of Double Stars) database are automatically selected for you in the **Object Types & Databases** tab.

5. Click the **Filters** tab to define a filter that limits our search to just the G5 double stars. In the **Attributes** list, expand **Double Stars**, then select **Spectral Type** and click the **Create Attribute Filter** button.

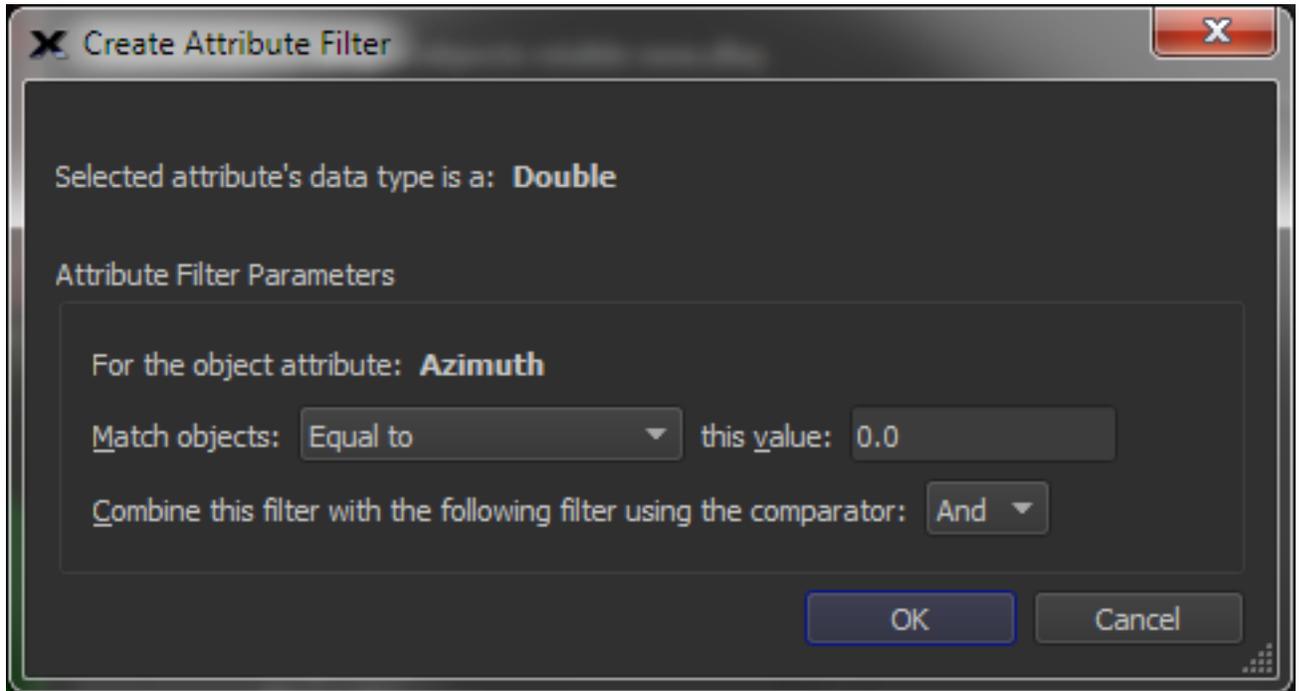


Figure 125: The Create Attribute Filter window.

6. On the **Create Attribute Filter** window, select the **Equal To** command from the **Match Objects That** pop-up menu.
7. Type the text **G5** into the **This Value** text input and click **OK**.
8. On the **Constellations** tab, click the **None** button, then turn on the check mark next to **Orion**.
9. On the **Open/Save Query** tab, click the **Save As** button, and specify the name of this query as **G5 Double Stars in Orion**. It's always a good idea to save your work.
10. Click the **Run Advanced Query** button to run the query and create the observing list on the **Observing List** window (**Display** menu).

The Observing List window now shows forty-three G5 double stars in Orion.

When you highlight an object in the Observing List, the green laser pointer will direct you to it in the Sky Chart.

The **Show on Sky Chart** pop-up menu affects how the object is shown in the Sky Chart. You can choose among **Wide-field view**, **Constellation view**, **Small-field view**, or **Do not show** at all.

- Click the **Center** button to center the object in the Sky Chart's field of view.
- Click the **Copy Text** to copy the object text to the clipboard.
- **Print Information** lets you print out the data from the list about the object.

- If you would like to slew a connected telescope to the object, simply click **Slew** to make it so.

## **Observing List Window**



The Observing List window lets you create, edit, and manage objects your observing lists.

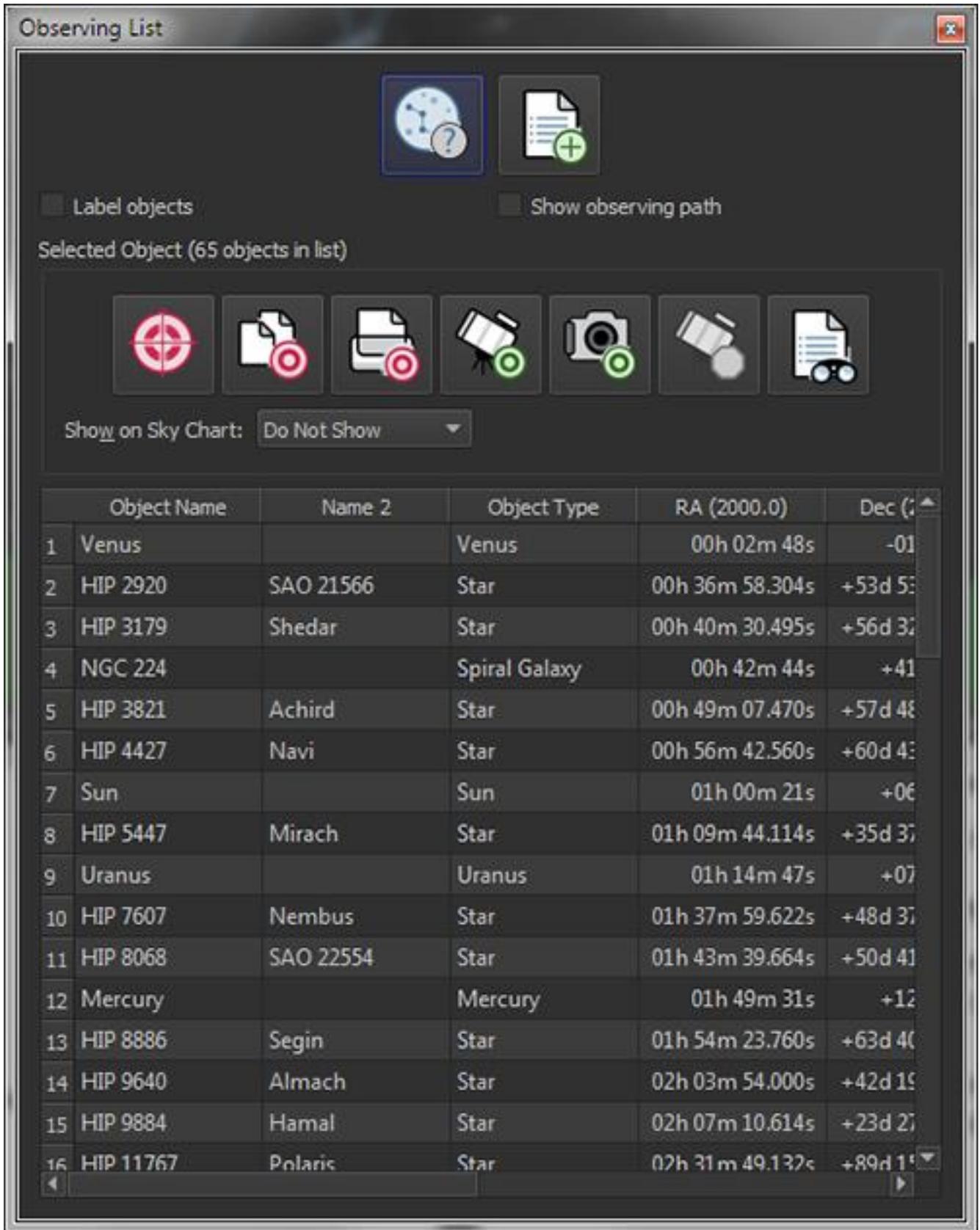


Figure 126: The Observing List window (Observing List command from the Display menu).

Observing lists can be created from *TheSkyX* in several different ways:

- **Manually add items:** For each object in the list, double-click **<Add>** on the spreadsheet control, enter the name of the object and the press the Return key (Enter key on Windows).
- **What's Up?:** Click the **What's Up?** button located on the top left of the window to generate a list of objects (page 103).
- **Manually type or paste a list of object names from the Clipboard:** Click the **Manage Observing List** button on the top of the Observing List window, then click the **Add Objects** tab. From here, you can type the list of object names, or paste a list of names that have been copied to the Clipboard by clicking the **Paste Object Names** button. When the list is complete, click the **Add Objects to Observing List** button to update the Observing List spreadsheet.
- **Create an advanced query:** Click the **Manage Observing List** button on the top center of the window to define simple or extremely complex database queries that produce exactly the observing list you need. See "*Observing Lists*" on page 288 for details.

#### ***Labeling Observing List Objects (Label objects in observing list)***

Turn this option on to display a text label next to each object in the observing list.

#### ***Draw a Line Between Observing List Objects (Draw a line connecting list objects)***

Drawing a line that connects each object in the list helps visualize the path the telescope must take to view each object in the list.

#### ***Centering Objects in the List (Center)***

Highlight an object in the list, then click the **Center** button to center this object in the Sky Chart. The chart's field of view stays the same.

#### ***Copying Object Information to the Clipboard (Copy Text)***

Highlight an object in the list, then click the **Copy Text** button copy the object's information to the Clipboard. This text report can be pasted into any text editor.

#### ***Print Information***

Click this button to print the **Object Information Report** for selected observing list object on the default printer.

#### ***Slew the Telescope (Slew)***

Slew the telescope to the selected object.

#### ***Add Observing Notes (Add to Observer Log)***

Use the **Observing Log** window to keep a track of the objects you have observed. You can even rate the object and seeing conditions, as well as add personalized notes.

Select the observed object in the list, then click the **Add Observer Log** button to show the **Edit Observation** tab of the **Observer Log** window.

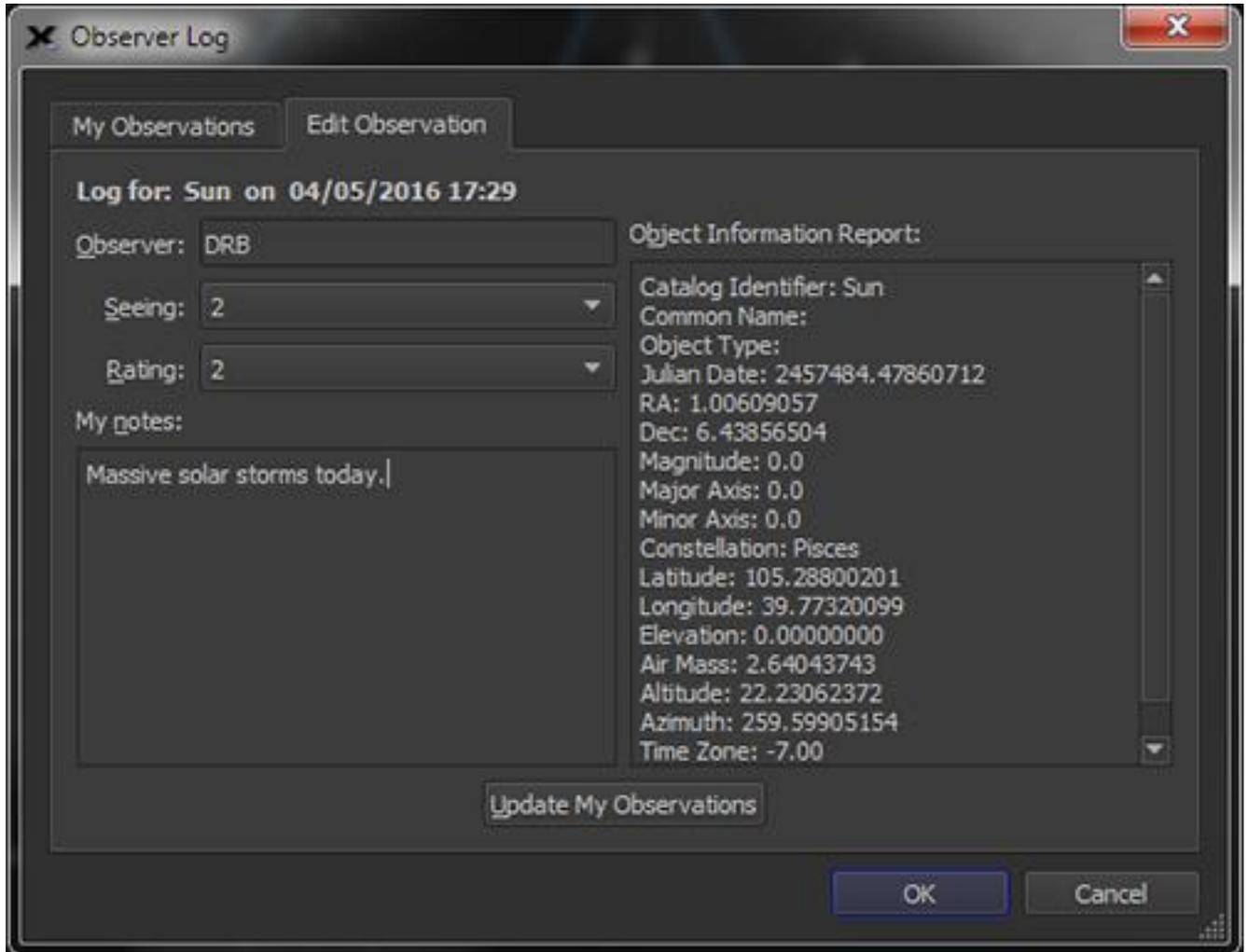


Figure 127: The Edit Observation tab on the Observing Log window (click the Add Observer Log button on the Observing List window to view this window).

***Name of the Observer (Observer)***

Type your name, or the list of observers' names, here.

***Rate the Current Seeing Conditions (Seeing)***

Atmospheric turbulence, moisture, light pollution, and many other factors influent local *astronomical seeing* conditions. Seeing conditions are typically rated on a scale from 1-5, the higher the rating, the better the seeing.

***Rate the Current Object (Rating)***

Like rating seeing, the subjective quality or appearance of the object that you're observing can also be rated. Again, a higher the number indicates a better rating.

***Enter Personal Comments (My notes)***

Critique the observed object by typing your notes here.

### Updating the Observations Table (Update My Observations)

Click this button to add notes, ratings, and object information to the table on the **My Observations** tab.

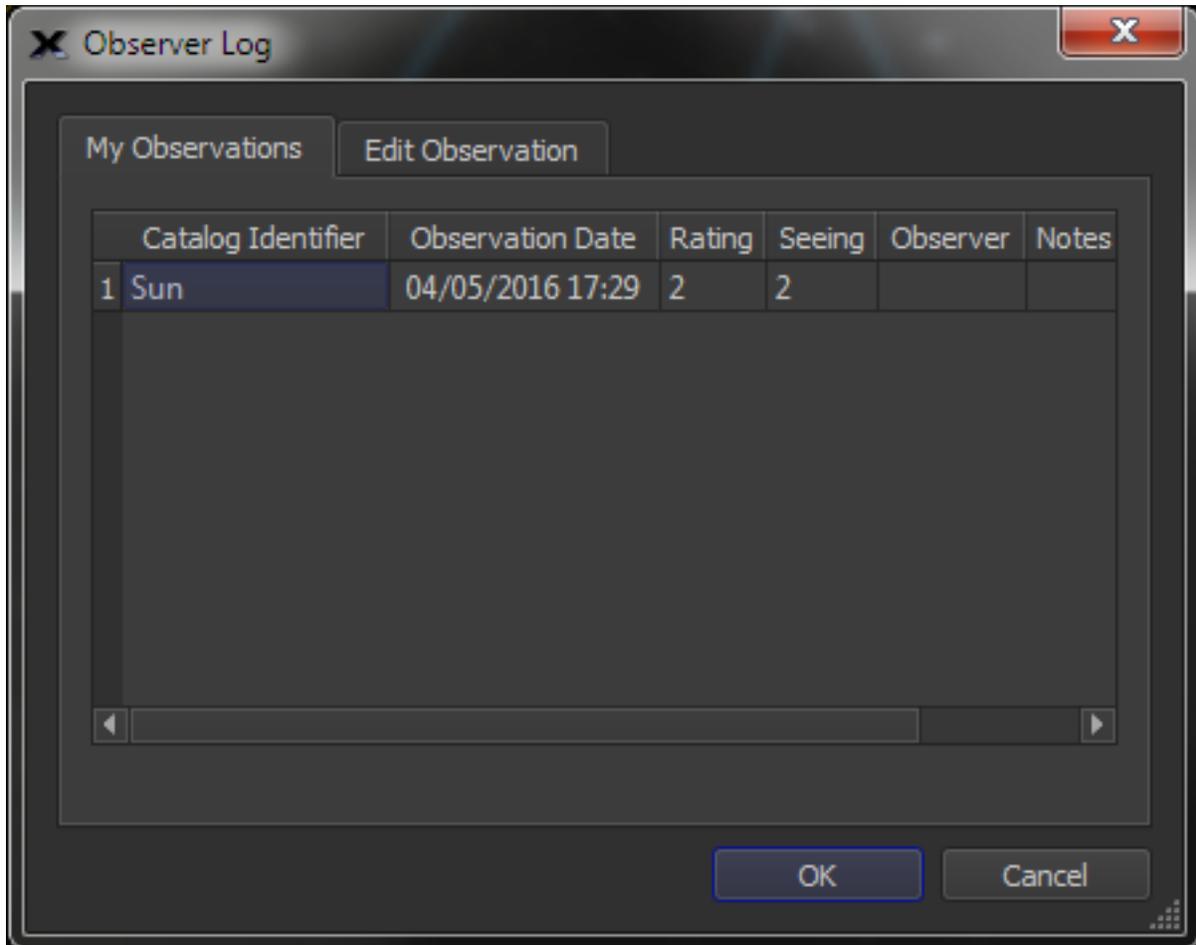


Figure 128: The *My Observations* tab on the *Observer Log* window (click the *Add Observer Log* button on the *Observing List* window to view this window).

The **My Observations** table shows the list of objects that you have observed. The **Observing List** table shows an icon next to objects to indicate they have been observed.



Figure 129: This graphic is displayed next to observing list objects after adding or editing an observation.

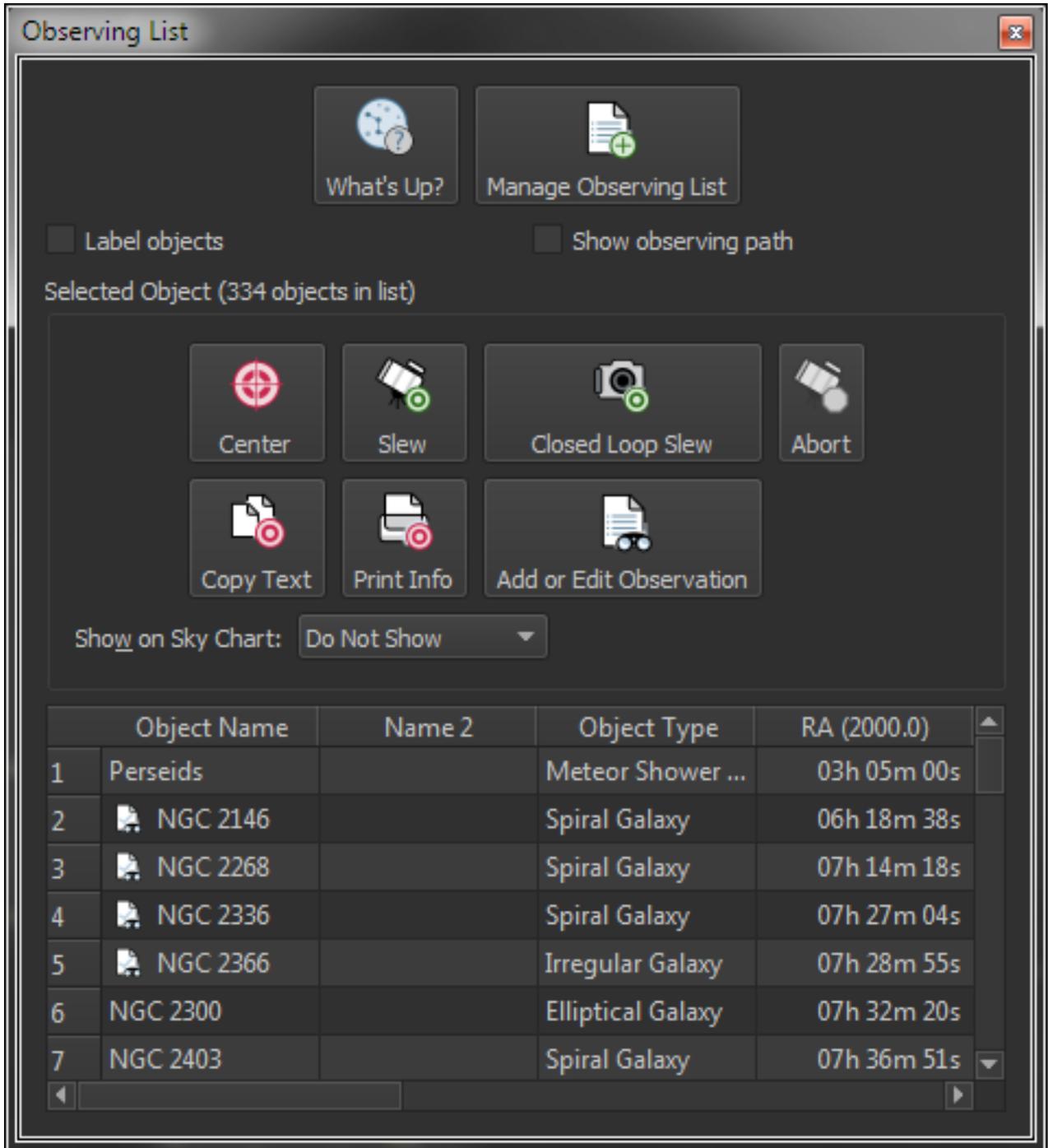


Figure 130: Objects that have been observed include the observation check mark icon next to them in the Observing List.

To permanently remove an observation from the list, select it and press the DELETE key.

### **Manage Observing List Window Orientation**

The orientation and position of the controls in the Observing List stacked window changes based on the window's *aspect ratio* (that is, the ratio of the height to the width of the window).

This allows the Observing List window to float in a vertical orientation or be docked to the left or right side of the main window. The window can also float in a horizontal orientation or be docked to the bottom of the main window.

You can choose which orientation works best for your workflow and hardware (screen size, aspect ratio, resolution, number of screens, etc.).

By default, the Observing List window is docked to the left side of *TheSkyX's* main window in the vertical orientation. To undock it, first make sure it's the topmost stacked window by clicking on the **Observing List** tab on the left side of the window. (Click the **Observing List** command from the **Display** menu to turn it on if necessary.)

Once visible, click and drag the topmost portion (the *caption*) of the Observing List window and move it off the stacked windows.

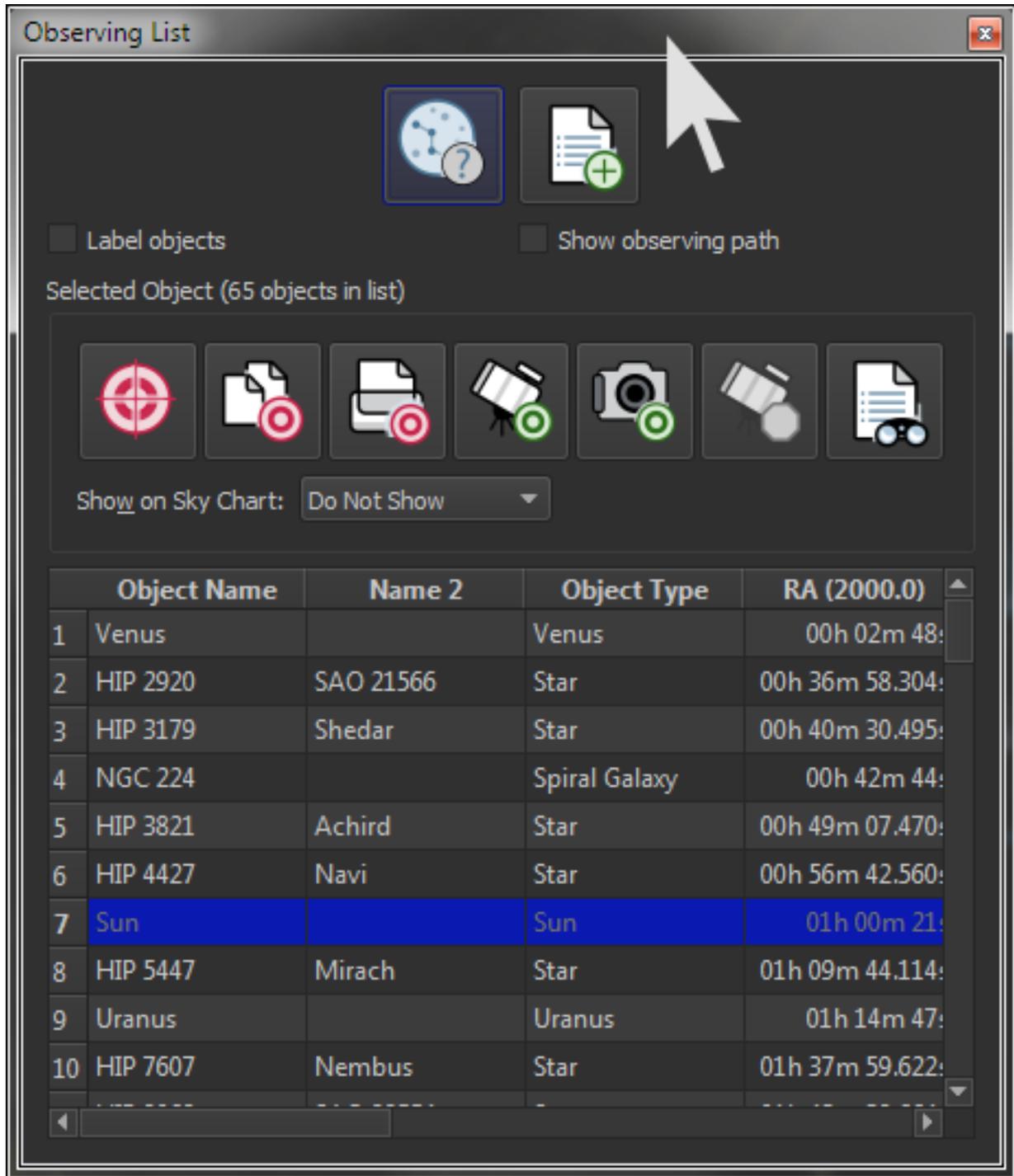


Figure 131: Click and drag the mouse on the Observing List window to move it.

The window can now be positioned where you want, even on a second monitor (if you're lucky enough to have two!).

**Horizontal Orientation**

The controls on the Observing List window automatically switch between the vertical and horizontal orientation as the window is sized.

When the window is taller than it is wide, the controls appear in a vertical orientation. When the window is wider than it is tall, *and* the window is wide enough to fit the controls in a horizontal orientation, the controls are automatically repositioned.

To make the Observing List controls appear a horizontal orientation, click the lower right corner of the Observing List window (or the size control in the lower right corner on the Mac) and drag the window wider (while not making it taller). Once the window is wide enough to fit the controls horizontally, they're repositioned automatically.

When the Observing List window is in the horizontal orientation, it can also be "docked" to the bottom of the main window (see Figure 132). To dock it to the bottom of the main window, click and drag the caption to the center of the bottom of the main window. When the top of the caption is near the bottom of the main window, positions of the Sky Chart and stacked windows are adjusted to make room for the Observing List window. At this point, release the mouse to dock the window.

### ***Observing List Orientation Notes***

The Observing List window cannot be docked to the bottom of the window when the Observing List controls are in the vertical orientation.

The main window will not allow the Observing List window to be docked at the bottom if there's not enough room for it to fit. So, maximize the main window before attempting to dock the horizontal Observing List window.

The Chart Status Window can be closed or undocked to make room, if necessary. If all attempts at "bottom docking" fail, then close all other stacked windows. If the window refuses to dock, it means there is insufficient screen real estate for this control to be placed at the bottom of the window.

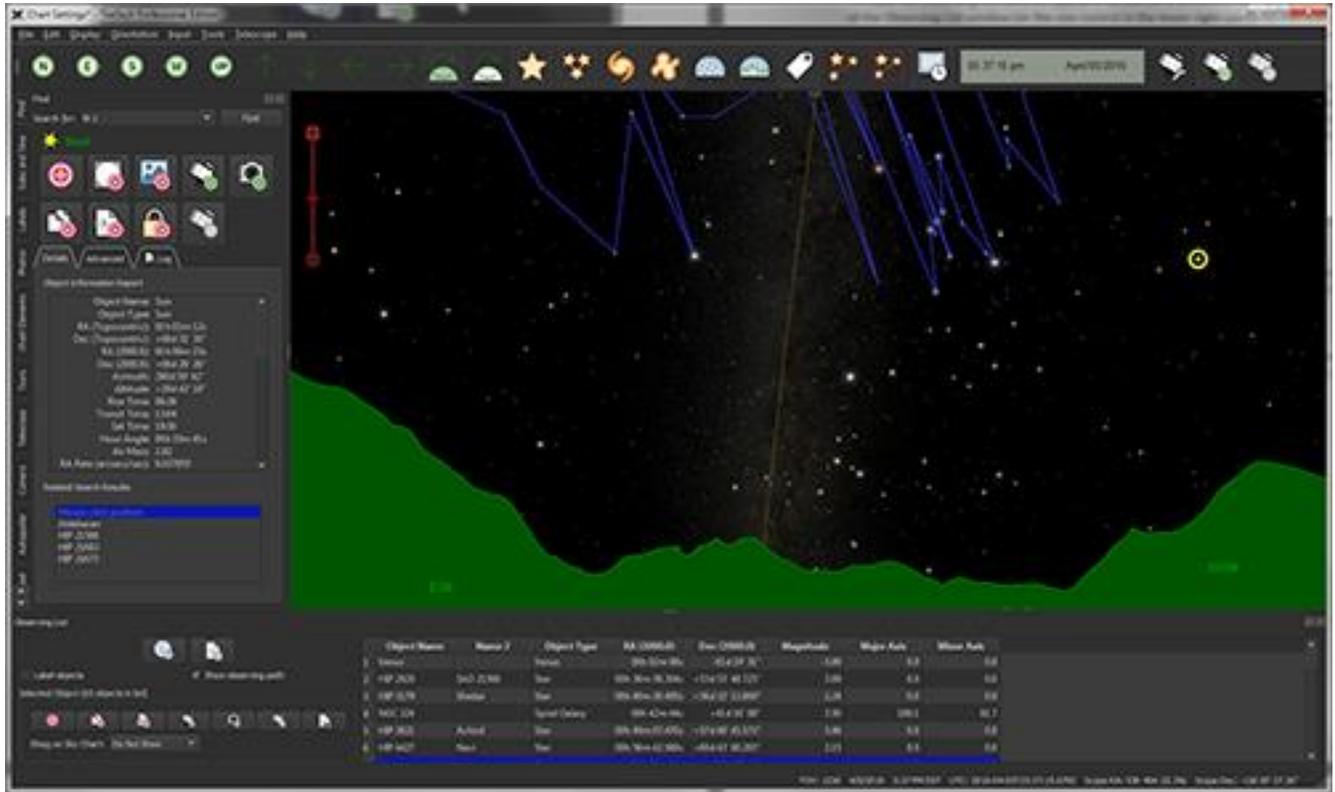


Figure 132: The Observing List controls in a horizontal orientation and docked to the bottom of the main window.

This configuration allows you to access items in the observing list while viewing the Sky Chart and still have access to the controls in the other stacked windows.

## Creating Sky Chart Mosaics

PROFESSIONAL



The **Mosaic Grid** command on the **Tools** menu can be used to divide a rectangular area of the sky into smaller rectangular regions (called *tiles*), each of which has the dimensions of a selected field-of-view indicator (FOVI) or any other custom size. Once the mosaic is created, you can slew the telescope to the center of any rectangle simply by clicking on it.

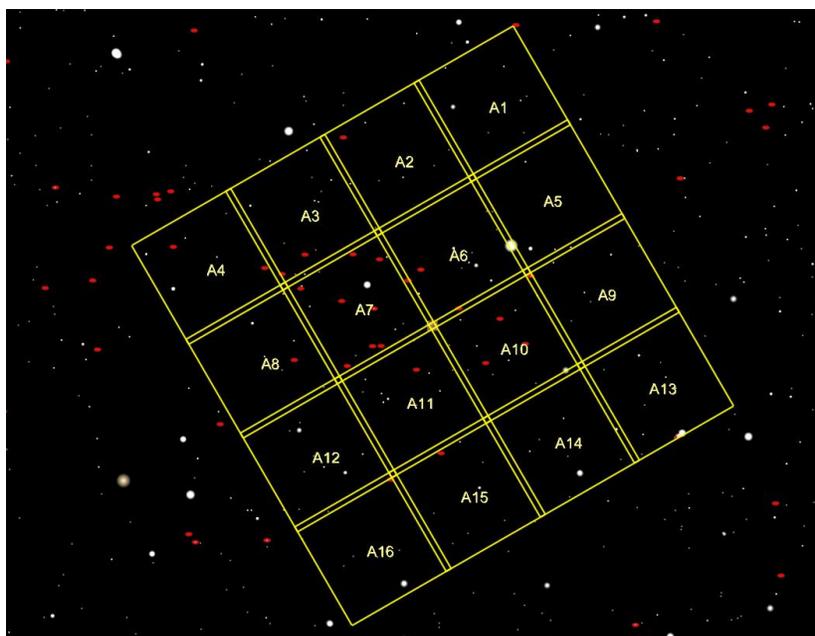


Figure 133: Sample mosaic grid on the Sky Chart.

1. Select the ***Mosaic Grid*** command from the ***Tools*** menu to show the ***Mosaic Grid*** window.

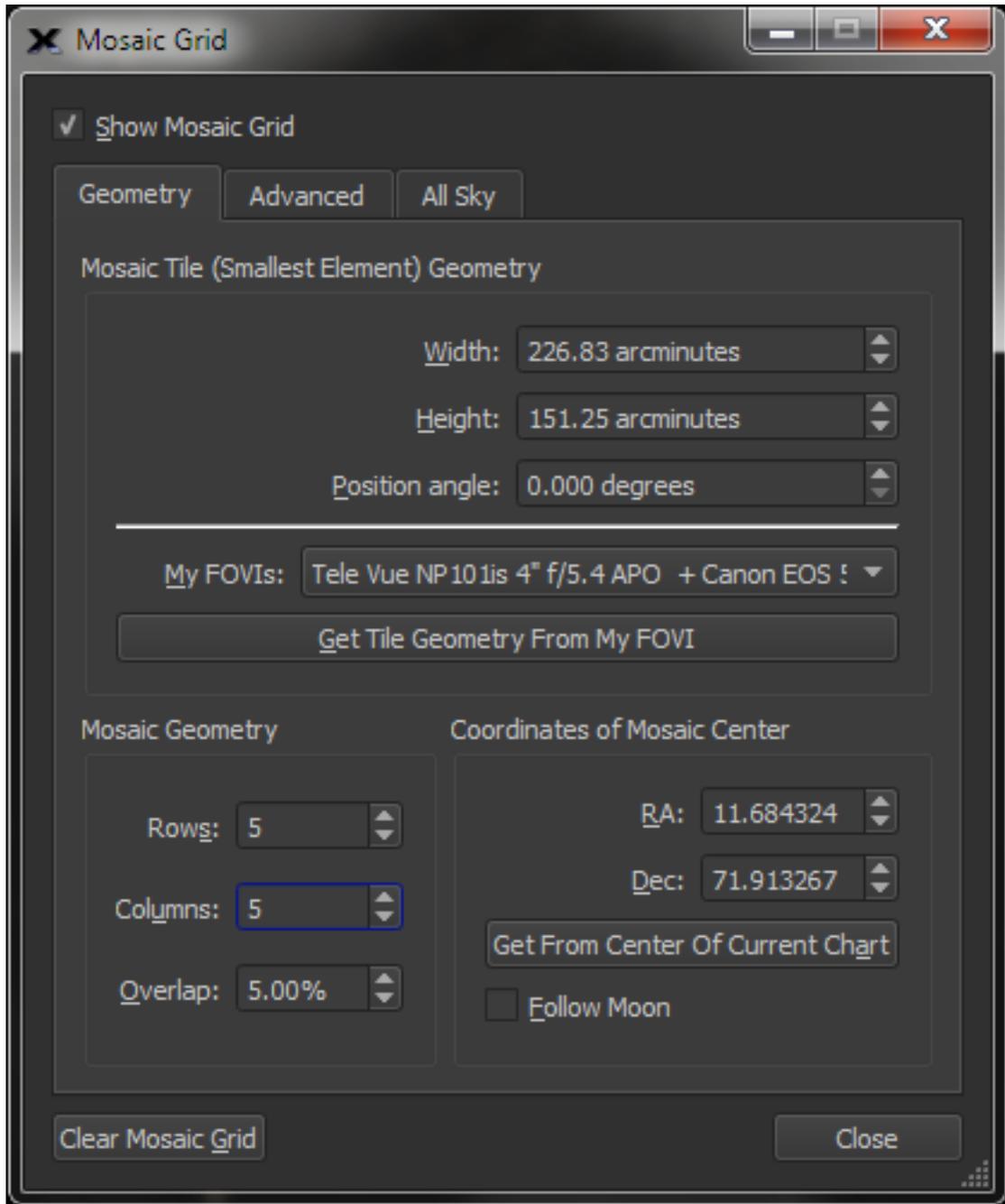


Figure 134: The Mosaic Grid window.

### **Mosaic Tile Geometry**

Use the options on the **Geometry** tab to define the **Width** and **Height**, in arcminutes, of each mosaic tile and each tile's rotation, or **Position Angle**, in degrees, measured counterclockwise from North. You can optionally select a field of view indicator in the **My FOVIs** list.

Next, enter the number of **Rows** and **Columns**, the **Overlap** of the *primary* mosaic grid and the grid's position on the celestial sphere, equatorial coordinates.

Turn on the **Follow Moon** checkbox so that *TheSkyX* will slew to the current position of the Moon, instead of a fixed equatorial coordinate.

Turn on the **Show Mosaic Grid** checkbox to show the mosaic grid then click the **Create and Show Mosaic Grid** button to center and frame the mosaic on the Sky Chart.

2. **Click the Advanced tab.** The **Advanced** pane can be used to create a duplicate of the primary mosaic grid on the Sky Chart that is at a specific X and Y offset from the primary grid.

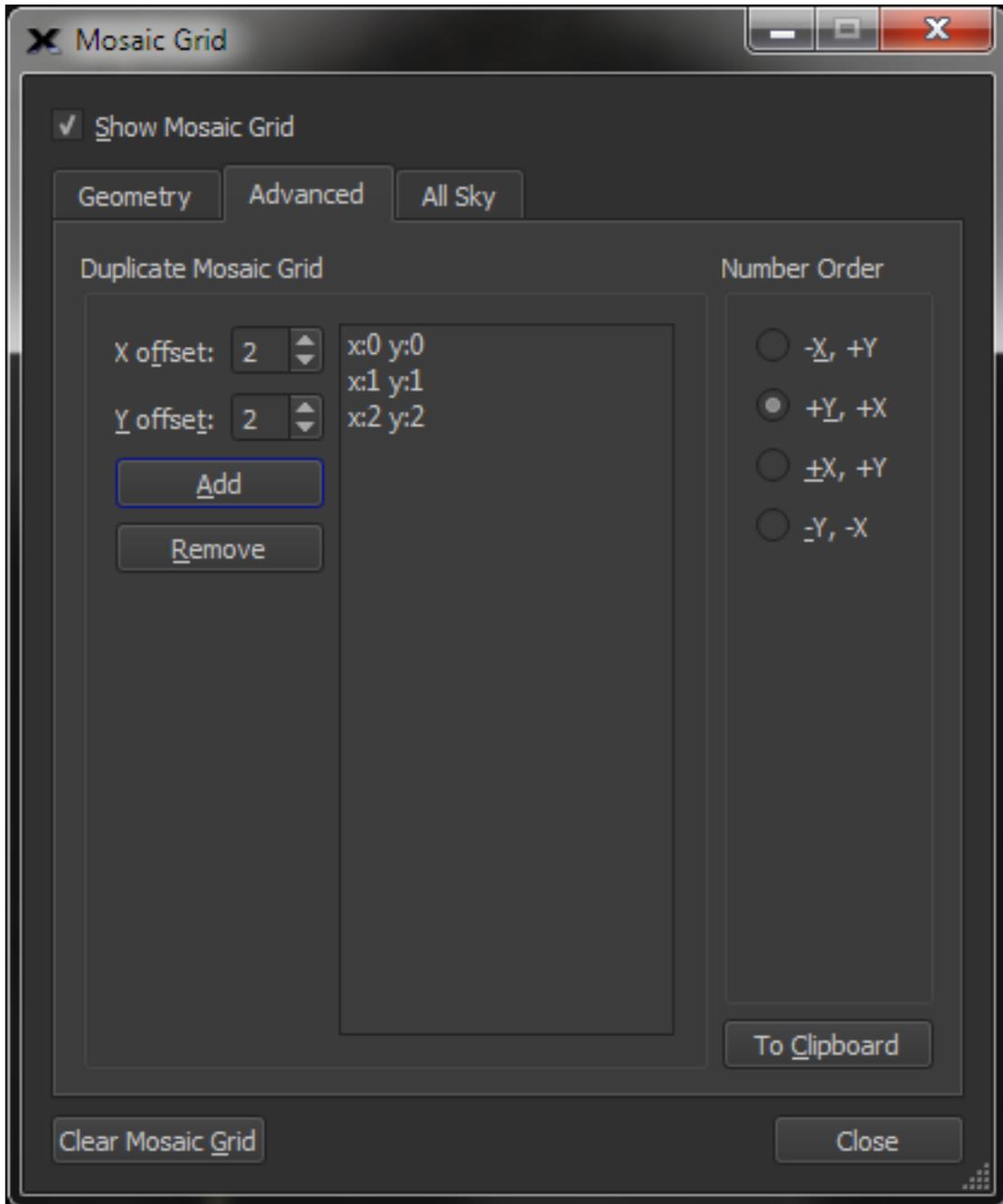


Figure 135: Advanced tab on the Mosaic Grid window.

Enter the horizontal (x-axis) and vertical (y-axis) offset for the new mosaic. The offset unit is defined as the “width of the primary mosaic.” A value of 1 in the “X offset” will place the replicated mosaic’s upper left corner next to the primary mosaic’s upper right corner. (The offset is always relative to the upper left corner of the primary mosaic.)

An offset of 0, 0 is allowed and will place another mosaic on top of the primary mosaic. The mosaics centers are numbered starting at one through the total number of mosaic regions. Mosaics are ordered alphabetically.

Click the “Add” button to create the new mosaic and add the offset to the mosaic replication list.

3. Specify the numbering convention for the mosaic centers.

- **-X, +Y:** Mosaic center numbers are incremented *right to left* by row, starting in the upper left corner of the mosaic.
- **+Y, +X:** Mosaic center numbers are incremented *top to bottom* by column, starting in the upper left corner of the mosaic.
- **+X, +Y:** Mosaic center numbers are incremented *left to right* by row, starting in the upper right corner of the mosaic.
- **-Y, -X:** Mosaic center numbers are incremented *bottom to top* by column, starting in the lower left corner of the mosaic.

**To Clipboard Button**

Click the button to copy the equatorial coordinates of the centers of selected mosaic to the Clipboard. These coordinates can be used to generate a script that slews your telescope to each position.

Sample mosaic grid data:

|    |   |    |            |              |
|----|---|----|------------|--------------|
| 1  | A | 0  | 9.32121655 | -29.04969590 |
| 2  | A | 1  | 9.32119169 | -28.89969638 |
| 3  | A | 2  | 9.32116702 | -28.74969737 |
| 4  | A | 3  | 9.32114254 | -28.59969785 |
| 5  | A | 4  | 9.30977751 | -29.04991248 |
| 6  | A | 5  | 9.30976922 | -28.89991265 |
| 7  | A | 6  | 9.30976100 | -28.74991333 |
| 8  | A | 7  | 9.30975284 | -28.59991349 |
| 9  | A | 8  | 9.29833849 | -29.04991248 |
| 10 | A | 9  | 9.29834678 | -28.89991265 |
| 11 | A | 10 | 9.29835500 | -28.74991333 |
| 12 | A | 11 | 9.29836316 | -28.59991349 |
| 13 | A | 12 | 9.28689945 | -29.04969590 |
| 14 | A | 13 | 9.28692431 | -28.89969638 |
| 15 | A | 14 | 9.28694898 | -28.74969737 |
| 16 | A | 15 | 9.28697346 | -28.59969785 |

### **Reset Slewed**

Once you have slewed your telescope to a given frame, parentheses are placed around the number in the center of the block, indicating that this frame has been imaged. If you wish to start the mosaic process over, click this button to clear all the parentheses.

### **All Sky Mosaic Grid**

*TheSky Professional Edition* can create a mosaic grid that covers the entire celestial sphere (or, optionally just the northern half of the celestial sphere). The grid can aid in producing an all sky photograph or performing an all sky survey.



*The maximum number of frames in an all sky mosaic grid is limited to about 15,000 frames. This means each frame must cover about four square degrees or more, depending on the overlap.*

For each frame generated, the camera position angle is assumed to be north up, or north down. The grid computations do not consider camera rotation angles outside these two orientations.

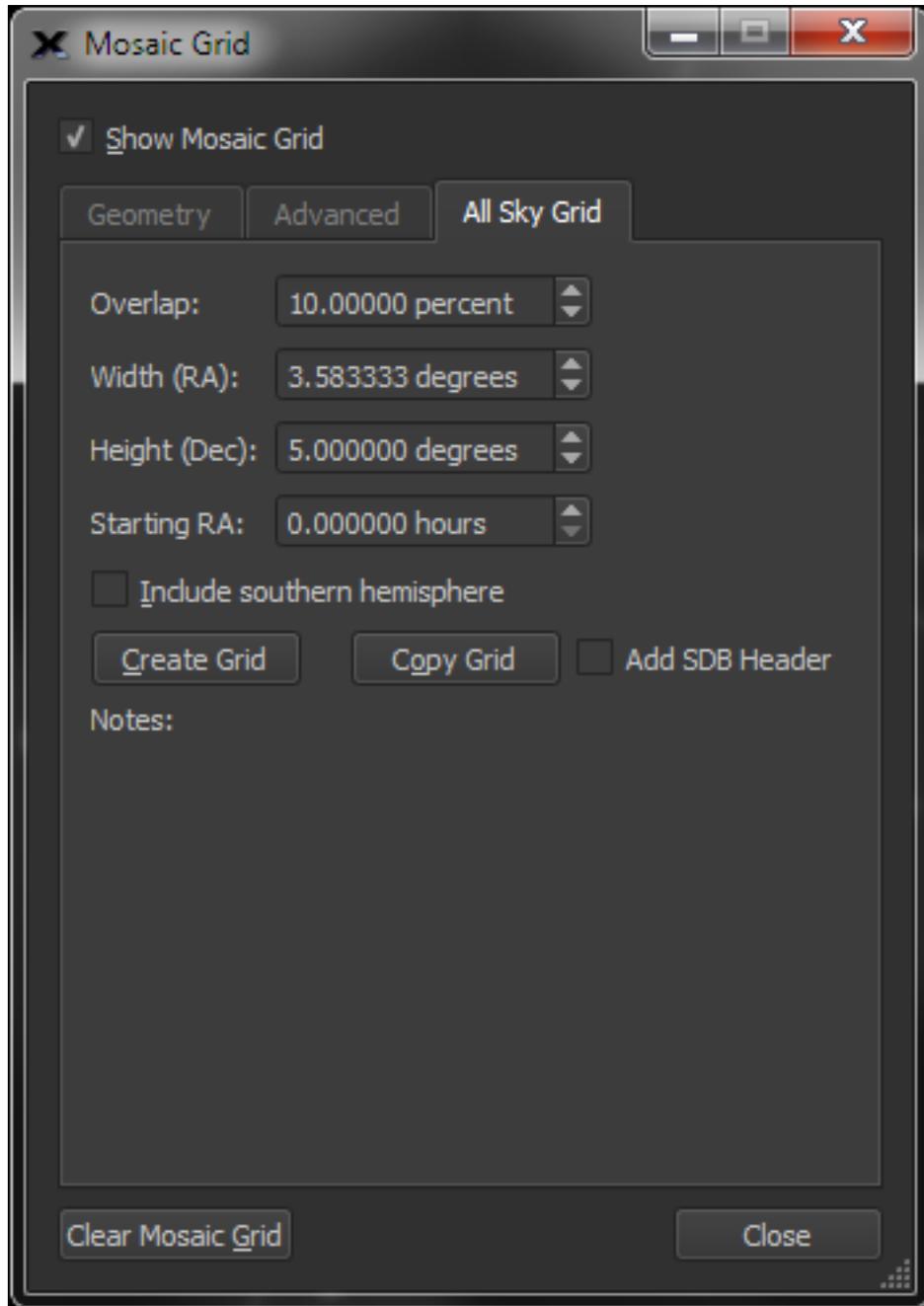


Figure 136: The All Sky Grid pane.

**Overlap**

Enter the percentage of overlap for each tile in the mosaic grid.

**Width (RA)**

Enter the angular width, in degrees, of each tile.

Near the celestial equator, the distance around the celestial sphere is nearly 360 degrees, so the number of frames will be near 360 divided by the **Width (RA)** value. As the declination increases,

or decreases, the number of frames around the particular declination decreases. Each declination band starts at RA 0.0, unless a different value is entered in the **Starting RA** text box.

Once a grid is computed, it will be displayed on screen, and the text on the **Create Grid** button changes to **Clear Grid**.

### **Height (Dec)**

The celestial sphere is divided into declination “bands” based on the Height (Dec) input value and the overlap percentage. For example, a Height of 5 degrees with a 10% overlap will yield declination bands that are spaced at 4.5-degree intervals.

### **Starting RA**

Enter the right ascension, in decimal hours, to start the all sky grid.

### **Create Grid**

Click this button to create a mosaic grid that covers the northern hemisphere using the FOVI from the **Geometry** pane.

### **Include Southern Hemisphere**

Turn on this checkbox to create the grid for the entire celestial sphere.

### **Copy Grid**

Click this button to copy the grid centers to the Clipboard in XML. This format can be used to quickly generate a Sky Database of the grid, or imported into a spreadsheet application.

```
<?xml version="1.0"?>
<!DOCTYPE TheSkyDatabase>
<TheSkyDatabaseHeader version="1.00">
  <identifier>Mosaic</identifier>
  <sdbDescription>Locations of Mosaic centers</sdbDescription>
  <specialSDB>0</specialSDB>
  <plotObjects>1</plotObjects>
  <plotLabels>1</plotLabels>
  <plotOrder>0</plotOrder>
  <searchable>1</searchable>
  <clickIdentify>1</clickIdentify>
  <epoch> 2000.0</epoch>
  <referenceFrame>0</referenceFrame>
  <crossReferenceType>0</crossReferenceType>
  <defaultMaxFOV> 360.0000</defaultMaxFOV>
  <defaultObjectType index="62" description="Mosaic
point"></defaultObjectType>
  <raHours colBeg="12" colEnd="23"></raHours>
  <decDegrees colBeg="25" colEnd="36"></decDegrees>
  <majorAxis colBeg="38" colEnd="43"></majorAxis>
  <minorAxis colBeg="45" colEnd="50"></minorAxis>
  <positionAngle colBeg="52" colEnd="57"></positionAngle>
  <labelOrSearch colBeg="1" colEnd="10"></labelOrSearch>
  <sampleColumnHeader>
;dentifier RA Dec;-----
</sampleColumnHeader>
```

</TheSkyDatabaseHeader>

| Identifier | RA          | Dec        | Wid    | Ht     | PA   |
|------------|-------------|------------|--------|--------|------|
| Mp0        | 11.68432400 | 0.00000000 | 226.83 | 151.25 | 0.00 |
| Mp1        | 11.92194776 | 0.00000000 | 226.83 | 151.25 | 0.00 |
| Mp2        | 12.15957152 | 0.00000000 | 226.83 | 151.25 | 0.00 |
| Mp3        | 12.39719529 | 0.00000000 | 226.83 | 151.25 | 0.00 |
| Mp4        | 12.63481905 | 0.00000000 | 226.83 | 151.25 | 0.00 |
| Mp5        | 12.87244281 | 0.00000000 | 226.83 | 151.25 | 0.00 |
| Mp6        | 13.11006657 | 0.00000000 | 226.83 | 151.25 | 0.00 |
| Mp7        | 13.34769034 | 0.00000000 | 226.83 | 151.25 | 0.00 |

### **Add SDB Header**

When the **Copy Grid** button is clicked, and this checkbox is turned on, the grid center positions are copied to the Clipboard in an XML format so that the grid can be compiled and displayed as a Sky Database (page 274).

## **Using the Mosaic Grid**

Once a link with the telescope is established, click anywhere within one of the mosaic tiles, and the telescope will automatically slew to its equatorial center.

If you are viewing or photographing the Moon, turning on the **Follow Moon** checkbox. The telescope's tracking rate will automatically be set to the lunar rate. (The previous rate is restored when the mosaic is removed.)

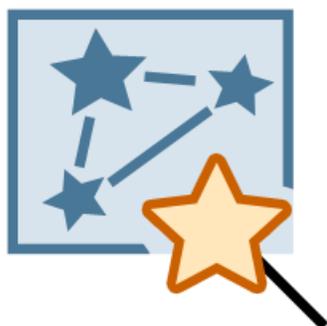
Although each tile is numbered sequentially, you can slew to them in any order. (If *TheSkyX*'s window is not maximized, or the field of view is too small, the numbers might not be displayed to avoid screen clutter.) A selected frame's border changes color from magenta to red, to indicate that it has been "visited." To reset each tile to its original color, click the **Reset Slew** button.

If you are using the Mosaic Grid feature to take pictures, the CCD or DSLR camera must be aligned with the mosaic frames. You must therefore either position the camera to align it with the Sky Chart, or orient the Sky Chart to the camera. *TheSkyX* can help you. Use Image Link to align one of your photographs with the Sky Chart, the "Image Link Information" gives the orientation of the image as an angular offset from North. You can then adjust the camera mount or the Sky Chart's orientation accordingly.

The Mosaic feature works best with equatorial telescopes. Azm/Alt telescopes suffer from field rotation, which causes the field of view to gradually rotate. The severity of this effect varies with the altitude coordinates of the area being photographed, and the length of time needed to complete the photography. A field-rotation corrector might be needed.

## Image Link and Automated Astrometry

PROFESSIONAL



TheSkyX Professional Edition's Image Link™ and automated astrometry feature make it possible to overlay *Flexible Image Transport System* (FITS) photos on the Sky Chart.

Image Link creates an “inventory” of stars and other light sources on the photo, then compares patterns of stars in the photo against known star catalogs to determine the photo's *astrometric solution* (sometimes referred to as a “plate solve”). Once a match is found, the photo can exactly overlay the Sky Chart – stars and galaxies in the photo match the corresponding objects on the Sky Chart.

Image Link can be used with photos from the Digitized Sky Survey for areas of the sky of up to about 2° square, or on your photos up to about ten-degree fields of view.

Your photos become part of the interactive Sky Chart. Objects in the photo can be viewed, labeled and identified, just as if they were part of the Sky Chart.

The astrometric solution can be used to precisely locate the position of variable stars, optical components of gamma ray bursts, supernovae, comets and asteroids. It can also be used to automate calibration runs using the *TPoint Add On*.

### **Photo Requirements**

An astrometric solution can be determined for photos with the following attributes.

- A photo that adheres to the Flexible Image Transport System (FITS) standard.
- A minimum of eight distinct stars in the photo.
- A field of view of *ten degrees* or smaller. For photos with relatively narrow fields of view (10-20 *arcminutes*), Software Bisque recommends using one of the larger star catalogs from *TheSkyX Professional Edition Database Add On* (page 637).

- The approximate equatorial coordinates of the photo must be known or otherwise available.
  - FITS photos acquired with the *Camera Add On* are saved with the telescope's right ascension and declination and the Sky Chart is adjusted to this position when the photo is opened from the *Image Link* window.
  - The Sky Chart must be manually oriented to match the approximate position and field of view of the photo if the FITS header does not include the OBJCTRA and OBJCTDEC keywords. Note that these keywords are automatically added to the FITS header when TheSkyX is connected to a telescope and the Camera Add On acquires the photo.
- The approximate image scale of the photo, in arcseconds per pixel, must be known or computed.



### *Don't know your image scale?*

- The Field of View Indicator Report (page 119) shows the theoretical image scale for your optical setup (camera plus telescope). While the theoretical image scale may exactly match the actual field of view, it is usually close enough for Image Link to find the astrometric solution, and determine the actual image scale.
- All Sky Image Link's *Blind* search option (page 334) determines the image scale empirically.
- All Sky Image Link's *Search A Range of Image Scales* option searches for solutions between a specified lower and upper image scale.

The photo's actual image scale is displayed in the *Status* window after a successful Image Link or All Sky Image Link.

- Square pixels. Determining an astrometric solution from a photo taken with cameras that have rectangular-shaped pixels may fail. If your camera's pixels are not square, make sure to resize the photo so that the pixels are square.

Let's use a FITS photo from the Digitized Sky Survey to demonstrate how Image Link and automated astrometry work together.

1. On the *Find* tab, enter *M81* and then click the *Frame* button. This sets the field of view to about 40 arcminutes and frames M81 on the Sky Chart.
2. Select the *Digitized Sky Survey* command from the *Tools* menu.
3. On the *Setup* tab, turn on the *Web* option to retrieve Digitized Sky Survey photos from the web.
4. On the *Create Photo* tab, click the *Create* button in the *Show in FITS Viewer* section. The photo is downloaded from the web and displayed in the *FITS Viewer* window.
5. On the *FITS Viewer* window, click the *To Image Link* command in the *Photo* pop-up menu. The photo is now displayed in the *Image Link* window. You'll normally open your FITS

photos that are acquired from a CCD or digital camera by clicking the **Open FITS** button on the **Image Link** window.

- Click the **Find Astrometric Solution** button.

The **Astrometric Solution** tab on the **Image Link** window shows the equatorial coordinates of the photo, the scale, position angle and the list of stars used in the solution.

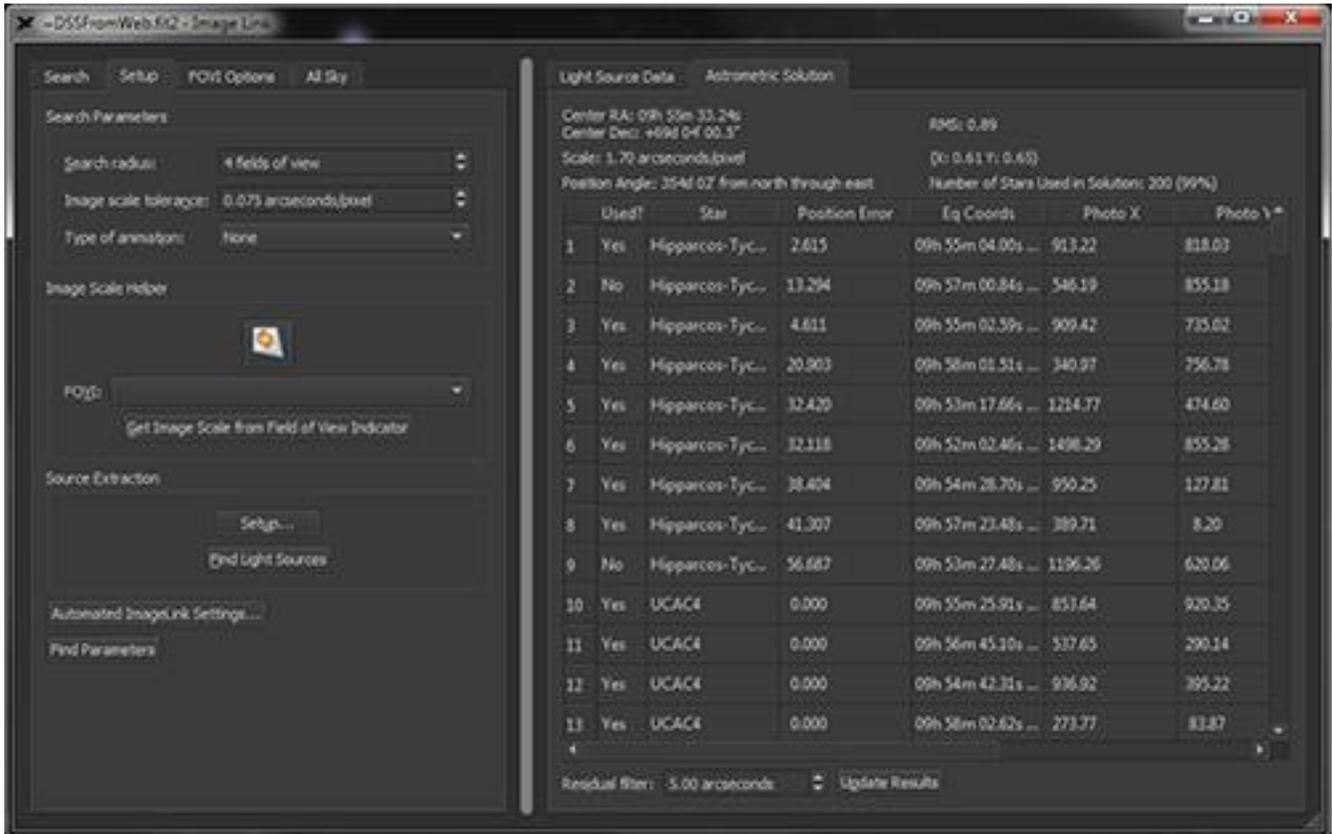


Figure 137: The Astrometric Solution tab of the Image Link window.

The photo of M81 also appears on the Sky Chart at the appropriate location. Turn on the **Show Photo In Front of Chart Elements** option to show the photo “on top of” the other chart elements.



Figure 138: M81 “linked” to the Sky Chart.

The default Image Link settings can be used to perform astrometric solutions on photos acquired from a wide range of optical systems. If an Image Link fails, check the following settings on the **Setup** tab of the **Image Link** window.

## Search Tab

Image Link’s **Search** tab is used to open one or more FITS photos, configure the image scale, initiate the Image Link or astrometric solution, show the progress of the Image Link and define how the photo is displayed on the Sky Chart.

### Open FITS

Click this button to display the **Open FITS** widow and select a FITS photo to Image Link. Multiple photos can be selected and are Image Linked in succession. The results of each photo’s Image Link are displayed in the **Status** text box.



When opening a FITS photo, if the FITS header contains the photo’s equatorial coordinates (specifically, the OBJCTRA and OBJCTDEC keywords), or World Coordinate System (WCS) information, the center of the Sky Chart is automatically adjusted to match these coordinates. The Sky Chart’s field of view is also changed to approximately match the photo’s field of view (based on the value of the image scale).

- When *TheSkyX* is used to control the telescope, the FITS header in photos acquired with the *Camera Add On* use the current position of the telescope for the OBJCTRA and OBJCTDEC keywords.
- If the position of the Sky Chart does not change when a FITS is opened, the photo’s coordinates cannot be determined from the FITS header. In this

case, you'll need to manually center the Sky Chart on the approximate right ascension and declination of the photo to find the astrometric solution.

### ***Find Astrometric Solution***

After opening a FITS photo, and configuring the ***Image Scale***, click this button to start searching for the astrometric solution.

### ***Abort***

The text on the ***Find Astrometric Solution*** button changes to ***Abort*** while Image Link is searching for the astrometric solution. Click it to end the search.

### ***Unknown Scale***

When the ***Unknown Scale*** option is turned on, *TheSkyX must know the approximate image scale of the photo*. Image Link will fail otherwise. Make sure that the ***Image Scale (Best Guess)*** value is "close to" the actual scale (plus or minus two arcseconds per pixel).

Image Link uses the ***Image Scale (Best Guess)*** as a *starting point* to find the astrometric solution of the photo. If a solution is not found using this value, larger and smaller image scale values (based on the ***Scale Tolerance*** on the ***Setup*** tab) are used.

Use the ***Unknown Scale*** option if you do not know the image scale of your optical system. After the astrometric solution is found, turn on the ***Know Scale*** option and click the ***Set*** button to use the image scale that was computed from the astrometric solution.

### ***Known Scale***

When the ***Known Scale*** option is turned on, enter the actual image scale of the photo to plus or minus 0.5 arcseconds per pixel. In contrast to the ***Unknown Scale*** option, the ***Known Scale*** does not perform an iterative search, so Image Link will always fail when the wrong ***Known Scale*** is used.

### ***Image Link Status***

The ***Status*** text box provides diagnostic feedback of the search for the astrometric solution. When an astrometric solution is found, the following information is displayed in the ***Astrometric Solution Results***:

- The equinox 2000.0 right ascension and declination of the photo's center.
- Image scale, in arcseconds per pixel.
- Height and width, in pixels.
- Angular size.
- Position angle, measured counterclockwise from north.
- Shows the total root mean square of the residual errors in the astrometric solution, and the RMS error in each axis.
- The number of cataloged stars used in the solution.
- The full-width, half maximum (FWHM) of the stars in the x- and y-axis.

For example, the solution for M81 displays the following results:

```
***** ASTROMETRIC SOLUTION RESULTS *****
Center RA (2000.0): 09h 55m 22.8s
Center Dec (2000.0): +69° 02' 49.7"
Scale: 1.70 arcseconds/pixel
Size (pixels): 963 x 670
Angular Size: 0° 27' 17" x 0° 18' 59"
Position Angle: 353° 59' from North
RMS: 0.93 (X: 0.71 Y: 0.59)
Number of Stars Used in Solution: 91 (98%)
FWHM: 2.74 pixels, 4.65 arcseconds
*****
```

Image Link Succeeded.

### **Verbose**

Turn this checkbox on to show extra information about the status of the search.

## **Photo Overlay Options**

When Image Link finds the astrometric solution, the Sky Chart is adjusted to exactly match the field of view and the orientation of the photo (even mirrored, if necessary). How the photo appears on the Sky Chart is configurable using the **Photo Overlay Options**.

### **Show Photo**

Turn on this checkbox to show the Image Link photo on the Sky Chart.

### **Percentage of Sky Chart**

This value defines the relative angular size of the photo compared to the Sky Chart's field of view after a successful Image Link. For example, a value of 75% means the Sky Chart's field of view is adjusted so that the resulting Image Link photo overlay occupies 75 percent of the Sky Chart.

### **Show Photo In Front of Chart Elements**

Turn this option on to place the Image Link photo "on top of" the objects and symbols on the Sky Chart. This hides the simulated stars and other elements on the chart.

### **Show Photo behind Chart Elements**

Turn this option on to place the Image Link photo "behind" objects and symbols on the Sky Chart. This option reveals stars and other elements on the chart on the photo.

### **Break Link**

When a photo's astrometric solution is found, the photo is pinned or "image linked" to the Sky Chart so the photo becomes part of the chart. Click this button to break the Image Link so that the photo is displayed in the center of the window and does not move when the position or field of view of the Sky Chart is changed.

### **Close FITS**

Click this button to break the Image Link and remove the FITS photo from the Image Link window.

## **Image Link Setup Tab**

The Image Link options on this tab should be used to configure Image Link settings.

### **Search Radius**

This value defines how far “away” from the Sky Chart’s current coordinates Image Link will search for a matching star field and is based on the photo’s field of view.

When the FITS header includes World-Coordinate System information, or the telescope’s coordinates when the photo was acquired, the Sky Chart is automatically centered at these coordinates when the photo is opened in the **Search** tab. Provided these coordinates are accurate, Image Link should not need to search the nearby region more than 2 fields of view to locate a match.

If the telescope’s coordinates do not match the photo’s actual position (due to inherent pointing errors, for example), then Image Link can be configured to search a region up to 8 field of view from the current Sky Chart position to find a match.

When the photo’s coordinates are not known, if possible, be sure to manually center the Sky Chart as close to the photo’s actual position on the celestial sphere as possible before attempting an Image Link. If the photo contains an unidentifiable star field, use All Sky Image Link (page 332) instead of Image Link.

### **Scale Tolerance**

Image Link needs to know the image scale, in arcseconds per pixel, of the imaging system that produced the photo. If you’re unsure of the exact image scale, enter a higher value for the scale tolerance. Doing so allows Image Link to locate matches by varying the **Image Scale** entered on the **Search** tab.

If you have no idea about the photo’s image scale, use image scale helper options below, or All Sky Image Link (page 332) to determine it for you.

### **Type of Animation**

The Sky Chart can be configured to animate a successful image link.

- **None** produces no animation.
- **Overshoot** zooms and rotates the Sky Chart slightly past the image link position before matching the Sky Chart to the photo.
- **Zoom and Rotate Separately** zooms and rotates the Sky Chart when aligning the Sky Chart to the photo.

### ***Image Scale Helper***

These options can be helpful to determine the approximate image scale of your camera and optical system.

### ***Field of View Indicators Button***

Click this button to show the ***Field of View Indicators*** window (page 119), and, if you have not already done so, create a FOVI based on your equipment.

### ***FOVI Pop-Up***

This pop-up menu lists all of the available FOVIs. Choose the description that best matches your setup.

### ***Get Image Scale From Field of View Indicator***

Click this button to retrieve the select FOVI's image scale and update the Image Scale text box on the Search tab with this value.

### ***Source Extraction***

*Source Extractor* is a powerful photo analysis tool that finds, measures and catalogs the sources of light (stars, extended objects like nebulas, asteroids, etc.) in photos.

### ***Setup***

Click this button to show the Source Extraction Setup window with the configuration settings for this tool.

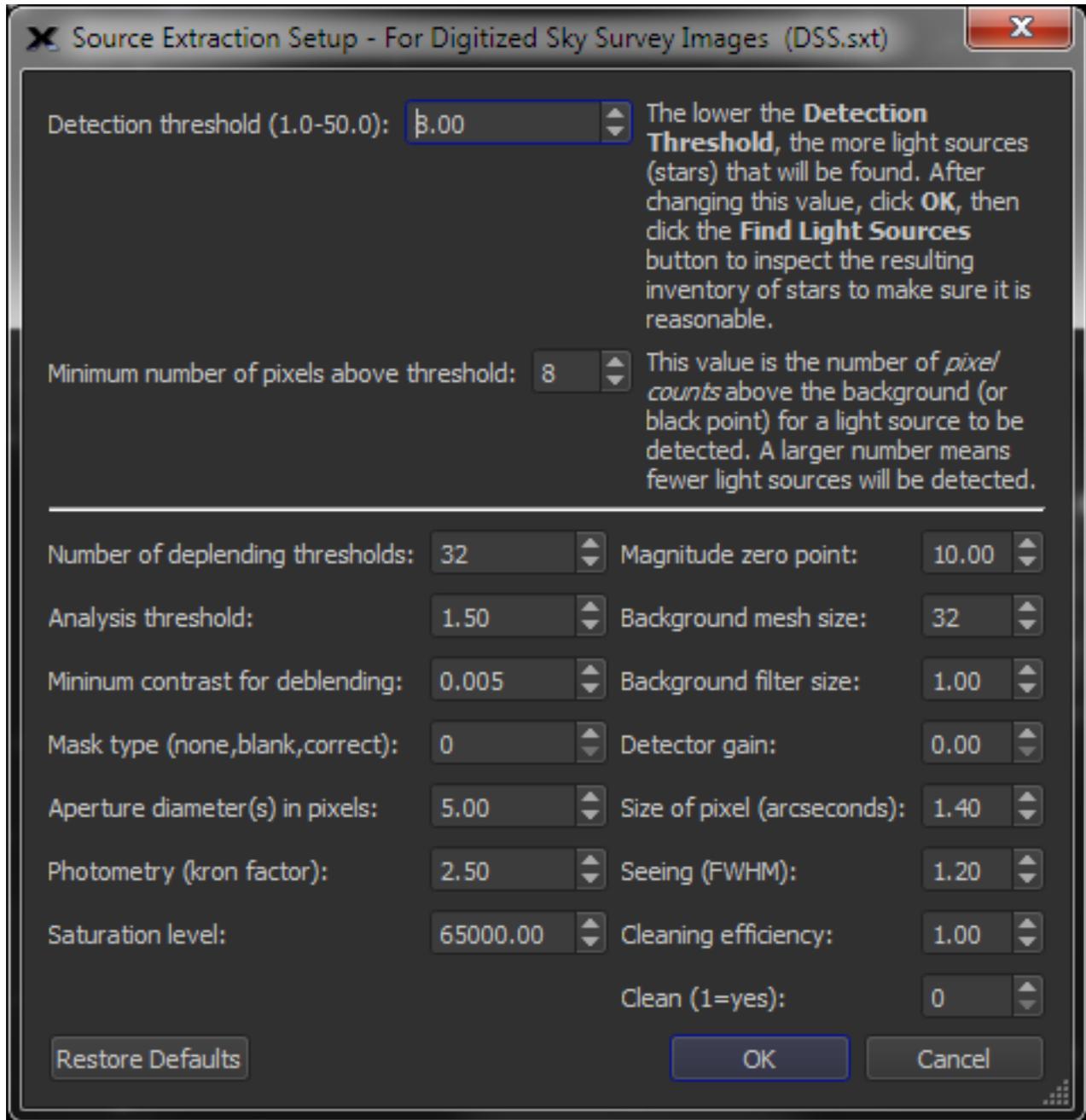


Figure 139: The Source Extraction Setup window.

Generally, the only two settings that need to be adjusted are the values for the **Detection Threshold** and/or the **Minimum Number of Pixels Above Threshold**. Each is described below.

### **Detection Threshold**

The **Detection Threshold** can range from 1.0 up to 50.0. Smaller values detect more light sources in the photo, larger values detect fewer light sources. If the **Detection Threshold** too small, then potentially too many light sources, or light sources that are actually noise can be detected, and will cause the astrometric solution to fail.

Source Extraction settings are saved to different text files, based on the current task, in the Application Support Files folder (page 27).

- **default.sxt** contains the default Source Extraction parameters. Click the **Restore Defaults** button to restore the default settings.
- **DSS.sxt** contains the Source Extraction parameters that work well for FITS photos from the Digitized Sky Survey.
- **AutomatedPointingRun.sxt** contains the Source Extraction parameters that are used to find the inventory on photos acquired during an automated pointing calibration run.

The current source extraction text file name appears in the window's caption.

#### ***Minimum Number of Pixels Above Threshold***

The ***Minimum Number of Pixels Above Threshold*** is the number of "pixel counts" above the background (or black point) that a light source must be to be detected. Increase this value by increments of 5 or so until the astrometric solution is found.

Advanced users can read [Source Extractor for Dummies](#) by Dr. Benne W. Holwerda of the Space Telescope Science Institute for a technical explanation of each source extraction parameter.

### **Light Source Data Tab**

The Light Source Data tab on the right side of the Image Link window shows a preview of the currently open FITS photo.

#### ***Show Light Sources***

Turn this checkbox on to show the inventory of stars and other light sources on the photo after the ***Find Astrometric Solution*** button is clicked. Light sources are shown with green circles.

#### ***Show Astrometric Stars***

Turn this checkbox on to show purple circles that represent the known cataloged stars used in the astrometric solution.

### **Astrometric Solution Tab**

The table on the ***Astrometric Solution*** tab shows the details of the astrometric solution.

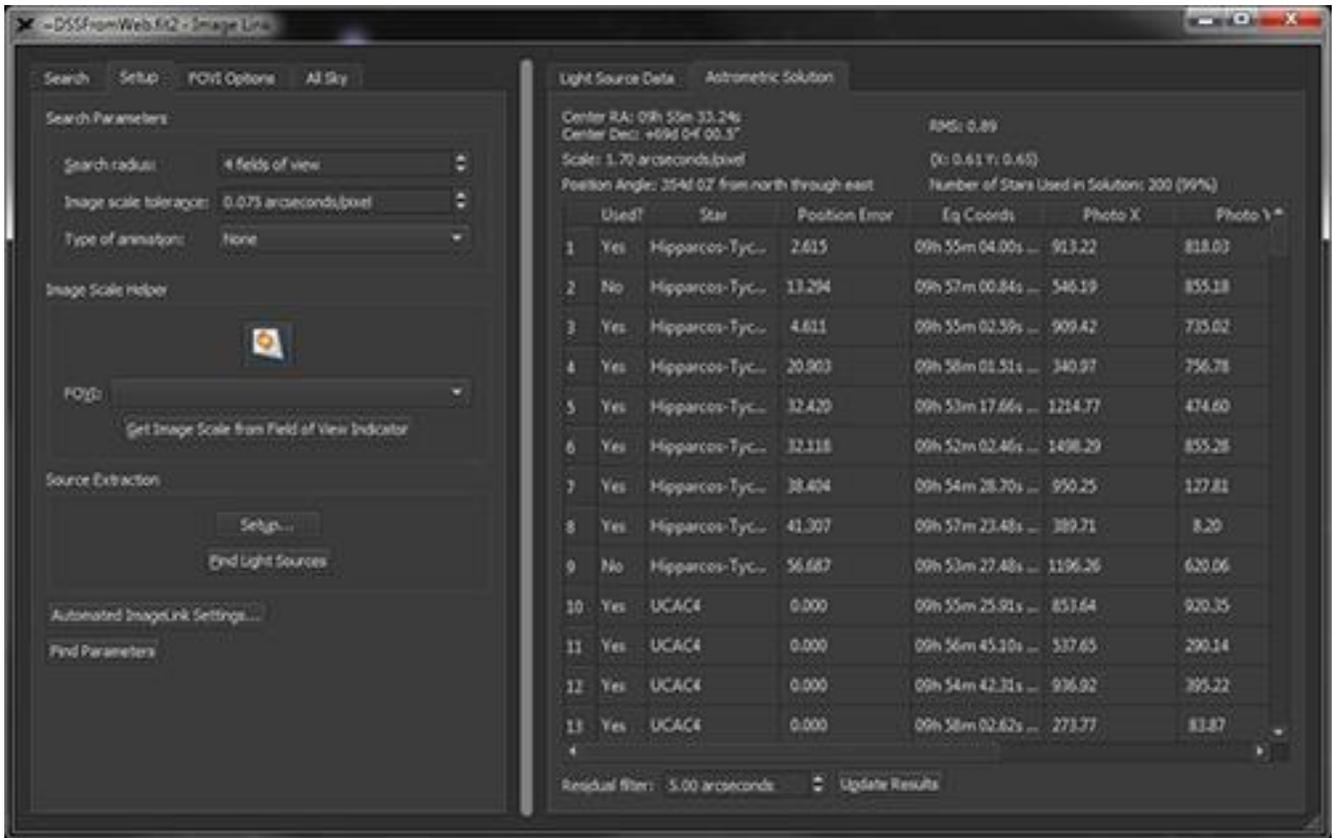


Figure 140: The Astrometric Solution tab.

**Center RA and Dec**

Shows the Equinox 2000 coordinates of the center of the photo.

**Scale**

Shows the image scale of the photo, in arcseconds per pixel.

**Position Angle**

Shows the photo's position angle, measured counterclockwise from north.

**RMS**

Shows the total root mean square of the residual errors in the astrometric solution, and the RMS error in each axis immediately below.

**Number of Stars Used In Solution**

Shows the number of cataloged stars that we used in the astrometric solution.

Each row in the table represents a known or cataloged star that was used in the astrometric solution. The table below describes each column in the report.

| Column Name           | Description   |
|-----------------------|---|
| <b>Used?</b>          | The word Yes in this column indicates this star was used in the solution. No means the star was rejected because the <i>residual error</i> was greater than the <b>Residual Filter</b> value. |
| <b>Star</b>           | The astronomical catalog of the known star.   |
| <b>Position Error</b> | The error in the position of the cataloged star's coordinates.  |
| <b>Eq Coords</b>      | The Equinox 2000 coordinates of the cataloged star.   |
| <b>Photo X</b>        | The x-axis position of the cataloged star on the photo.   |
| <b>Photo Y</b>        | The y-axis position of the cataloged star on the photo.   |
| <b>Residual</b>       | The amount by which the position of the star in the photo differs from the cataloged position.  |

### **Residual Filter**

Enter the value of the maximum residual error that is permissible to use a given star in the astrometric solution.

### **Update Results**

Click this button to update the astrometric solution table based on the value of the **Residual Filter**.

## **FOVI Options Tab**

A Field of View Indicator can be generated automatically from a successful Image Link photo.

### **Current Image Link Photo**

Use these options to generate a FOVI from the Image Link photo.

### **FOVI Description**

Enter the description of the FOVI that will appear beneath it on the Sky Chart.

### **Create FOVI from Scale and Position Angle**

Click this button to generate a FOVI based on the Image Link photo, and add the FOVI to the list of **My FOVIs** (page 119).

### **Synchronize Rotator Angle to Position Angle**

Click this button to synchronize the rotator's current angle to the position angle of the Image Link photo.

### **Rotate FOVIs to Computed Position Angle**

When this checkbox is turned on, the position angle of *all* field of view indicators is updated to match the Image Link's position angle. Forcing the FOVI's position angle to always match the position angle of a photo can be useful when manually rotating the imaging camera to place an appropriate guide star on an on-axis guider.

## Troubleshooting Image Link Failures

While Image Link and All Sky Image Link are extremely powerful astrometric search engines that work on a wide range of photos, there are several different parameters that can affect the success or failure of the astrometric solution. The common causes of, and solutions to Image Link and All Sky Image Link (page 332) failure are described below.

### ***Examine your Photo***

When a photo does not meet the minimum requirements (page 312), Image Link will most likely fail. While this may seem obvious, a good first step is to look carefully at the photo that fails and manually count the number of distinct star stars that are visible. If there are fewer than ten or so “clearly distinguishable” stars on the photo, Image Link is going to have a difficult time matching these few stars to actual stars in the field.

### ***Verify the Image Scale***

One of the most common reasons for Image Link failure is when the wrong image scale is used. While Image Link attempts to find the image scale based on a “best guess”, if the guess is off by a factor of two, for example, the link will most likely fail. Likewise, setting a known scale to the incorrect value will always result in Image Link failure.

Remember that binned photos change the image scale by the bin factor (page 528). For example, if your optical system produces photos that have an image scale of 1 arcsecond per pixel when the camera is binned 1x1, then the image scale of a photo that is acquired at 2x2 binning would be 2 arcseconds per pixel, and 3 arcseconds per pixel at 3x3 binning.

To avoid failures, be sure to change the Image Scale parameter based on the photo’s binning.

### ***Check the Source Extraction Parameters***

If you are confident the photo has sufficient stars, and the image scale is correct, another troubleshooting step is to review the ***Source Extraction Setup*** parameters.

If your wide-field photo contains *too many light sources* (photos in the Milky Way, for example can have thousands, or tens of thousands of stars), or, alternatively, has a poor signal to noise ratio (from a short exposure), you’ll want to try altering two *Source Extractor* parameters accordingly to achieve a successful astrometric solution. In other words, if there are too many light sources, increase the ***Detection Threshold*** so that fewer stars are used on the astrometric solution. If there is an insufficient number light sources, decrease the ***Detection Threshold*** until a sufficient number is found.

Typically, the ***Detection Threshold*** is the only setting that needs to be adjusted to allow a successful astrometric solution.

If an astrometric solution fails for a photo, or for all the photos obtained your imaging system, then altering the ***Detection Threshold*** is usually the solution.

If changing the **Detection Threshold** over a range of values fails to find a solution, the next, not normally necessary, step is to change is the **Minimum Number of Pixels Above Threshold**.

Here are a few examples of how modifying the **Detection Threshold** parameter can affect the astrometric solution.

### ***Check the Telescope Coordinates in the FITS Header***

When TheSkyX takes a photo, and is also connected to a telescope, the telescope's right ascension and declination (equinox 2000.0) are saved in the FITS header using the SBIG FITS Extension `OBJRA` and `OBJDEC` keywords.

When the FITS photo is opened from the **Image Link** window, the Sky Chart is automatically centered at this position. From here, clicking the **Find Astrometric Solution** button begins a search for the cataloged stars that match the stars in the photo, *starting from the equatorial coordinates of the Sky Chart's center*.

If the equinox 2000.0 coordinates of the telescope are wrong, Image Link, which searches a small region around the Sky Chart's current center position, will most likely fail.

The **File Information** tab on the **FITS Viewer** window shows the FITS header. If Image Link fails for a photo, make sure the right ascension and declination (equinox 2000.0) in the header are close to the coordinates of the object in the photo.

For example, the equinox 2000.0 coordinates in the FITS header for a photo of M51 should be close to 13h 29m 53s, +47° 11' 44". If not, the telescope was most likely not properly initialized when the photo was acquired. So, attempting an Image Link using this photo will fail without manually centering the Sky Chart near M51 will fail. Another workaround is to edit the FITS header with the correct object coordinates.

If you suspect that incorrect telescope coordinates are causing Image Link to fail, use All Sky Image Link to determine the astrometric solution. All Sky Image Link does not use the `OBJRA` and `OBJDEC` keywords to determine the photo's position, and searches the entire celestial sphere for a match instead.

### ***Check the All Sky Image Link Crop Options***

For photos acquired with a camera that has more than 2500 pixels in one dimension, to speed searches, All Sky Image Link automatically crops the photo (see the **All Sky Image Link Crop Settings** under "Advanced Preferences" on page 225 to configure this option).

If a photo acquired with a large format camera has few stars in it, or a very poor signal to noise ratio, the All Sky Image Link crop process can result in "not enough stars" being found.

If your camera has more than 2500 pixels in either dimension, and All Sky Image Link fails, increase the default crop size to 80 percent or so and try All Sky Image Link again.

### Example Image Link Photos

The photos below were submitted to Software Bisque because Image Link failed.

#### Example 1

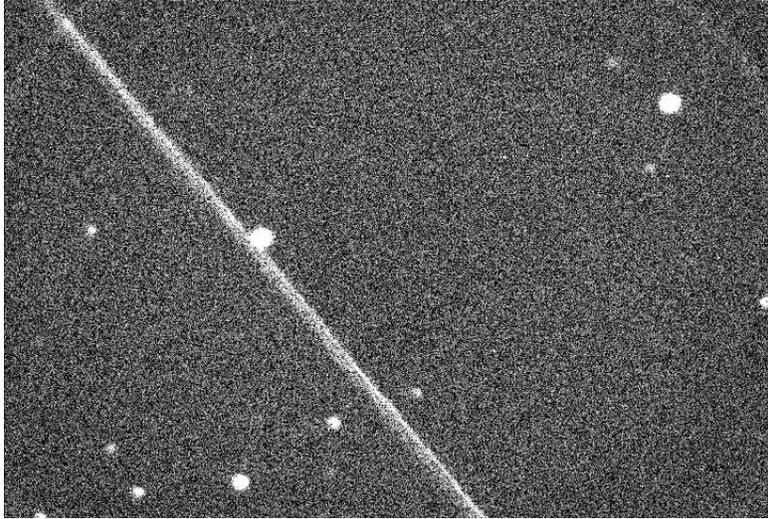


Figure 141: Photo with satellite trail.

The above photo has a satellite passing through it. Setting the **Detection Threshold** to 1, and then clicking the **Light Sources** button on the **Image Link Setup** tab shows the light sources in the photo.

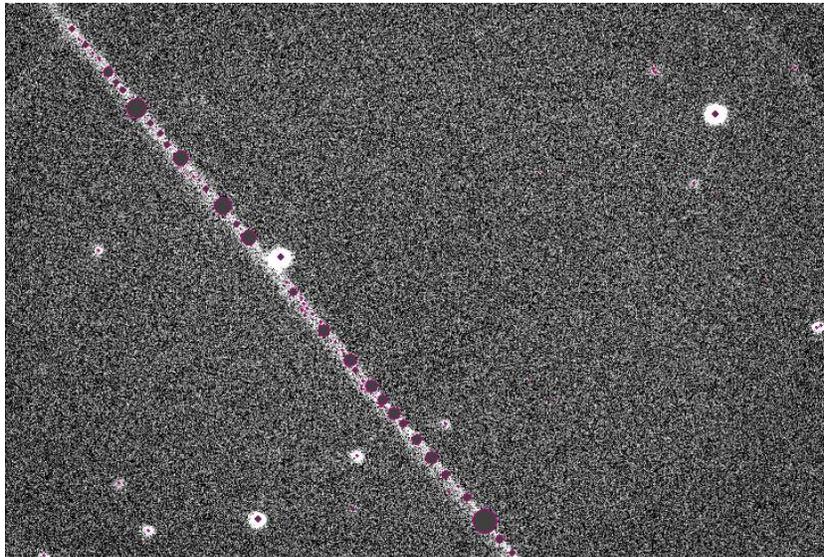


Figure 142: A “poor” inventory of light sources.

What’s wrong here? When the **Detection Threshold** is set to 1, the streak is *misidentified* as a series of non-existent light sources. These “stars” are then used in the astrometric solution, and, Image Link fails because these light sources do not actually exist.



Figure 143: "Correct" inventory.

Changing the **Detection Threshold** parameter from 5 to 10, shows no stars detected in the "streak" and only true "stars" are identified.

Note: Even though an astrometric solution can be found using this photo, it is a very poor photo for many reasons. It has very bad signal to noise ratio (the dynamic range is 65 counts out of a possible 65535), and it is also "deficient" in stars (about 6 are "inventoried"). A longer exposure is *highly* recommended for photos like this.

### Example 2

This photo also reveals the importance of the **Detection Threshold** setting.



Figure 144: Sample image.

The above photo contains relatively good signal and has many "well-defined" stars. However, notice how the nebulosity in the upper left affects the inventory using different **Detection Threshold** values.

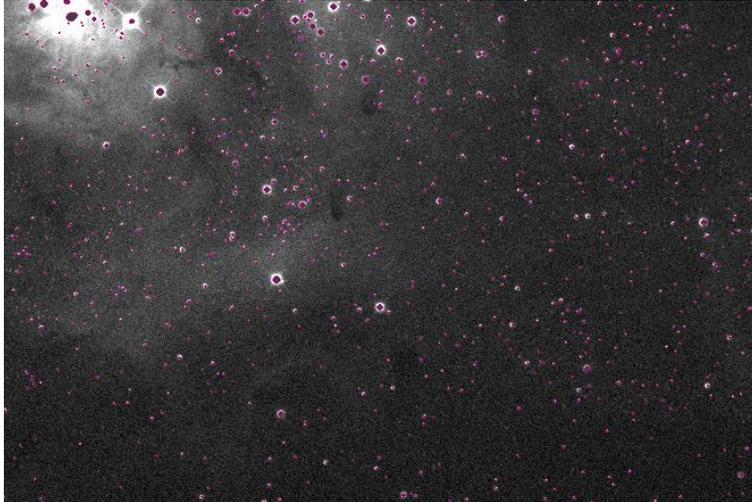


Figure 145: Note the incorrectly identified "stars" in the upper left corner.

A Detection Threshold setting of 6 identifies stars in the nebula that do not exist, and causes the astrometric solution to fail.

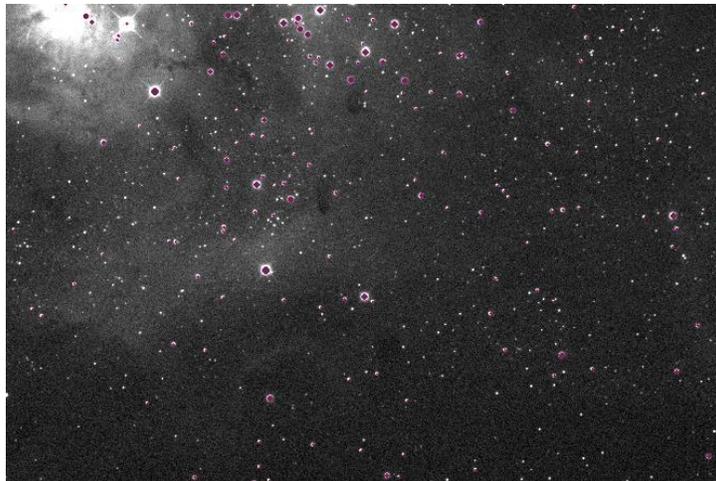


Figure 146: Changing the detection threshold correctly identifies stars in the nebula.

A **Detection Threshold** setting of 30 correctly identifies the stars in the nebula. Image Link is now successful.

**Example 3**



**Figure 147: Poor signal-to-noise ratio, poor focus and poor tracking make this a very poor candidate for an astrometric solution.**

At first glance, image in Figure 147 may appear to be a good candidate. Upon closer inspection, the image “falls apart”.

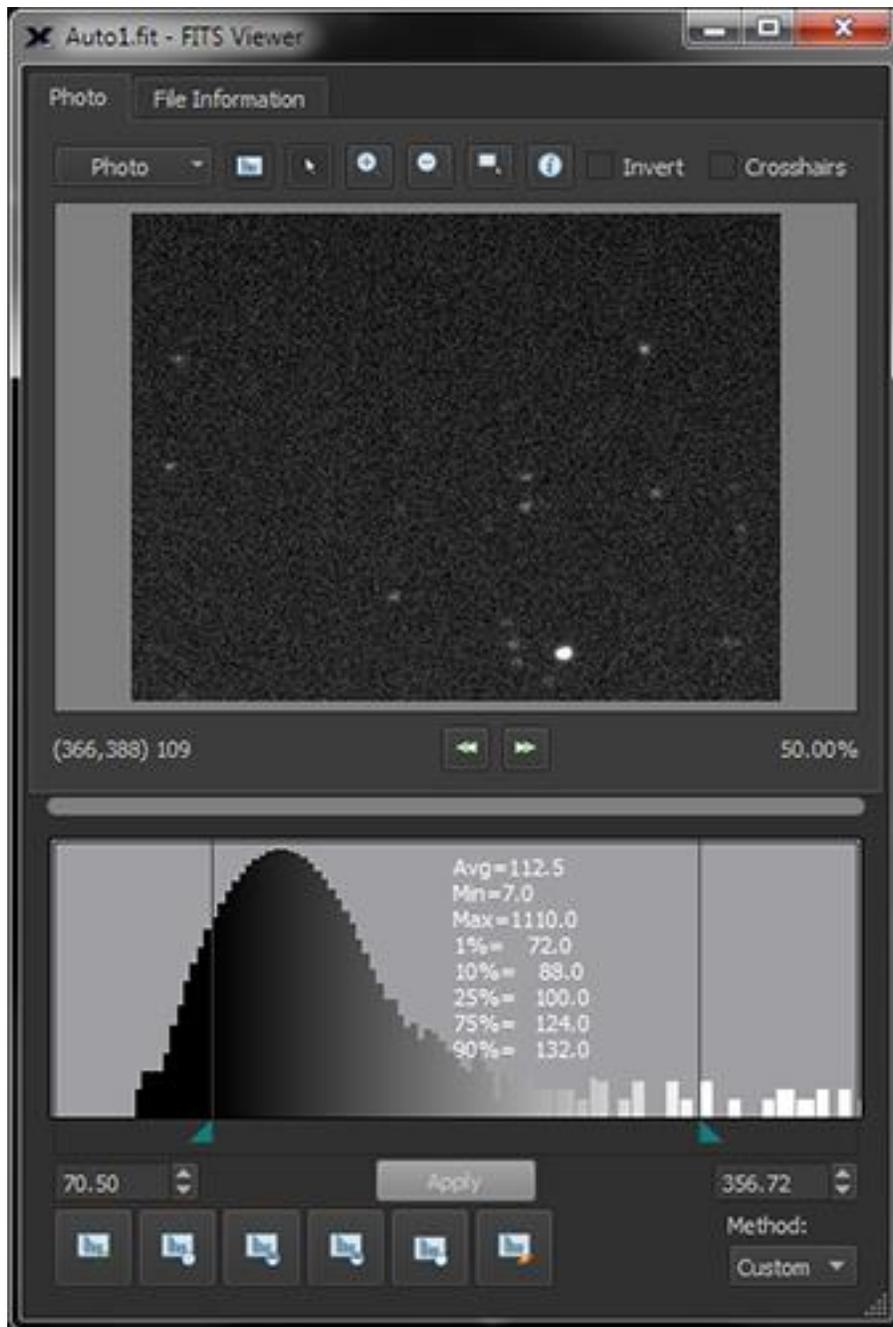


Figure 148: Histogram shows poor signal in the photo.

The histogram shows that there is very little actual *signal*. The default background and range settings differ by hundreds of counts using camera that has a much larger dynamic range (16-bit, or a total of 65,355 counts). Increasing the exposure time ensures better a signal-to-noise ratio.



Figure 149: Same image after adjusting the range or "white point"

After increasing the range (that is, increasing the "white point" in the image), another very important deficiency is revealed, specifically that the image is way out of focus. Notice the donut-looking stars.

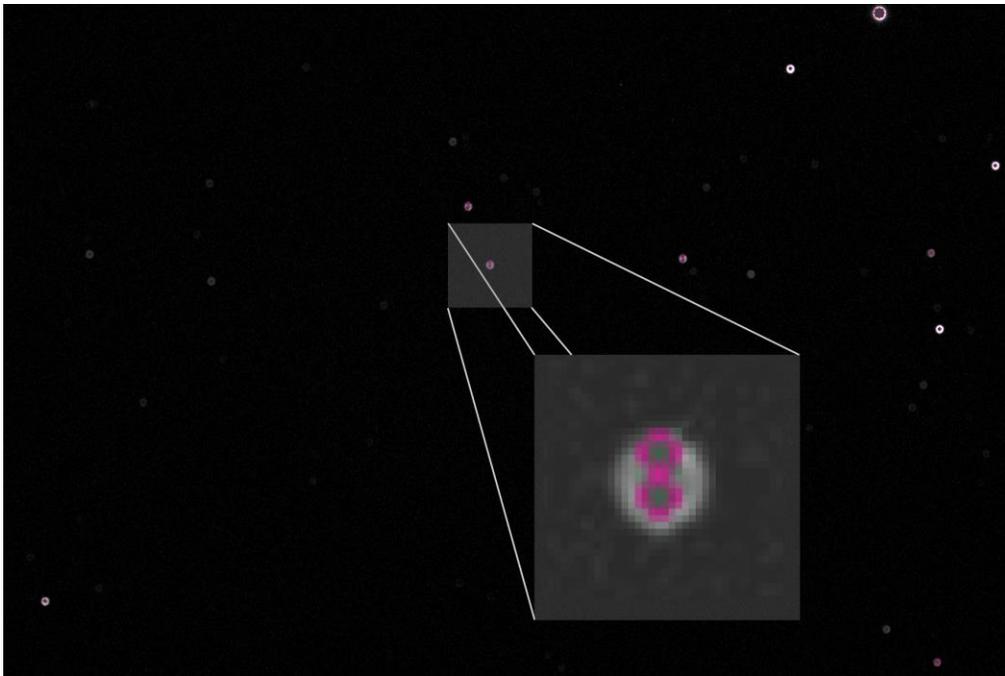


Figure 150: Two light sources (indicated by the two red circles) are detected for each "out of focus" stars.

The **Show Inventory** command, using a detection threshold of 10, reveals that several of the out of focus stars are identified as two separate light sources (stars), instead of just one! When multiple light sources are detected for a single star, the astrometric solution will almost certainly

fail. The solution is to adjust focus until the light coming from a point source is recorded correctly. Consider using @Focus (page 572) to achieve optimal focus.

## All Sky Image Link

### PROFESSIONAL

NASA's moniker for a technique satellites use to determine their orientation is "lost in space". To determine its orientation, the satellite acquires a photo of a star field, *any* star field, then matches the stars in the photo with the known positions of stars in astronomical databases. Once the photo's location on the celestial sphere is known, the satellite's orientation in space can also be determined.

All Sky Image Link applies a similar "lost in space" process to help initializing, calibrating, polar aligning, and precisely pointing (using the "Closed Loop Slew" feature, page 382) earth-based telescopes. Anyone who has ever tried to setup a telescope, especially one with a DSLR, video or CCD camera attached, knows that one of the most difficult tasks is finding or placing that very first star in the eyepiece, or on the detector so that the telescope's control system can be aligned with this position.

Once an uninitialized telescope acquires a FITS photo, anywhere on the celestial sphere, All Sky Image Link can find the photo's astrometric solution (a.k.a. "plate solution"). The astrometric solution is also saved to the FITS header using the World-Coordinate System (WCS) so that the equatorial coordinates of every pixel on the photo is known. This information can be used for the initial control system synchronization, or to calibrate the mount.

The optional TPoint Add On's *Automated Pointing Calibration* feature automates the process of choosing a target to photograph, slewing the telescope to the target, acquiring a photo, determining the astrometric solution, and adding this information to the pointing calibration data set. Choose the **TPoint Add On User Guide** command from the **Help** menu and search the PDF document for more information.

## All Sky Image Link Requirements

- The Camera Add On and a supported camera to acquire FITS photos.
- An optical system that produces a minimum field of view of 10 arcminutes for the smaller dimension. See "Advanced Preferences" on page 225 to configure All Sky Image Link for large format photos, or photos with 3-degree fields of view and wider.
- All Sky Image Link can be configured to search a range of image scales if it is not known. Once the image scale is determined, subsequent All Image Sky Image Links are significantly faster.

## Using All Sky Image Link

All Sky Image Link operates performs similar functionality as Image Link (see "Image Link and Automated Astrometry" on page 312). Image Link requires an approximate or "best guess" image scale and the approximate equatorial coordinates of the photo so that it can search a small region

of the sky to locate a pattern match between the stars in the photo and the actual stars. All Sky Image Link searches the *entire celestial sphere* to match the star patterns in your photo.

## **All Sky Image Link Database**

To perform an All Sky Image Link, the 1.8 GB “All Sky Image Link Database” named *10-180.allsky* must be present on the computer. This database contains millions of known star patterns for fields of view between 10 and 180 arcminutes.

### ***Installing the All Sky Image Link Database***

Due to its large size, the All Sky Image Link Database is distributed as a separate download. The procedure below describes how to download and save this file to your computer.

1. Click the ***Image Link*** command from the ***Tools*** menu.
2. On the ***All Sky*** tab, click the ***Download the All Sky Image Link Database*** link at the top of the window to download and save the All Sky Image Link Database archive, named 10-180.zip. Note that you must be signed in to the Software Bisque web page, and have a registered *TheSkyX Professional Edition* serial number with an active subscription to access this resource. Download access will be denied otherwise.
3. Unzip or extract the file named 10-180.allsky from 10-180.zip and save it to the ***Astrometry*** folder in the “Application Support Files” folder (see page 26 for details about the location of this folder on your operating system).

Once the All Sky Image Link Database has been copied to your computer, you are ready to perform an All Sky Image Link.

1. Choose the ***Image Link*** command from the ***Tools*** menu.
2. Click the ***Open FITS*** button on the ***All Sky tab*** of the ***Image Link*** window.
3. Navigate to the folder on your computer where the photo resides, highlight it, and then click the ***Open*** button.
4. Configure the All Sky Image Link options described below, and click the ***Find All Sky Image Link***.

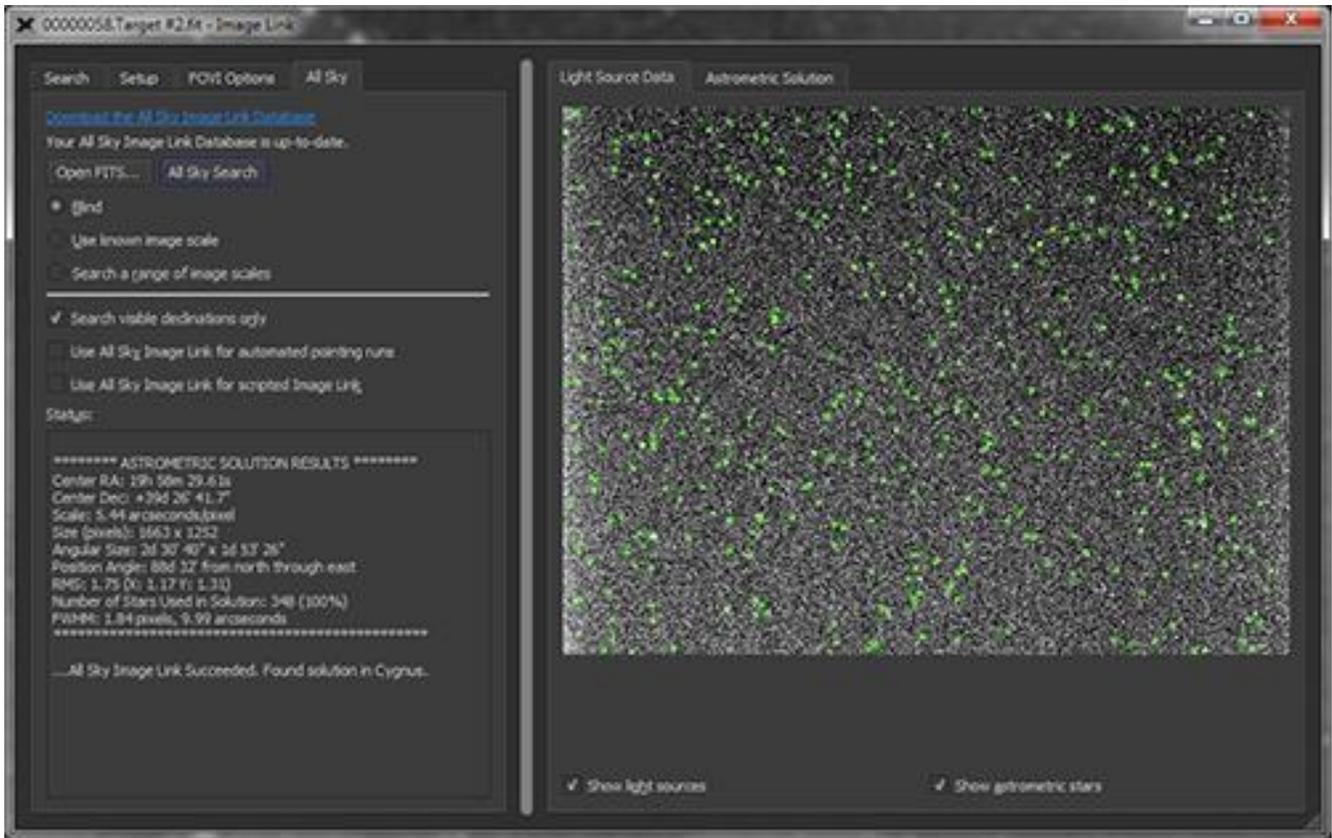


Figure 151: Successful All Sky Image Link using a photo with a limited star field.

### **Download the All Sky Image Link Database**

When visible, click this link to open a browser on the All Sky Image Link Database download page.

The URL to this page is: <http://www.bisque.com/allskydownload>. You must be signed in to the Software Bisque web page, and have a registered *TheSkyX Professional Edition* serial number with an active subscription to access this resource.

### **Open FITS**

Click this button to open the FITS photo on which to perform an All Sky Image Link.

### **All Sky Search**

Click this button to begin searching the entire celestial sphere (or, the visible declinations, when the **Search Visible Declinations Only** checkbox is turned on) for an Image Link. Depending on the size of the photo, and the search parameters below, the search time can be from a few seconds, to a minute or more. The button text changes to **Abort** so that the process can be stopped if needed.

### **Blind**

Turn this option on if you do not know the image scale, in arcseconds per pixel, for the photo.

### ***Minimum/Maximum Scale***

When the ***Blind*** option is selected, enter the range of image scales to use during the all sky image link search. All Sky Image Link starts with the lower image scale, performs an all sky search, and when no match is found, increments the image scale and continues this process, up to the maximum image scale, or until a match is found.

The above process can be very time consuming, so please be patient. Once the image scale has been found for optical configuration, use the ***Known Image Scale*** option to speed searches.

### ***Use Known Image Scale***

Use this option when you know the image scale of the photo to minimize the time it takes to find an All Sky Image Link.

#### ***Image Scale***

Enter the image scale for the photo, in arcseconds per pixel.

#### ***Image Scale Tolerance***

For best results, the image scale of the photo should be accurate to within a few hundredths of its actual value. In practice, determining image scale this accurately without Image Link can be difficult. Setting a larger ***Image Scale Tolerance***, specified as a percentage of the photo's image scale, can help find the astrometric solution when only the approximate image scale is known.

### ***Search a Range of Image Scales***

If you're unsure of your imaging system's image scale, use this option to specify a range of image scales to search to find the Image Link.

#### ***Image Scale Search Range***

Enter the ***Minimum*** and ***Maximum*** image scales, in arcseconds per pixel, to search.

### ***Mirror Option***

Choose the appropriate option for your telescope. The time required to find a matching star patterns in photos with the patterns of cataloged stars can be greatly reduced if you know whether the photos generated by your optical system are mirrored.

#### ***Photo is Not Mirrored***

Choose this option if photos produced by your optical system (telescope, camera, focal reducer, etc.) are not mirrored.

#### ***Photo is Mirrored***

Choose this option if photos produced by your optical system (telescope, camera, focal reducer, etc.) are mirrored.

### **Unknown or Not Sure**

Choose this option if you are unsure or do not know the details of the optical system that was used to produce the photo.

### **Search Visible Declinations Only**

When this checkbox is turned on, All Sky Image Link determines the lowest visible declination based on *TheSkyX's* current latitude settings (page 33), and then only searches at or above this declination to speed up all sky searches.

### **Use All Sky Image Link for Automated Pointing Runs**

Turn this checkbox on to use All Sky Image Link instead of Image Link during automated pointing calibration runs. This can be use helpful for portable setups, before the polar alignment is

### **Status**

This text box provides status of the search and reports the astrometric solution results when successful (see Figure 151).

### **Show Light Sources**

Turn this checkbox on to show the inventory of stars and other light sources on the photo after the **Find All Sky Image Link** button is clicked. Light sources are shown as green circles.

### **Show Astrometric Stars**

Turn this checkbox on to show purple circles that represent the known cataloged stars used in the astrometric solution.

## **Differences between Image Link and All Sky Image Link**

Understanding the minor differences between how Image Link and All Sky Image Link work can be helpful to troubleshoot failures using either method.

### **Image Link Specifics**

- *Image Link* uses the RA/Dec coordinates from the FITS header's OBJCTRA and the OBJCDEC keywords for the approximate locate of the photo on the celestial sphere, and then searches a relatively small region around these coordinates to find the astrometric solution.
- When the RA/Dec of the photo is available, the Sky Chart is automatically centered on these coordinates once the Image Link search is started. If the angular separation between the RA/Dec in the *FITS header* compared to the *actual coordinates* is "relatively large", then Image Link can fail.
- The OBJCTRA and the OBJCDEC coordinates in FITS photos are obtained from the telescope's current position (where the telescope "thinks" it is pointing. If the telescope's position is not correct (which can be the result of poor polar alignment, pointing errors, improper synchronization, etc.), then the OBJCTRA and the OBJCDEC coordinates in the FITS header do not match the *actual coordinates of the photo*.

- If the FITS header does not contain RA/Dec information, you must manually adjust the position of the Sky Chart for Image Link to be successful.

***All Sky Image Link Specifics***

- All Sky Image Link *does not* use the RA/Dec from the FITS keywords to obtain the photo's coordinates, it searches the entire celestial sphere for stars that match the inventory of stars in the photo instead.
- After a successful All Sky Image Link, the RA/Dec center of the Sky Chart is changed to match the photo's RA/Dec.



# Imaging System Setup

## PROFESSIONAL

Use the Imaging System Setup window to configure the hardware-specific settings and preferences for the following devices:

- Mount
- Focuser
- Camera
- Dome
- Filter Wheel
- Rotator
- Video Device
- Autoguider Camera
- Autoguider Filter Wheel
- Autoguider Video Device

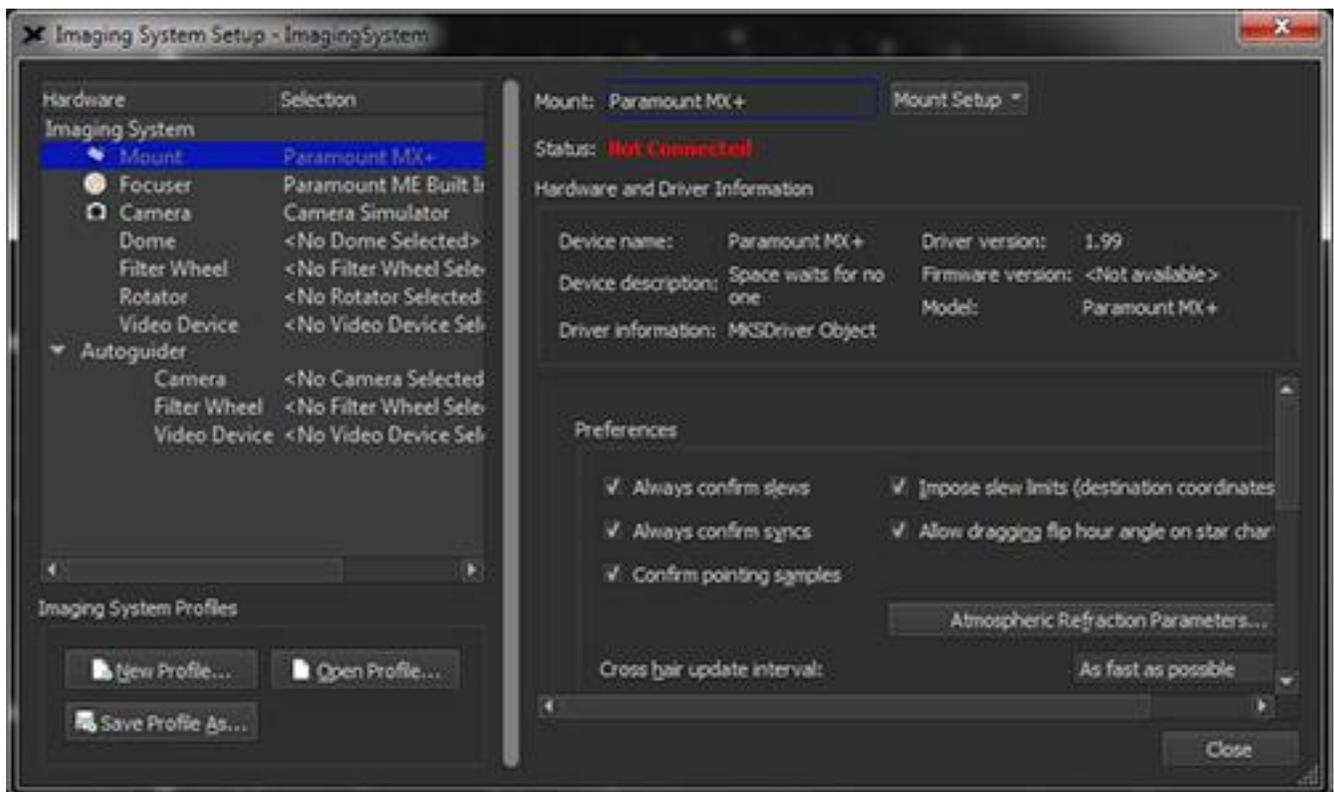


Figure 152: The Imaging System Setup window.

The left side of the **Imaging System Setup** window lists the devices that make up your imaging system. Note that this list may be incomplete compared to the above list if you do not own all the Add Ons.

To configure *TheSkyX Professional Edition* to use a device, either double-click its name in the list, or highlight the name by clicking once, then click the **Choose** command from the **<Device Name Here> Setup** pop-up menu (where <Device Name Here> is the name of the device). The list of supported devices appears on the **Choose <Device Name Here>** window.

For example, to use the SBIG ST-2000M model camera, highlight it in the list, and then click **OK**.

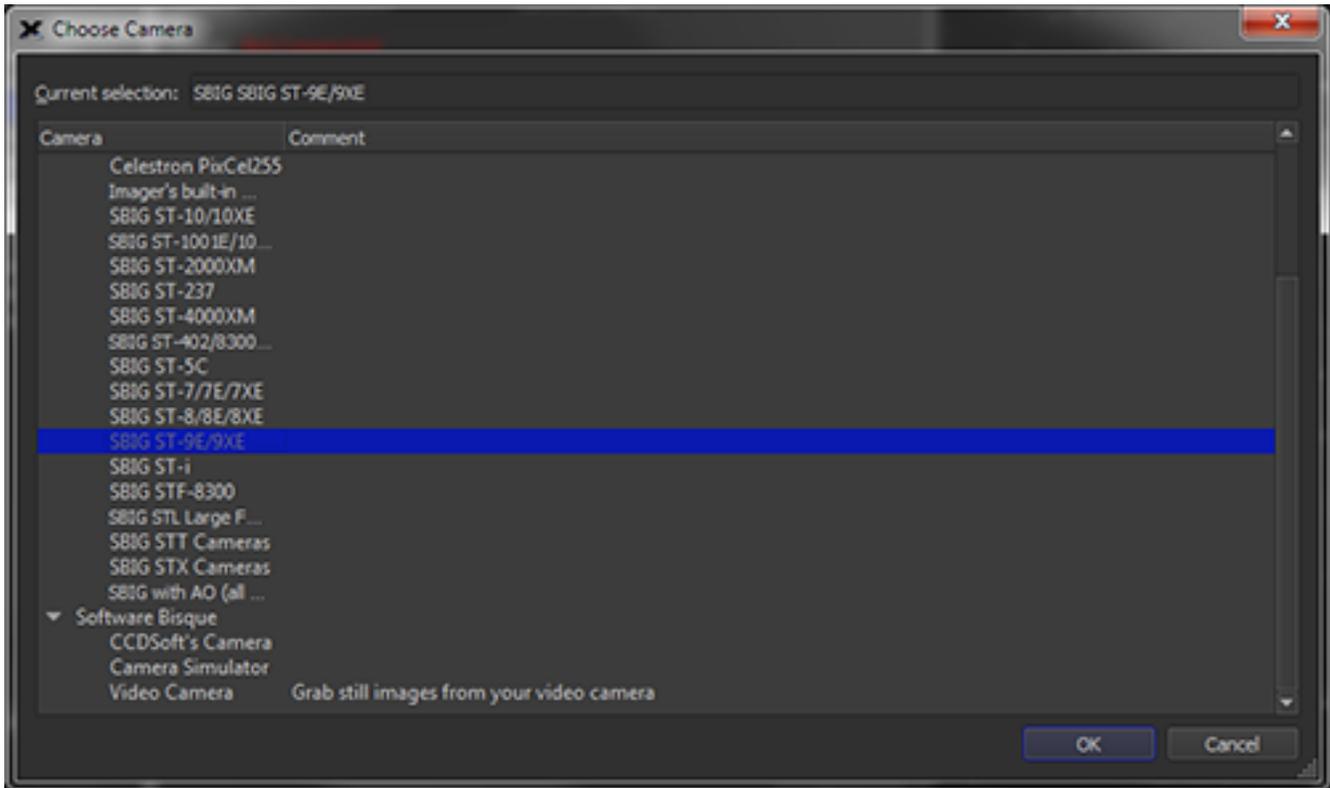


Figure 153: The Choose Camera window.

This same procedure can be used to choose each device in your system. Once a device is selected, the right side of the Imaging System Setup window reveals hardware and driver information, and other options that are particular to that device.

These settings are saved automatically as they're made, to the profile named `imagingssystem.ini` (page 27) and the caption of the Imaging System Setup window shows the name of the current profile in use.

## Imaging System Profiles

An imaging system profile represents a snapshot of all the hardware and hardware-specific settings related to one imaging system. Multiple imaging systems can be saved and opened using the buttons located at the lower left of the **Imaging System Setup** window.

***New Profile***

Click this button to restore all the hardware to “none selected” with default settings so that you can “start from scratch” setting up a new imaging system.

***Open Profile***

Click this button to choose an existing profile.

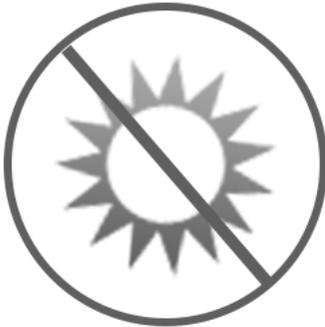
***Save Profile As***

Click this button to save the existing profile’s settings using a name other than the default name (imagingsystem.ini).

## Telescope Control



*TheSkyX* can control many go to and computer-aided (or “push to”) telescope mounts.



***NEVER attempt to observe the Sun through your telescope!***

Without a specially designed solar filter, viewing the Sun – for even a fraction of a second – will cause instant, irreversible eye damage. When observing during the day, do not point the telescope near the Sun. Do not use *TheSkyX Professional Edition’s* automatic slew feature to find objects during the day.

Children should *never* use a telescope during the daytime without strict adult supervision.

### ***Telescopes with Optical Encoders (Push To)***

If your telescope is equipped with optical encoders, *TheSkyX* can show and track its position with the aid of a “serial interface box”. The encoders read the rotation of the telescope’s axes, and return numbers that represent how much they moved. The following serial interface boxes are compatible with *TheSkyX*.

- AB Engineering
- BBox (Software Bisque)
- NGC-MAX (JMI)
- NGC Sky Commander (Lumicon)
- Sky Commander (SkyComm Engineering)
- Sky Wizard 3 (Lumicon)
- Sky Tour (Tele Vue)
- SkyQuest IntelliScope Computerized Object Locator (Orion Telescopes & Binoculars)

Jim’s Mobile, Inc. ([www.jimsmobile.com](http://www.jimsmobile.com)) is a good source to purchase software-guided telescope (SGT) hardware.

## **Telescopes with Go To Control**

*TheSkyX* comes with native telescope drivers that can send positioning and other commands to the following “go to” telescope systems.

- Astro-Physics GTO mounts (all models)
- Celestron™ Advanced Series (all models)
- Celestron™ NexStar (all models)
- Celestron™ CG Series (all models)
- Celestron™ CGE Series (all models)
- Celestron™ CPS Series (all models)
- Celestron™ GT Series
- Celestron™ SLT Series (all models)
- Celestron™ NexStar i Series (all models)
- Celestron™ *Ultima 2000*™ telescopes\*
- Gemini Telescope Positioning System (Losmandy and MI-250)
- iOptron™ SmartStar™ Series
- Meade™ *LX200*™ (Classic) Telescopes
- Meade™ *LX200*™ 16-inch (Classic) Telescopes
- Meade™ Autostar (classic) telescopes
- Meade™ Autostar II (LX200 GPS) Telescopes and Mounts
- Meade™ Autostar III Telescopes and Mounts
- Orion® Telescopes & Binoculars Atlas™ EQ-G Equatorial Mounts and Sirius™ EQ-G Equatorial Mounts
- SkyWatcher mounts using the SynScan Controller
- StellarCAT™ Computer Assisted Telescope Innovations
- Takahashi™ Temma mounts (all go to models)
- Vixen™ Sphinx™ and Sphinx Deluxe mounts

\* The Celestron Ultima 2000 telescope is considered a “legacy mount” since so few of them are still in use. While *TheSkyX* includes a driver for the Ultima 2000, we no longer provide technical support for this mount. Sorry for any inconvenience.

In addition, *TheSkyX* can simulate a telescope link. You can experiment without actually having a telescope connected.

Whether your telescope has optical encoders, or computer control, the Sky Chart tracks the telescope’s position. In addition, *TheSkyX* can command “go to” telescope systems. Select an object from *TheSkyX*’s database and it will point the telescope at it.

All systems using optical encoders are set up the same way and are explained below in a single section. Computer-controlled telescopes are each set up slightly differently.

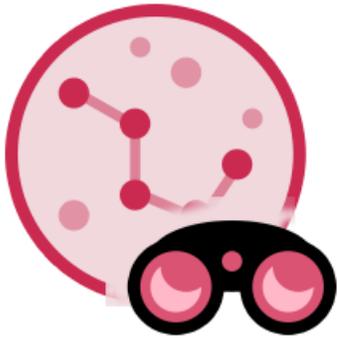
## ***X2 and Third-Party Telescope Drivers***

*TheSkyX Professional Edition* and *TheSkyX Serious Astronomer Edition* can control telescopes using third-party telescope drivers with the X2 Driver Standard (see “Appendix G: TheSkyX Pro Device Driver Architecture” on page 659).

## ***Setting the Correct Time***

Computer-controlled drive systems typically have an internal clock that must be set with high accuracy. (Encoder-based systems do not need as high degree of accuracy.) The best method for keeping accurate time on your computer is to use an Internet time server. Most modern operating systems include time synchronization as part of their ***Date & Time*** settings.

## ***Night Vision Mode***



Selecting the ***Night Vision Mode*** command from the ***Display*** menu (or clicking the Night Vision button) redraws the display in red to minimize loss of dark adaptation.

On the Mac, turning on Night Vision Mode will show the entire desktop, and all other applications that are running, red. Turning off Night Vision Mode, or exiting *TheSkyX* restores the screen colors.

Under Windows, by default, turning on Night Vision Mode reddens only *TheSkyX's main window*. To change the color of the desktop, you must configure *TheSkyX* to use a Windows Theme. See the “Night Vision Setup (Display Menu)” below for details.

## Night Vision Setup (Display Menu)



TheSkyX for Windows allows you to change screen elements or both screen elements and the Windows theme to red. (You can learn more about Windows Themes by searching Windows help.) Each method has advantages and disadvantages. Together they can provide an effective way to minimize screen brightness that should satisfy even the most discriminating astronomer.

The **Night Vision Setup** window lets you configure how colors are changed when entering and exiting Night Vision Mode.

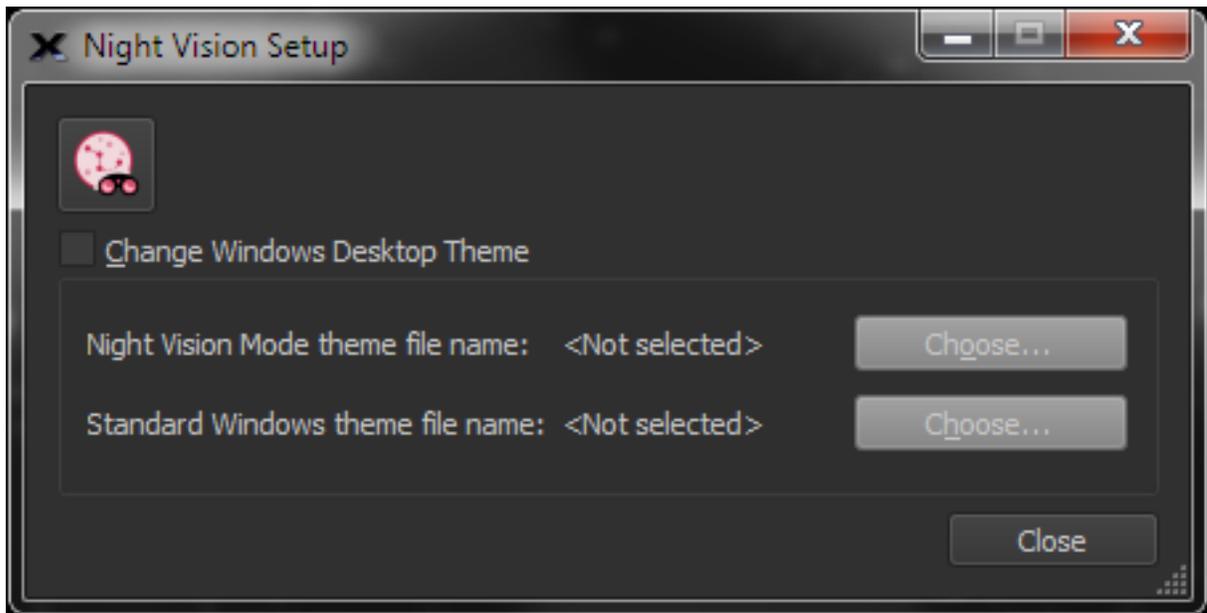


Figure 154: Night Vision Setup window (*Night Vision Setup* command, *Display* menu, Windows OS only).

When the **Change Windows Desktop Theme** checkbox is off, and the Night Vision Mode button clicked on, TheSkyX's screen changes to red.

Note that when the **Change Windows Desktop Theme** checkbox is turned off, the options to set theme names are disabled.

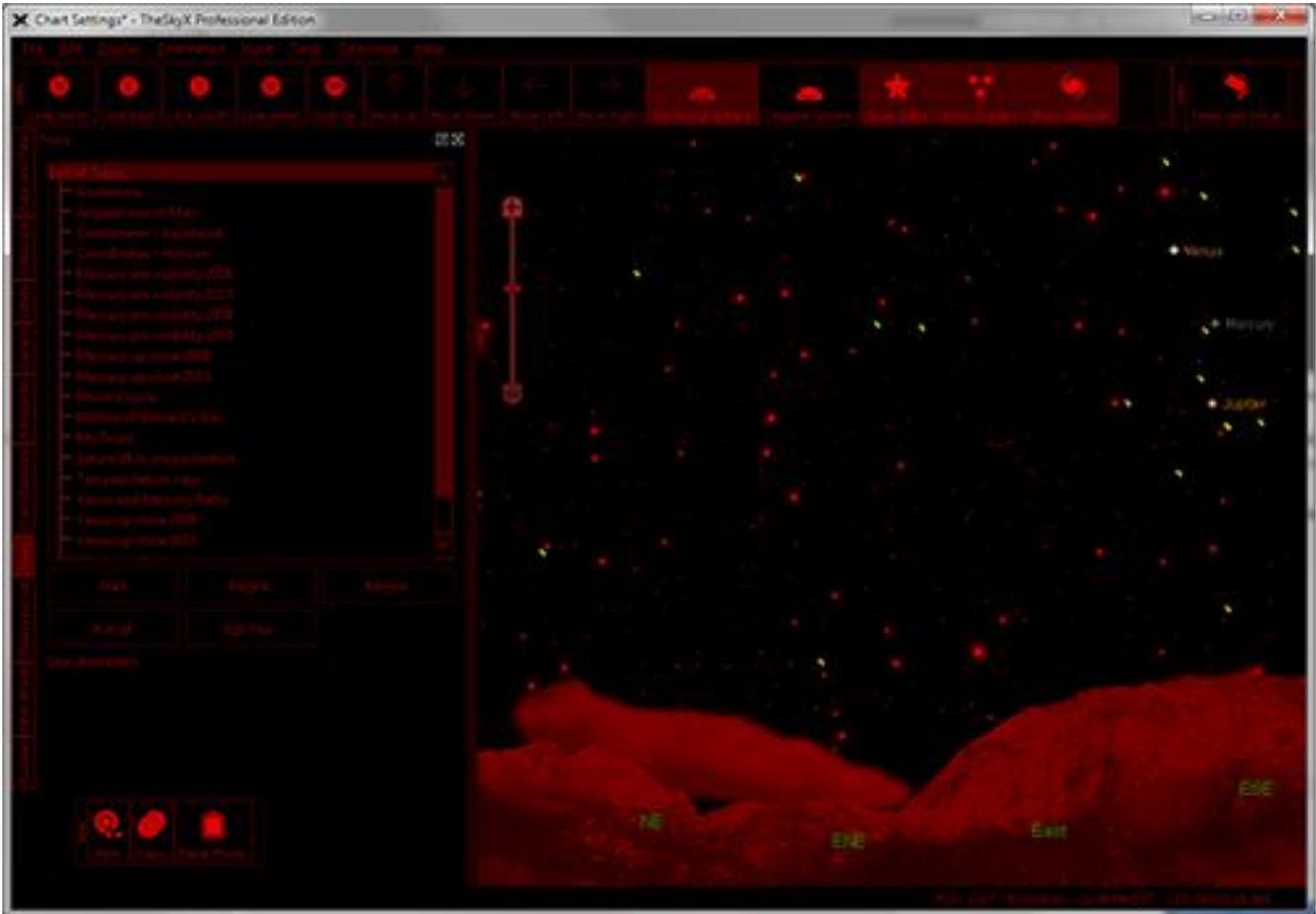


Figure 155: Sample Night Vision Mode Screen using the standard Windows Desktop Theme.

When the **Change Windows Desktop Theme** checkbox is on and the **Night Vision Mode** button is clicked on, the selected **Night Vision Mode Theme File Name** is loaded.

Themes are changed automatically under Windows 7, 8 and 10.

#### **Night Vision Mode Theme File Name**

Click the **Choose** button to select the theme file name to load when Night Vision Mode is turned on.

#### **Standard Windows Theme File Name**

Click the **Choose** button to select the theme file name to load when Night Vision Mode is turned off.

Before you can choose a theme file name, you save one to your hard drive.

#### **Saving a Theme File (Windows 7 and 8)**

1. Click **Start > Control Panel**.
2. Click the Change the Theme link under Appearance and Personalization.

3. Under the ***Change the Visuals and Sounds on your Computer*** window, select the desired theme. The easiest way to save a theme file under Windows 7 is to modify an existing theme, then save it. (There's no other obvious way just save a "supplied" theme.) For example, after selecting a theme to use, click the Window Color icon at the bottom of this window and then modify the color's intensity before clicking the ***Save Changes*** button. The now "modified" theme appears in ***My Themes***.
4. Right-click the modified theme, then click the ***Save Theme for Sharing*** command.
5. Enter a name for the "theme pack file" (.themepack), such as ***My Theme***, and then click ***OK***. The Windows 7 default location to save themes is the ***Libraries > Documents*** folder. Remember this folder name.

### ***Windows 7 Starter Edition and Themes***

If you are using a Netbook computer, chances are it runs *Window 7 Starter Edition*. Windows themes on this "streamlined" operating system are very limited and cannot be saved to a file, or restored from a file. These limitations make *TheSkyX's* Night Vision Mode less than ideal. To best preserve dark adaptation when using Windows 7 Starter Edition, we recommend covering the computer screen with a sheet of red velum, which is available at most hobby stores.

Once you've saved the theme file, to select it in Night Vision Setup window, click the ***Choose*** button next to the ***Standard Windows Theme File Name***, then navigate to the folder where the file resides, and double-click the theme pack name. *TheSkyX* will now load this theme when exiting Night Vision Mode.

## ***Setting Up and Using Push To Telescope Systems***

Other than the encoders and their interface box, the extra hardware required includes a standard serial (RS232) cable to connect the interface to your computer and a USB to serial adaptor. The serial cable is usually supplied with the encoder system; USB to serial adaptors can be purchased at almost any computer store. Make the appropriate connections from the encoders to the interface box, and the box to your computer.

### ***Configuring the Hardware***

You are now ready to configure the hardware.

Select the ***Telescope Setup*** command from the ***Telescope*** menu. The Telescope Setup window is displayed.

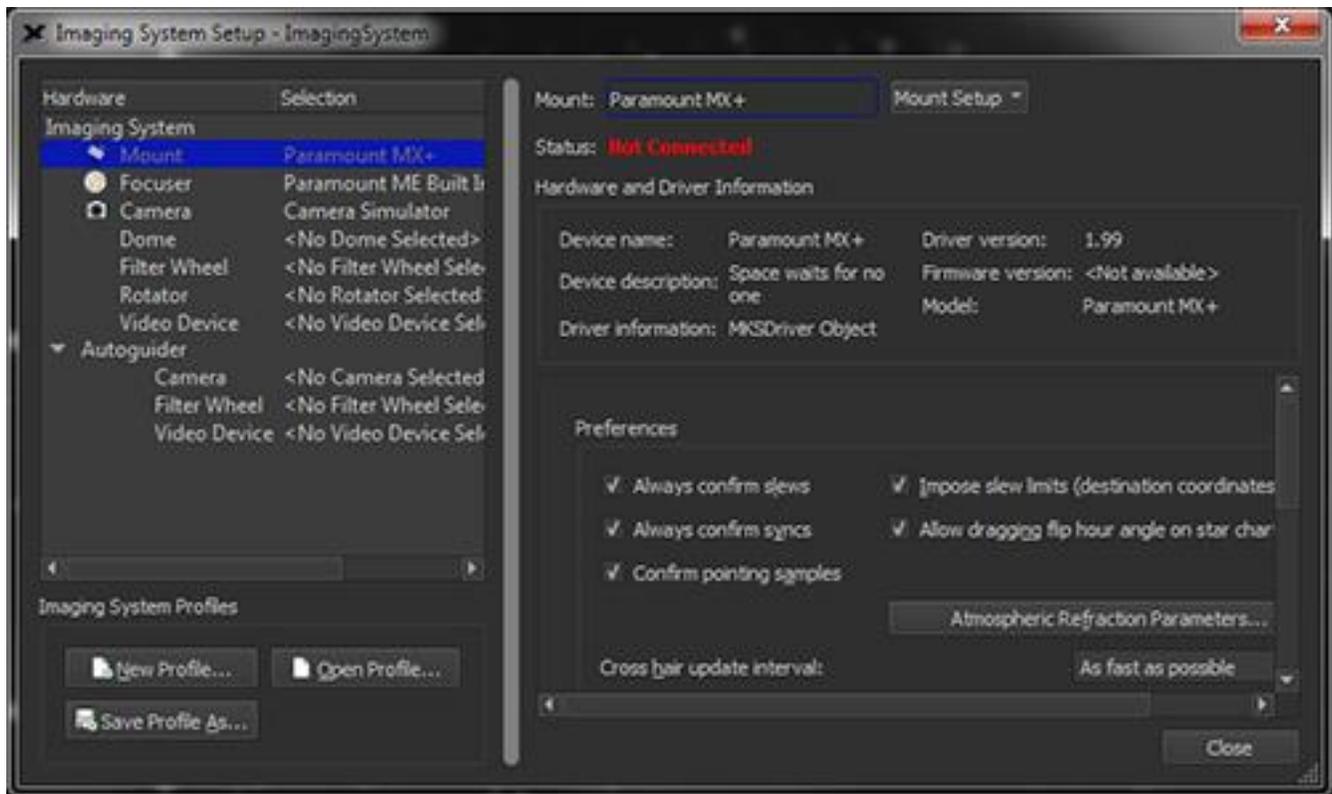


Figure 156: The Imaging System Setup window.

1. From the **Mount** pop-up, click the **Select Mount** button. On the **Select Mount** window, select **SGT**. Or select the name of your serial interface box, if it's listed then click **OK**.
2. Click **Settings**. The Telescope Settings window appears.

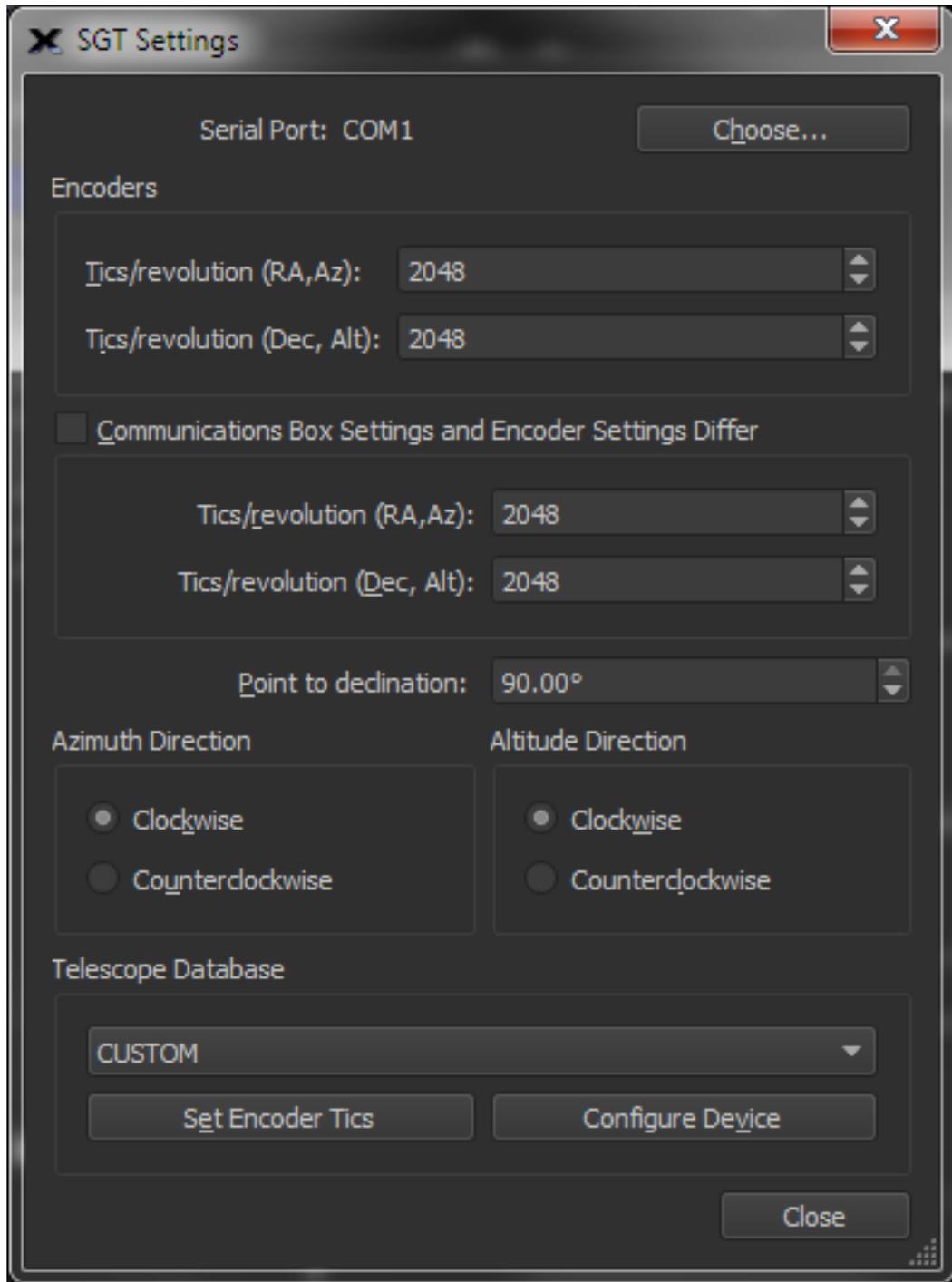


Figure 157: The SGT Settings window.

Click the **Serial Port** button to select the serial port to which the interface is connected. All telescope serial interface boxes use RS232 serial communication. Since most modern computers are not equipped with a serial port, you'll most likely need to purchase a USB to serial adaptor to convert a USB port into a serial port. Follow the manufacturer's instructions for installing the software drivers for this hardware. On the Mac, choose the port that contains the manufacturer of your USB to serial adaptor's name. On Windows, use the Device Manager to determine the

- communications port number (COM number) for the adaptor, and enter “COMN”, when “N” is the number of the port reported by the Device Manager.
3. Select your telescope model from the Telescope pop-up menu. If it isn't listed, choose the CUSTOM option. The number of encoder tics per revolution for the selected telescope is displayed in the **Encoders** text boxes to the right. If your telescope isn't listed, don't worry. Just manually enter the correct values in the Encoders edit boxes. If you don't know these values, contact the manufacturer.
  4. Enter the *same values* in the **Tics/Rev** text boxes. The RA and Dec values are sometimes different. Don't switch them. If you own version 1.7 through 1.99 of the BBox, or version 2.93 through 3.49 of NGC-MAX, enter 32768 for both axes.
  5. Set the **Clockwise/Counterclockwise** options for Azimuth and Altitude Direction. If you aren't sure which way the encoders are supposed to be mounted, contact the manufacturer. Or continue with the setup, and see which way the cross hairs move when you link the telescope and computer. If the cross hairs move in the wrong direction, you've selected the wrong direction.
  6. Click the **Configure Device** button. This step applies only if you own a BBox, version 1.7 (or later). If not, skip to the next step. The BBox is automatically configured for the selected number of encoder tics. If you get the message “Cannot configure BBox,” try again. If you still cannot configure the box, please refer to the “Troubleshooting” section on page 398. This step need be done only once, as the interface box stores the configuration in non-volatile memory.
  7. Click **Close** to save the configuration.

### **Aligning the Encoders**

*TheSkyX* is now configured to communicate with the encoders. The next step is to align the encoders by aiming the telescope at specific stars. This gives *TheSkyX* the information it needs to calculate where the telescope is pointing.

*Any two stars* that are visible from your location can be used during the alignment procedure.

1. After your telescope is setup, select the **Connect** command from the **Telescope** menu to show the SGT Alignment window.
2. **Click the Start Alignment button.** If your telescope is mounted equatorially (that is, the RA axis is pointing to the celestial pole), point it at declination 90°, by default. Choose a different declination (or azimuth) from the **Point Scope At** pop-up menu if your telescope cannot be pointed at 90°.
3. **If your telescope has an azimuth/altitude mounting, point it at 90° altitude.** Specifically, you're looking for the telescope position where rotation in right ascension (or azimuth) causes no rotation in declination (or altitude). The default angle is 90°.
4. **Point the telescope at the first alignment star.** The default first-alignment star is Polaris. To use a different star, use the Find command to locate the star (or just click on it in the Sky Chart). Then click Align On in the **Telescope** sheet of **Object Information** window.
5. **Point the telescope at the second alignment star.** The default second-alignment star is Capella. To use a different star, use the Find command to locate the star (or just click on it in the Sky Chart). Then click Align On in the Object Information window. The difference between the actual angular separation of the alignment stars and the angle measured by

the encoders is displayed. A difference of zero indicates a “perfect” alignment. Experience shows that a difference of 1 degree or less is acceptable. If the difference is substantially greater, you should try pointing to two different stars.

6. **Click Accept Alignment.** The alignment is complete. You should see cross hairs in the Sky Chart, marking the approximate center of the field of view of the telescope.

As you move the telescope, the cross hairs move to show where the telescope is pointing. As the cross hairs reach the edge of the screen, the Sky Chart automatically scrolls to keep the cross hairs visible.

The **Connect** button on the toolbar is “down” to show the telescope link is active.

### Selecting Alignment Stars

If you can choose different alignment stars, don’t pick closely spaced ones. The greater the angular separation of the alignment stars (in both right ascension and declination), the more errors inherent to the system are “averaged out” across the sky.

### Realignment with Each Use

TheSkyX has no provision for saving alignment settings because you must align the telescope each time you use it, *even when observing from the same location.*

## Mount and Status

When **Mount** is highlighted in the **Imaging System** list, the name of the selected mount driver is displayed on the top, right side of the **Imaging System** window. The **Status** of the connection is shown below it. Common status messages include the following. Green-colored text indicates normal operation; red indicates either no communication, or a communication failure.

| Status Text   | Description  |
|---------------|--|
| Not Connected | <p>The red text indicates there is no connection between <i>TheSkyX</i> and the mount.</p> <p>To connect to the mount:</p> <p>Choose your mount from <b>Mount List</b> window on the <b>Mount Setup</b> pop-up menu from the <b>Telescope Setup</b> window</p> <p>Choose the communication port by clicking the <b>Settings</b> command on the <b>Mount Setup</b> pop-up menu</p> <p>Click the <b>Connect</b> command from the <b>Telescope</b> menu, or the <b>Connect Mount</b> command from the <b>Start Up</b> pop-up menu on the <b>Telescope</b> window to connect to the mount.</p> <p>See the step-by-step setup instructions below for your specific mount.</p> |

| Status Text   | Description  |
|---------------|--|
| Connecting    | <p>This message is displayed while <i>TheSkyX</i> attempts to establish communication with the mount.</p> <p>If connection fails, double check:</p> <ul style="list-style-type: none"> <li>• The mount is powered on.</li> <li>• The communication cable is plugged into the correct port on the mount and computer.</li> <li>• When using the device’s RS232 communications port (serial port), make sure the USB to Serial Adaptor driver for your operating system are installed. Under Windows, check the Device Manager to ensure the driver is recognized and functioning properly.</li> <li>• Click the <b>Settings</b> button on the <b>Telescope Setup</b> window to make sure <i>TheSkyX</i>’s Telescope settings are correct.</li> <li>• Make sure the RS232 telescope cable is wired correctly for your model telescope.</li> <li>• Make sure the USB cable is working properly by using it on a different USB device. As a troubleshooting test, remove any USB hubs, USB extenders and plug a 15-foot USB cable directly into computer’s USB port, and directly into the USB adaptor.</li> </ul> |
| Disconnecting | <p>This message appears while <i>TheSkyX</i> terminates communication with the mount.</p>  |
| Not Homed     | <p>The green <b>Not Homed</b> status message means <i>TheSkyX</i> is successfully communicating with the mount’s control system, but the mount has not been homed.</p> <p>Click the <b>Find Home</b> command from the <b>Start Up</b> pop-up menu on the <b>Telescope</b> window slew the mount begin the homing process.</p>  |
| Finding Home  | <p>This message appears while the mount is searching for the homing sensors.</p>   |
| Not Synced    | <p>Synchronization is the procedure where the optical tube assembly is pointed to a position on the celestial sphere (typically a bright star) and the mount is synchronized to this specific equatorial coordinate. See “Software Synchronization” on page 377 for more information.</p> <p>To perform a synchronization from <i>TheSkyX</i>, identify the bright star on the Sky Chart, center this star in the telescope’s field of view, then click the <b>Sync</b> button on the <b>Telescope Star Synchronization</b></p>  |

| Status Text               | Description   |
|---------------------------|---|
|                           | <p>window. (To display the <b>Telescope Star Synchronization</b> window, click the <b>Star Synchronization</b> command from the <b>Start Up</b> pop-up menu on the <b>Telescope</b> window.)</p> <p>Provided <i>TheSkyX's</i> location, date, time, time zone and Daylight-Saving Option is configured correctly, and the correct star is identified on the Sky Chart, and the telescope is actually pointing to the identified star, the mount is now oriented with the celestial sphere so that when you tell the mount to "slew to this RA/Dec" it will actually slew to the correct position.</p> |
| Tracking at Sidereal Rate | <p>The mount's right ascension axis is rotating at the same rate as the stars, so that there will be no apparent motion in the eyepiece.</p> <p>This "steady state" message appears when the mount is tracking at the sidereal rate (and not a custom tracking rate).</p>   |
| Tracking at Custom Rates  | <p>The mount has been configured to track at a rate other than the sidereal rate. See "Set Track Rates" on page 394 for details about configuring custom rates.</p>   |
| Slewing to Target         | <p>This message appears after clicking the <b>Slew</b> button (or right-clicking an object on the Sky Chart that is above the horizon and selecting the <b>Slew</b> command) and while the mount slews to the target object. See "Slewing to Objects" in <i>TheSkyX Pro User Guide</i> for details.</p> <p>Click the <b>Abort</b> button on the <b>Telescope</b> window to stop the slew.</p>   |
| Joysticking               | <p>This message appears when the Paramount's joystick (Paramount ME) or hand paddle controller (Paramount MX) is being used to slew the mount.</p>  |
| Parking                   | <p>The mount can be slewed and "parked" to a custom position at the end of each observing session. Please carefully read the Defining the Park Position and Park Position Rules for more information.</p> <p>This message is displayed while the mount slews to the park position.</p>  |
| Parked                    | <p>When the mount reaches the Park Position, tracking is turned off. Once the mount is parked, make sure to disconnect from the mount to terminate the observing session.</p>   |

| Status Text                                  | Description   |
|--|---|
| Tracking<br>Satellite                        | <p>This message is displayed while the mount is tracking a satellite (the right ascension and declination tracking rates are configured for the satellite that is being tracked).</p> <p>Click the <b>Abort</b> button to terminate this process.</p> |
| Connection Lost<br>or Poor<br>Communications | <p>After multiple retries, when <i>TheSkyX</i> cannot reliably send/or receive commands to/from the telescope, the connection is terminated.</p>  |

## Mount and Driver Information

After selecting your mount, the Imaging System Setup window lists the mount’s driver-specific information. (The telescope driver is the software that “talks” to the mount’s control system.)

### **Device Name**

Displays the name of the mount or control system.

### **Device Description**

Displays a short description of the selected mount.

### **Driver Information**

Displays a short description about the telescope driver.

### **Driver Version**

Displays the software version of the telescope driver.

### **Firmware Information**

When available, the mount or control system *firmware* version is displayed. Remember, firmware is the internal software that is used by the control system and is different than the telescope driver version.

### **Model**

When available, the model of the mount is displayed.

## Telescope-Related Software Preferences

The Imaging System window provides the following additional preferences for both encoder and “go to” interfaces.

### **Always Confirm Slews**

When this option is turned on, after initiating a slew command (page 381), you must confirm whether you want to slew the telescope before the mount begins slewing.

Turn off the ***Always Confirm Slews*** option on the ***Confirm Slew*** window or on the ***Telescope Setup*** window so that confirmation is not required.

### ***Always Confirm Syncs***

When this option is turned on, after initiating a software synchronization (page 377), you must confirm whether you want to sync the telescope.

Turn off the ***Always Confirm Slews*** option on the ***Confirm Slew*** window or on the ***Telescope Setup*** window so that confirmation is not required.

### ***Confirm Pointing Samples***

When this option is turned on, after adding a new pointing sample, you must confirm whether you want to do so.

Turn off the ***Always Confirm Pointing Samples*** option on the ***Confirm Pointing Sample*** window or on the ***Telescope Setup*** window so that confirmation is not required.

### ***Impose Slew Limits (Destination Coordinates Only)***

Turn this option on to have *TheSkyX* try to stop slews to slew limit regions (page 362).

\*\*\*

### ***Atmospheric Refraction Parameters***

Click the ***Atmospheric Refraction Parameters*** button to set the temperature, pressure and other weather-related parameters that can change telescope pointing (specifically, refraction calculations) from night to night. Note that these parameters can usually be left unchanged for most observers. For those using the TPoint Add On's Super Model feature to achieve sub-10 arcsecond pointing, setting these parameters each night will help maintain superb pointing.

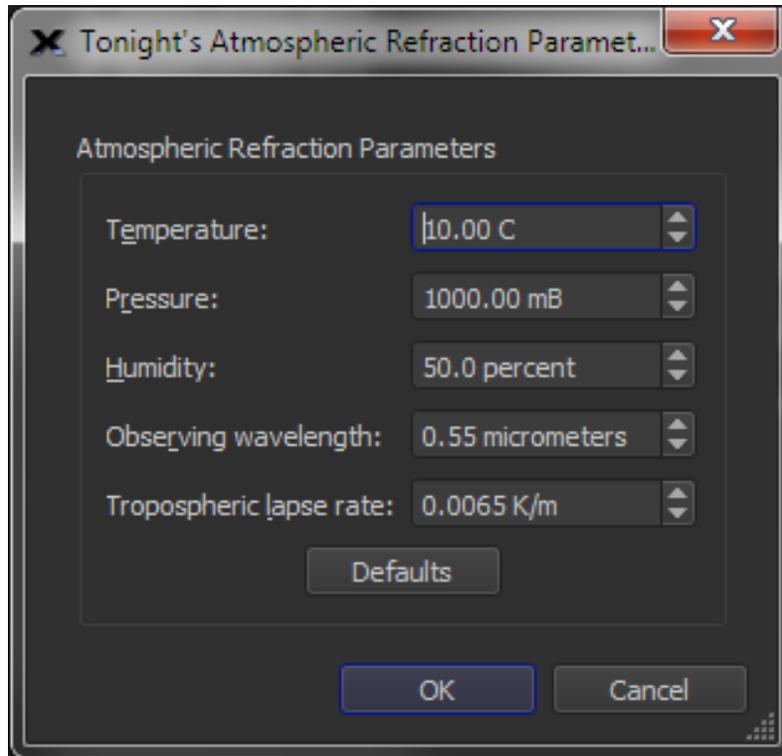


Figure 158: Tonight's Atmospheric Refraction Parameters window.

### **Temperature**

Enter tonight's ambient temperature.

### **Pressure**

Enter the barometric pressure, in mB. Note that the pressure TPoint needs is the *absolute pressure* at the observatory site (QFE), not the equivalent *sea-level pressure* (QNH). Websites and weather stations almost always give the latter, always around 1000 hPa, whereas the pressure at Golden, Colorado (for example) is about 820 hPa. If you mistakenly use the sea-level pressure you are likely to find the term TX10 appearing in your pointing model to correct the overestimate, not that it always means that.

### **Humidity**

Enter the relative humidity, as a percentage.

### **Observing Wavelength**

Enter the wavelength of light that is being observed. Yes, the atmosphere affects different wavelengths.

### **Tropospheric Lapse Rate**

In degrees K/m, the default value is 0.01. Note that the default value can be used in nearly all circumstances.

### **Defaults**

Click this button to restore the default atmospheric refraction settings.

\*\*\*

### ***Cross Hair Update Interval***

Enter the length of time, in milliseconds, that the coordinates of the telescope cross hairs are updated. The default setting is ***As Fast As Possible***; if you cannot establish communication with your mount, or encounter communication failures, it may be that your mount cannot keep up with *TheSkyX's* requests. If this is the case, try increasing the interval to 500 milliseconds or higher.

### ***Always Keep Telescope Cross Hairs Visible on Sky Chart***

The telescope cross hairs can be forced to remain visible on the Sky Chart so that you can more easily track its position. The other options in this list include:

- **No:** This option allows the telescope cross hairs to move independently from the Sky Chart. Use the ***Center Cross Hairs*** button to adjust position of the Sky Chart based on the telescope's current position.
- **Yes:** The telescope cross hairs remain visible on the Sky Chart. If the telescope is slewed, or the Sky Chart's position is changed, the Sky Chart is automatically updated to center the cross hairs.
- **Yes, Centered:** The telescope cross hairs are pinned to the center of the Sky Chart.
- **No, Suspend Connection:** The telescope link is suspended; the telescope cross hairs are no longer displayed, and Sky Chart's field of view can be changed.

### ***Telescope Field of View (FOV)***

Click the ***Choose*** button to choose the Field of View Indicator (page 119) for your imaging system.

## **Using the Software-Guided Link**

The cross hairs in the Sky Chart will now "follow" the telescope. This is true whether you move the telescope by hand, or let its motor drive turn it. Be sure you've clicked the ***Computer Clock*** button. The Sky Chart will then update automatically. If you select a specific date and time, the Sky Chart does not update; however, the Sky Chart may not match what you see through the telescope.

## **Terminating the Link**

On the Telescope menu, click the ***Connect*** command. Or, select ***Disconnect Telescope*** in the ***Shut Down*** pop-up menu on the ***Telescope*** window.

## **Finding an Object**

*TheSkyX* can help you position the telescope on an object.

1. Use the ***Find*** command on the ***Edit*** menu to locate the object.

2. Click the **Guide To Current Object** button. It is located on the Utilities tab of the SGT Alignment window. This will show the Guide To controls on the Sky Chart. When the telescope is pointing relatively near the target object, its position is represented by cross hairs on the RA/Azimuth and Dec/Altitude axis circles. When an axis is far from the object, a red and green line are shown instead. The red line rotates as the telescope is moved. The green line remains stationary. Your goal is to move the telescope until the red line is drawn on top of the green line. At this point, the lines fade away. Slowing move the telescope axis until the cross hair is over the center green circle.

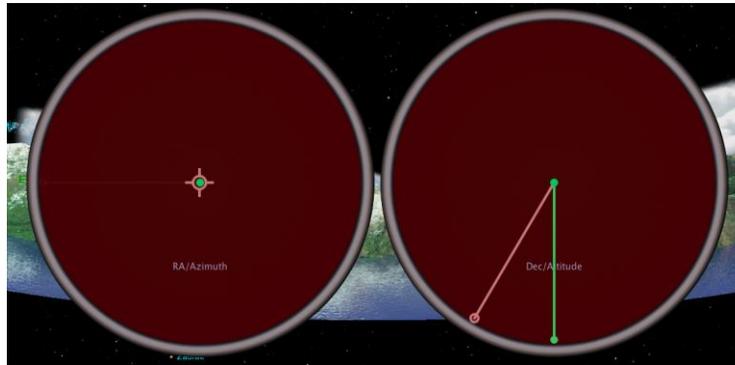


Figure 159: The SGT Guide To controls.

3. **Starting with the RA/Az axis**, move the telescope until the cross hairs are centered in the circle. Lock the RA/Az axis.

Repeat the last step for the Dec/Alt axis.

The Sky Chart's cross hairs are now over the desired object. When you look through the telescope, the object should be near the center of the field. If Impose Slew Limits are enabled, *TheSkyX* warns you if you try to move the telescope into a limit-line region.

## Setting Up and Using your Go To Telescope

*TheSkyX* can drive many popular commercial telescopes. Most telescopes that *TheSkyX* controls are *serial devices* (one exception is Vixen SX mounts; it uses an Ethernet connection). In order for a telescope that uses serial communications to “communicate” with the computer (and *TheSkyX*), the computer must have a *serial port*.

Unfortunately, serial ports have been replaced by USB ports on virtually every newer model computer. This means the physical USB hardware, as well as the USB protocol, is not compatible with older serial devices. Fortunately, there is a solution...

### USB to Serial Adaptors

The most common method to connect a personal computer that has a USB port to a telescope that uses serial (RS232) communication, is to use purchase a *USB to serial adaptor*. This hardware

device “converts” one of the computer’s USB ports into a virtual serial port that understands serial communication used by the telescope.

The most common way to do this is to use a USB to Serial Adaptor so that one of the computer's USB ports can accept RS232 commands. (Bluetooth or serial to Ethernet hardware devices are other, less common, and typically more expensive alternatives.)

USB to serial adaptors are relatively inexpensive and can be purchased at almost any computer store.

- Before purchasing the USB to serial adaptor, make sure the adaptor is compatible with your computer’s operating system. For example, some USB to serial adaptors are not compatible with Mac OS X Snow Leopard.
- Carefully follow the manufacturer’s setup instructions for your operating system. Remember, the USB to serial adaptor hardware requires that you install a separate software driver before it can be used to communicate with a telescope.

### ***Mac OS X Snow Leopard and USB to Serial Adaptors***

When you plug a USB to Serial Adaptor into a computer that is running Mac OS Snow Leopard, a message appears that a new network device has been connected, and prompts you to set it up (via the Network options in System Preferences).

Configuring the USB to Serial Adaptor as a network device will not allow TheSkyX to control a telescope that uses RS232 serial communication.

For *TheSkyX* to control a telescope that uses serial communications on Mac OS X, an OS X compatible USB to serial adaptor driver must be installed first.

Contact the manufacturer of your USB to Serial Adaptor hardware device, or visit the manufacturer’s Downloads page to obtain this driver.

After installing the Mac OS X-compatible USB to Serial Adaptor driver, you need to select it from *TheSkyX’s Telescope > Telescope Setup > Settings* window.

You’ll also need a telescope cable that connects your computer to USB to serial adaptor. Cables for Meade and Celestron products can be purchased from the Software Bisque Store.

We strongly recommend that you read the telescope’s owner manual carefully, and become thoroughly familiar with the telescope’s operation, before using *TheSkyX* to control it.

## **Configuring the Telescope Interface**

*TheSkyX* must be configured so your computer can communicate with the telescope. The following general procedure applies to most “go to” telescopes.

1. Turn off the telescope.

2. Using the appropriate telescope cable, connect the serial port on the telescope to an unused serial port. If your computer does not have a serial port, you'll need to use a [USB to serial adaptor](#).
3. Turn on the telescope.
4. Select the **Telescope Setup** command from the **Telescope** menu to show the **Imaging System Setup** window.

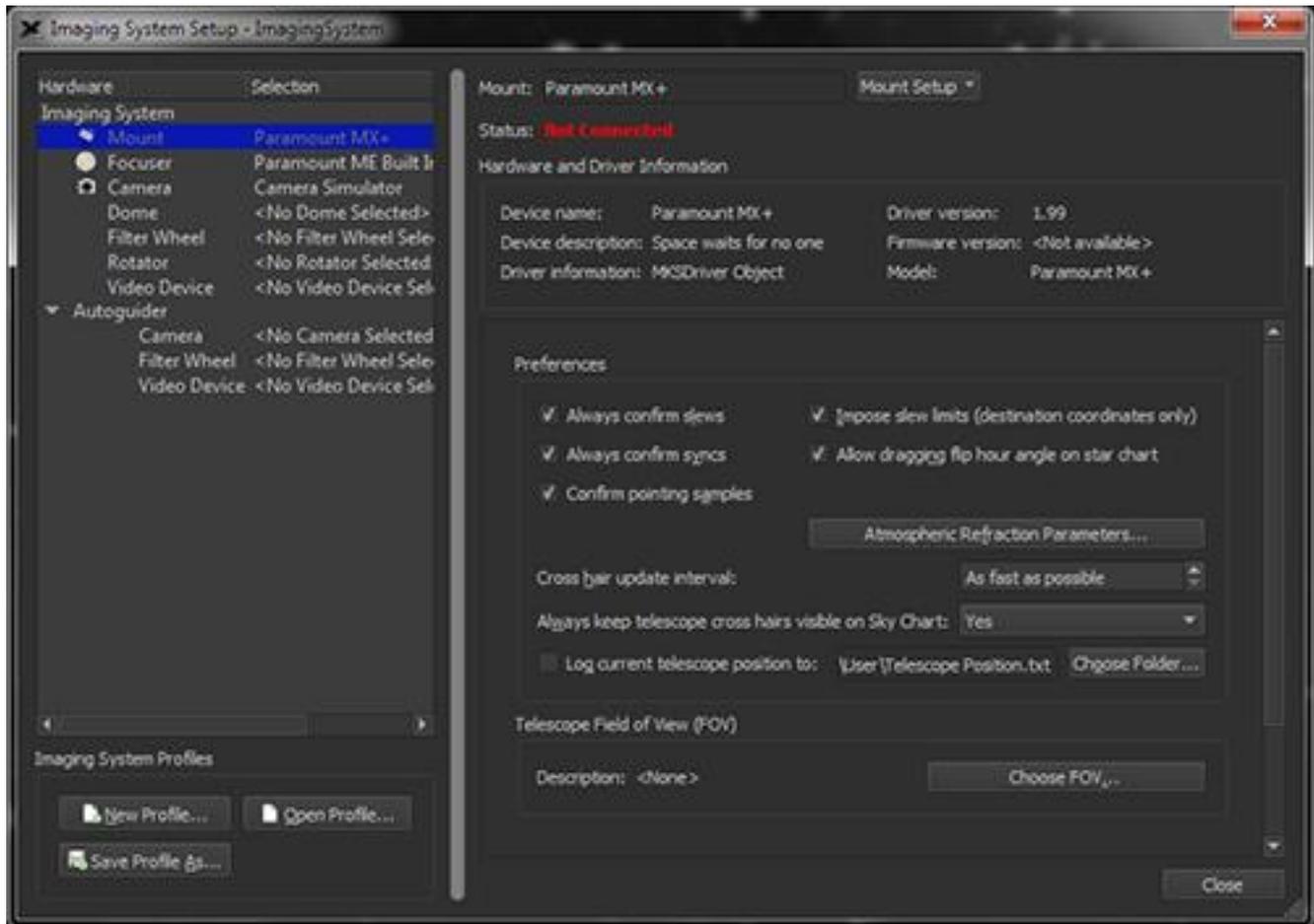


Figure 160: The default Imaging System Setup window.

5. Highlight **Mount** from the **Imaging System** tree on the left.
6. From the **Mount Setup** drop down menu, click the **Choose** command to select your telescope model and click **OK**.

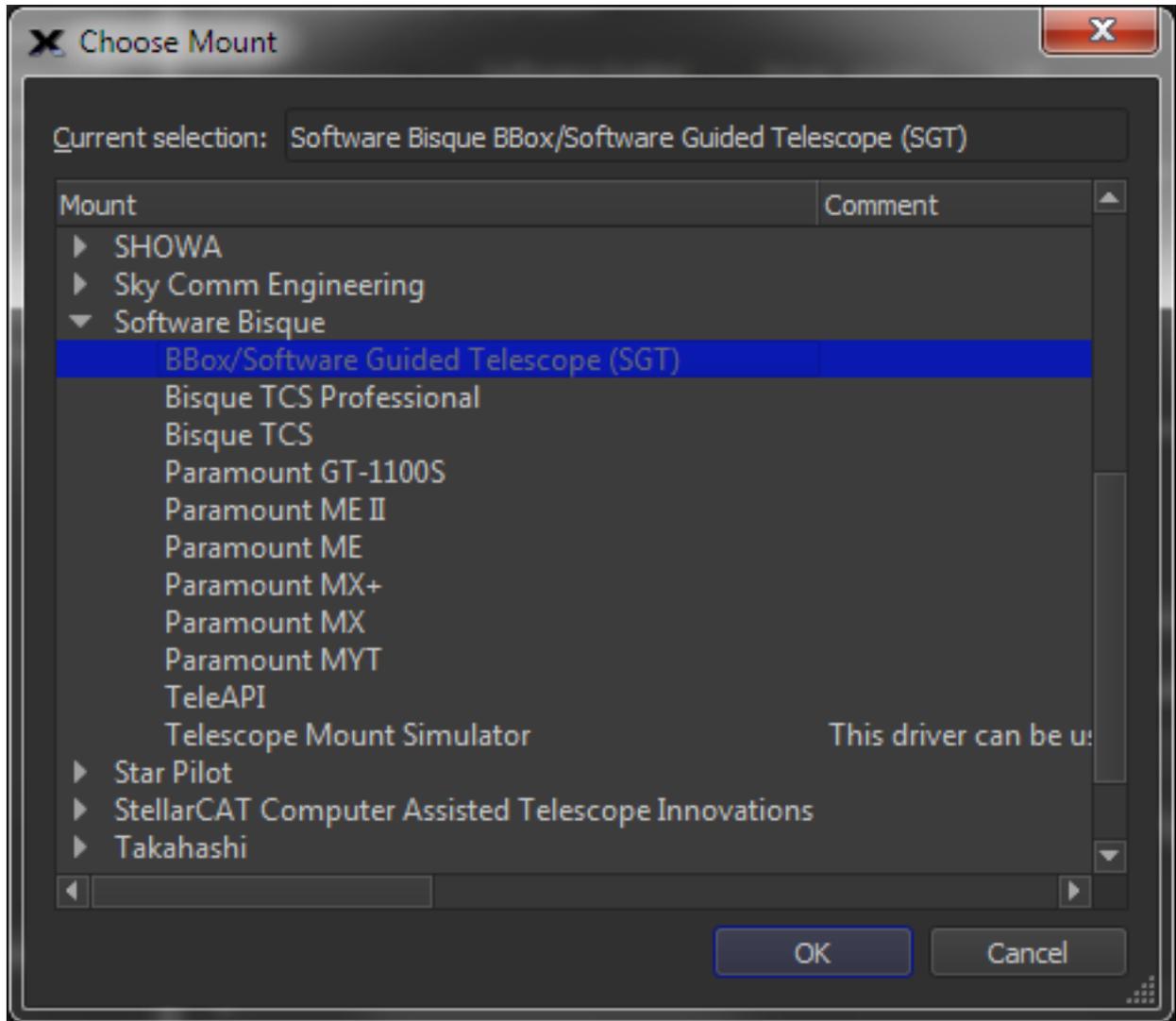


Figure 161: Select your mount from the list of supported telescopes.

7. From the **Mount Setup** drop down menu, click the **Settings** command. On the Mac, the **Serial Device Settings** window allows you to specify the USB to serial adaptor that your telescope cable is connected to.

#### **Windows Serial Port Notes**

- Only standard serial ports or [USB to serial adaptors](#) that are not being used by any other device should be used.
- Use Windows Device Manager to determine the COM port number for your serial ports, or USB to serial adaptor.

### **Linking To and Synchronizing the Telescope**

Most “go to” drive systems must be properly configured before *TheSkyX* can control them. You can do this “by hand,” using the telescope’s hand paddle. Or, you can do it from within *TheSkyX* by performing a process called synchronization.

(Note that Celestron telescopes using firmware version 4.1 and earlier cannot be synchronized from *TheSkyX* and must be aligned using the hand paddle before *TheSkyX* can control it.)

**Important Notes:**

- The local date, time, time zone, Daylight Saving Time and terrestrial coordinates must be manually input to the telescope's hand paddle. If the telescope is connected to your computer, you might find it easier to use *TheSkyX* to initialize the telescope's hand paddle with these values. If your telescope can be initialized by *TheSkyX*, click the **Location, Date, Time** command from the **Tools** pop-up menu on the **Telescope** window to do so (page 370).
- The telescope must be aligned with the celestial sphere. Follow the manufacturer's instructions for aligning the telescope with the night sky.

See "Software Synchronization" on page 377 for details how to synchronize your mount with *TheSkyX*.

## Telescope Setup Options

After choosing your telescope, the **Imaging System Setup** window displays mount and driver specific information, and allows you to specify your telescope preferences.

## Telescope Limits

Controlling the slewing limits of your telescope is a snap with *TheSkyX's* telescope limits command. There, you can set lower altitude and upper altitude and declination limits. To open the **Telescope Limits** window, select the **Telescope Limits** command from the **Telescope** menu.

### **Telescope Operation Disclaimer**

Any motor-driven telescope can – through improper initialization, accident, carelessness, or component failure – be run into its mechanical limits. Software Bisque provides the limit region feature as a convenience – not as a guaranteed cure for the problem. You are responsible for the safe use of your instrument.

### **Upper Limits**

When you first open the **Telescope Limits** window, you will first be given an opportunity to set the **Upper Limits** of your telescope's slewing control. Use the data fields to enter maximum values for declination and altitude slewing and to choose whether the telescope limits are plotted on the Sky Chart.

### **Lower Altitude Limit**

Choose the **Lower Altitude Limit** tab to set minimum altitude limits for your telescope setup. In the top portion of the window, you will see a graph upon which you can click and drag the mouse pointer to draw a set of altitude limit data for given azimuth values.

You can also choose to **Open** a pre-existing horizon file, and, once you have set altitude limits, you can save a horizon file for later use by clicking **Save As**.

Clicking **Set To** allows you to set altitude limits according to a number of values, such as a given set altitude, or to match the current horizon image. For more on horizon images, see **Horizon & Atmosphere Options**.

You can also import the telescope's current Az/Alt position into the window by clicking **Get Telescope Az/Alt**.

Here, too, you choose to have *TheSkyX* plot the set limits onto the Sky Chart by clicking **Show limits on Sky Chart**.

Once you are satisfied with the input limit data, click **OK** to commit. If you decide not to use these data, click **Cancel**.

## ***TPoint Add On***

*The TPoint Add On* is optional telescope pointing analysis software that allows you to analyze the errors inherent in your telescope system to drastically improve its pointing performance. Both *TheSkyX Serious Astronomer Edition* and *TheSkyX Professional Edition* supply a 90-day trial version of *TPoint*. The *TPoint Add On* can be accessed from the **Tools** menu.

Like many aspects of your imaging system, there is a learning curve. Fortunately, *TheSkyX* makes using *TPoint Add On* easier and you should be able to complete an automated calibration run on the first night to start analyzing and improving your telescope's pointing right away. The *TPoint Add On User Guide* is available by selecting the ***TPoint Add On User Guide*** from the **Help** menu.

## ***Telescope Controls***

The ***Telescope*** window holds the most commonly used telescope controls. Select the ***Telescope*** command from the ***Display*** menu to show it.

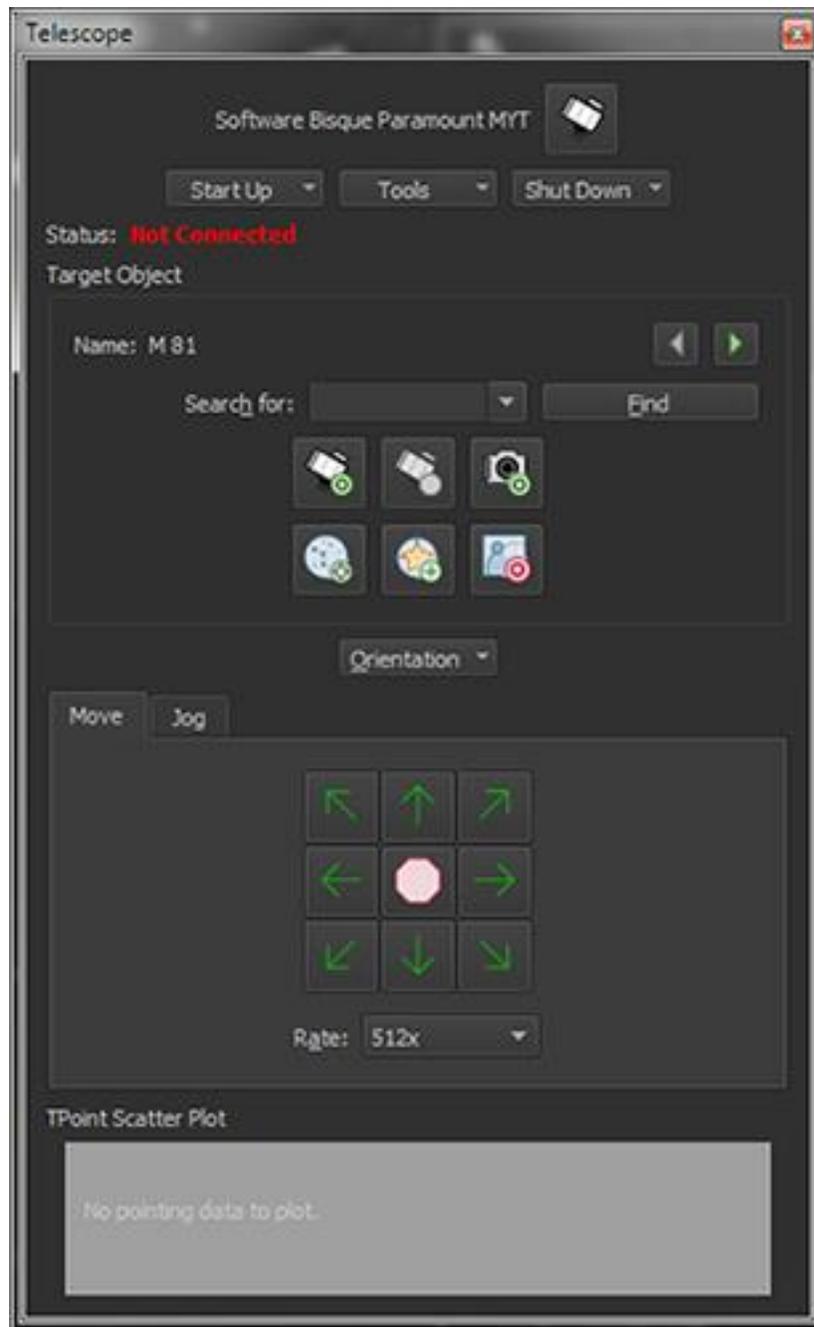


Figure 162: The Telescope window (*Telescope* command, *Display* menu).

Not all telescope mounts have the same feature set; the **Telescope** window shows the most commonly used mount controls. Note that the commands in the **Start Up**, **Tools** and **Shut Down** pop-up menus may change for each mount.

Manufacturer-specific telescope control features can be accessed from the appropriate *<Telescope Name>* command in the **Display** menu. For example, the control system specific commands for the Gemini are located on the **Gemini** window.

## Telescope Initialization

The **Start Up** pop-up menu on the **Telescope** window shows mount-specific commands that are used to connect to, synchronize, unpark or find the mount's home position, when applicable.

### **Connect Telescope Command**



This command is identical to selecting the **Connect** command from the **Telescope** menu. See “Linking To and Synchronizing the Telescope” for more information about this command.

### **Find Home Command**



Where supported, this command tells the mount to slew to its home position.

### **Star Synchronization Command**



Use this command to tell *TheSkyX* where the telescope is currently pointing. See “Software Synchronization” for more information about this command.

### **Telescope Setup Command**



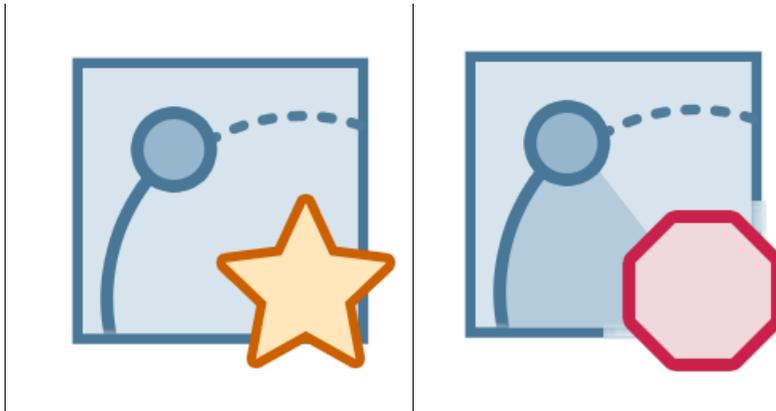
Shows the **Telescope Setup** window. See “Configuring the Telescope Interface” for more information about setting up your mount.

Once communication with the telescope is established, the **Telescope** window can be used to find objects, monitor the status of the communications between the mount and the computer, initialize the mount’s hand paddle or controller with *TheSkyX*’s location, date, time, and time zone values, methodically slew the telescope outward to search for a nearby star and more.

## **Telescope Tools**

The **Tools** pop-up menu contains the less-commonly used telescope control features.

## Turn Sidereal Tracking On/Off



Use the **Turn Sidereal Tracking On** and **Turn Sidereal Tracking Off** commands to enable or disable sidereal tracking on mounts that support this feature.

## Slew To Coordinates

Use this command to enter a specific right ascension and declination or altitude and azimuth coordinate. See “Slewing to a Specific Coordinate” on page 381 for more information.

## Slew Prior

Use this command to slew the telescope to its previous coordinates. For example, if you slew to M42, then to the Pleiades, selecting the **Slew Prior** command will return the mount to M42. Slews must have been initiated by *TheSkyX* for this command to work. In other words, using the telescope hand paddle to slew to an object, then attempting to slew to the previous object will not work.

## Star Search

The Star Search feature slews the telescope in a spiral pattern of increasing size to help locate an object in the eyepiece. Choose the **Star Search** command from the **Tools** pop-up on the **Telescope** window to show the **Star Search** window.

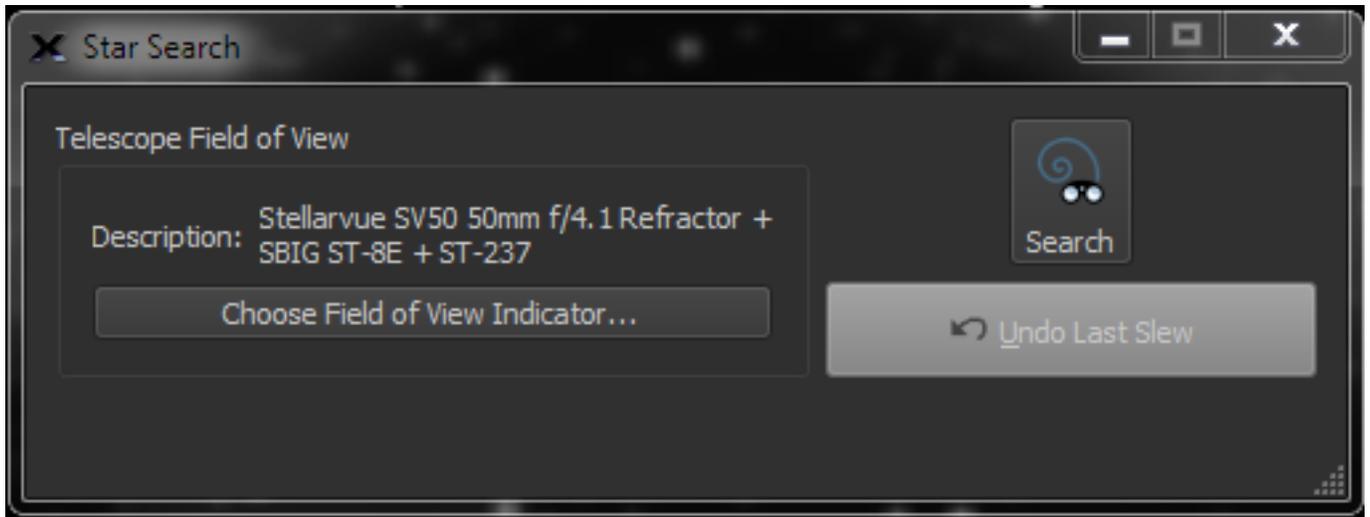


Figure 163: The Star Search window (Tools menu on the Telescope window).

### ***Begin Spiral Search (Star Search button)***



Clicking this button begins slewing the telescope in a “spiral” pattern, based on the size of the selected Field of View Indicator.

### ***Defining the Size of the Spiral (Telescope’s Field of View)***

The angular distance between slews when the telescope “spirals” outward can be configured to match the telescope’s field of view. Click the **Select From Field of View Indicators** button to tell *TheSkyX* the specifics of your optical system.

## **Communications Log**

The **Communications Log** command (**Tools** pop-up menu on the **Telescope** widow) shows the serial or network communications between *TheSkyX* and the telescope.

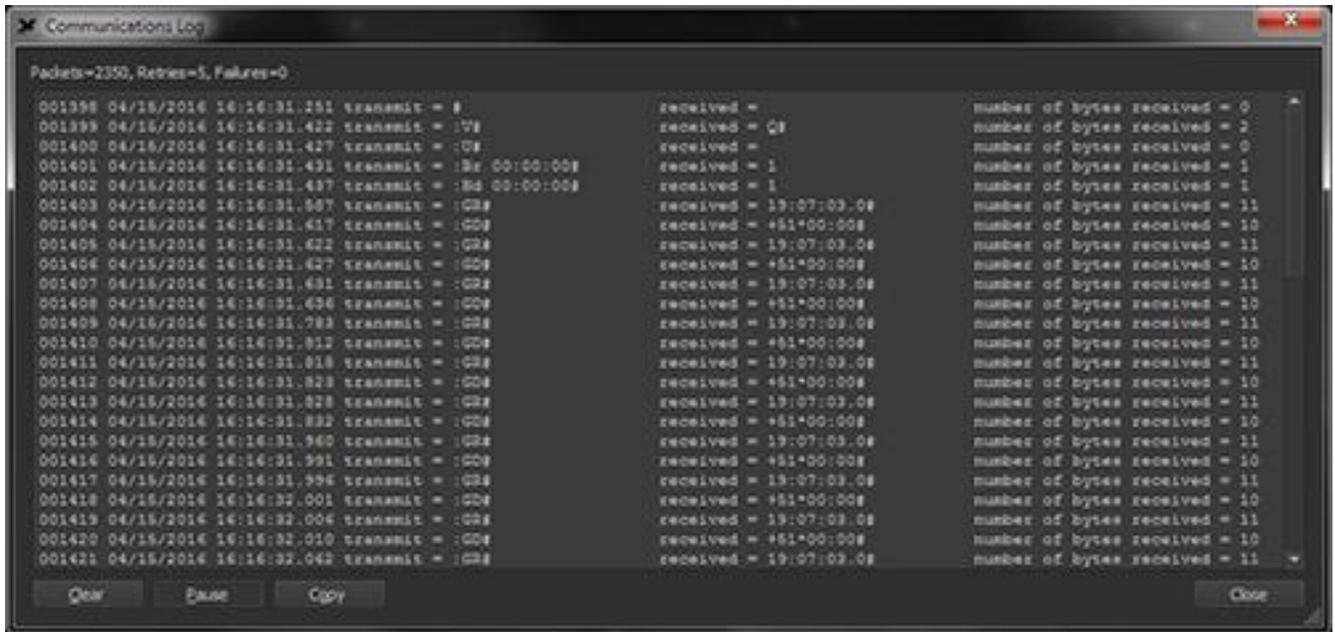


Figure 164: The Communications Log window.

The report contains six columns.

- **Packet Count** – The total number of packets or commands sent to the telescope, including retries and failures.
- **Date and Time** – The date and time the packet was sent.
- **Transmit** – The telescope-specific command that was sent to the telescope. Please refer the telescope protocol specifications for your telescope to decipher what each command means.
- **Received** – The response received from the telescope.
- **Number of Bytes Received** – The number of individual characters received.

This information can be useful when troubleshooting telescope connection problems.

### **Packets, Retries, Failures**

The number of **Packets** represents the individual commands that have been transmitted to the telescope. If the telescope does not respond to a command, TheSkyX resends or **Retries** to send the command three times. Failures mean the telescope did not respond to a command. Multiple failures usually indicate that there is a configuration, cabling or other hardware problem. To begin troubleshooting, check that the telescope is turned on, the serial cable plus the USB to serial cable is properly plugged in to the computer and the telescope’s communication port.

### **Clear**

Click the **Clear** button to clear the current report.

### **Pause**

Click the **Pause** button to temporarily stop the communications log report from being updated. Note that communications with the telescope continue when this button is pressed down.

## Location, Date, Time

Astro-Physics, Gemini, Celestron and Meade mounts allow *TheSkyX* to configure the control system's location, date, time and time zone information, rather than having to set them manually using the hand paddle. Choose the **Location, Date, Time** command from the **Tools** pop-up on the **Telescope** window to show the **Telescope Location, Date, Time** window.

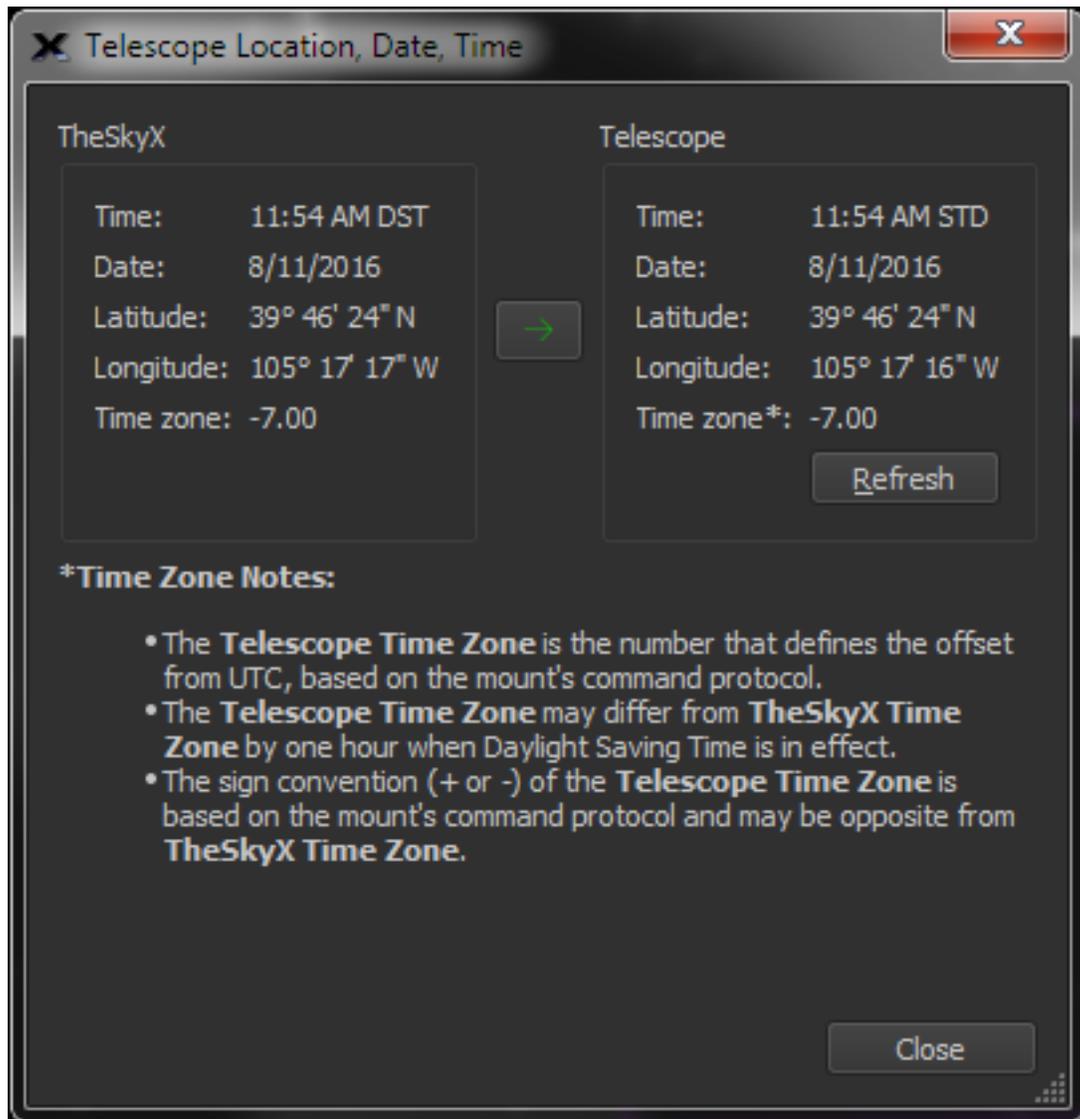


Figure 165: The Telescope Location, Date, Time window (Tools menu on the Telescope window).

For the telescope to be commanded to the correct coordinates, the telescope must use the same parameters as *TheSkyX*.

### **Refresh Button**

Click the **Refresh** button to get the telescope's current settings.

**Arrow Button**

Click the green arrow button to configure the hand paddle’s settings to match *TheSkyX*’s current time, date, latitude, longitude and time zone settings.

*TheSkyX*’s settings may not *exactly* match the telescope’s settings for the following reasons.

| <b>Parameter</b>                     | <b>Reason for Difference</b>   |
|--------------------------------------|--|
| <b><i>Time</i></b>                   | The time display is not updated continuously on this window, so the seconds may differ.  |
| <b><i>Latitude and Longitude</i></b> | The telescope protocol may not allow arcsecond accuracy for latitude and longitude.<br>The telescope’s coordinate convention may differ from <i>TheSkyX</i> ’s convention. For example, the Astro-Physics longitude is displayed from 0–360°; <i>TheSkyX</i> measures longitude from 0–180° East or West of GMT.   |
| <b><i>Time Zone</i></b>              | <i>TheSkyX</i> uses a different time zone sign convention as compared to the telescope protocol, so the sign of <i>TheSkyX</i> ’s time zone is opposite from the telescope.<br><i>TheSkyX</i> sets the telescope’s time zone to the nearest whole number.<br>When Daylight Saving Time is in effect, the telescope protocol must be configured to use a one hour offset from the actual time zone. This convention means <i>TheSkyX</i> ’s time zone will differ from the telescope by one hour. |

These differences are normal and expected and ensure the telescope is properly configured for *TheSkyX* control.

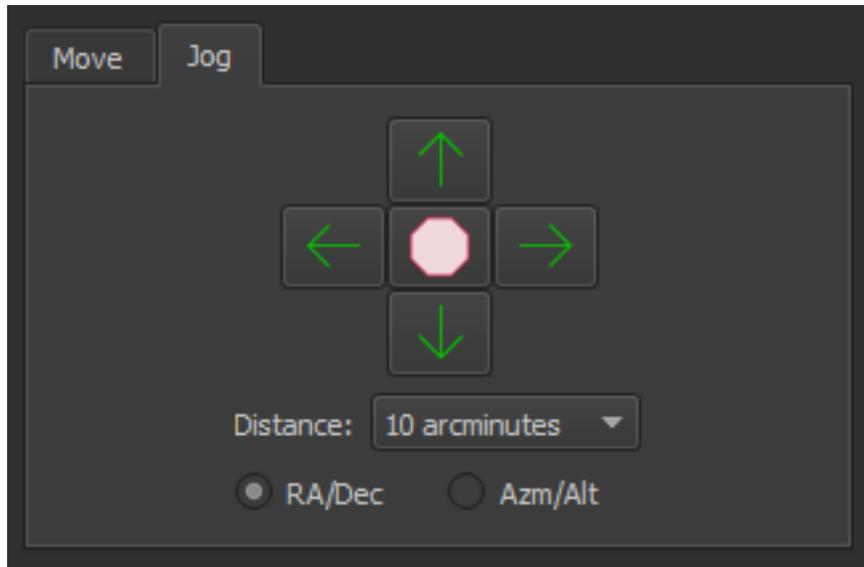


Figure 166: The Jog pane on the Telescope window.

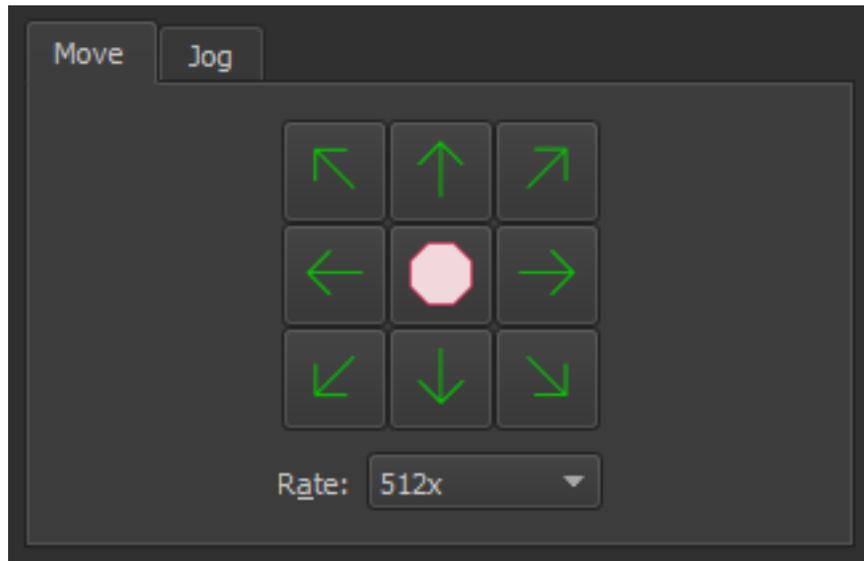


Figure 167: The Move pane on the Telescope window.

## Bisque TCS

### PROFESSIONAL

*Paramount Robotic Telescope Systems* (page 423) use the Bisque Telescope Control System (Bisque TCS) for dual axis motion control. The **Bisque TCS** command provides access to control system specific features. See the Paramount User Guide for Bisque TCS documentation.

## Virtual Telescope

The **Virtual Mount** window simulates the orientation and motion of your mount, and can be especially helpful for monitoring and troubleshooting remote mount operation. As the actual mount is commanded to slew, the simulated, virtual mount follows.

The current simulated mounts include:

- Astro-Physics Mach1 GTO
- Software Bisque Paramount ME
- Software Bisque Paramount MX

The simulated telescope on the simulated mount is a Newtonian optical tube assembly shown in Figure 168. We hope to add other simulated mounts and telescopes in future versions of *TheSkyX*.

Choose the **Virtual Mount** command from the **Tools** pop-up on the **Telescope** window to show the **Virtual Mount** window.

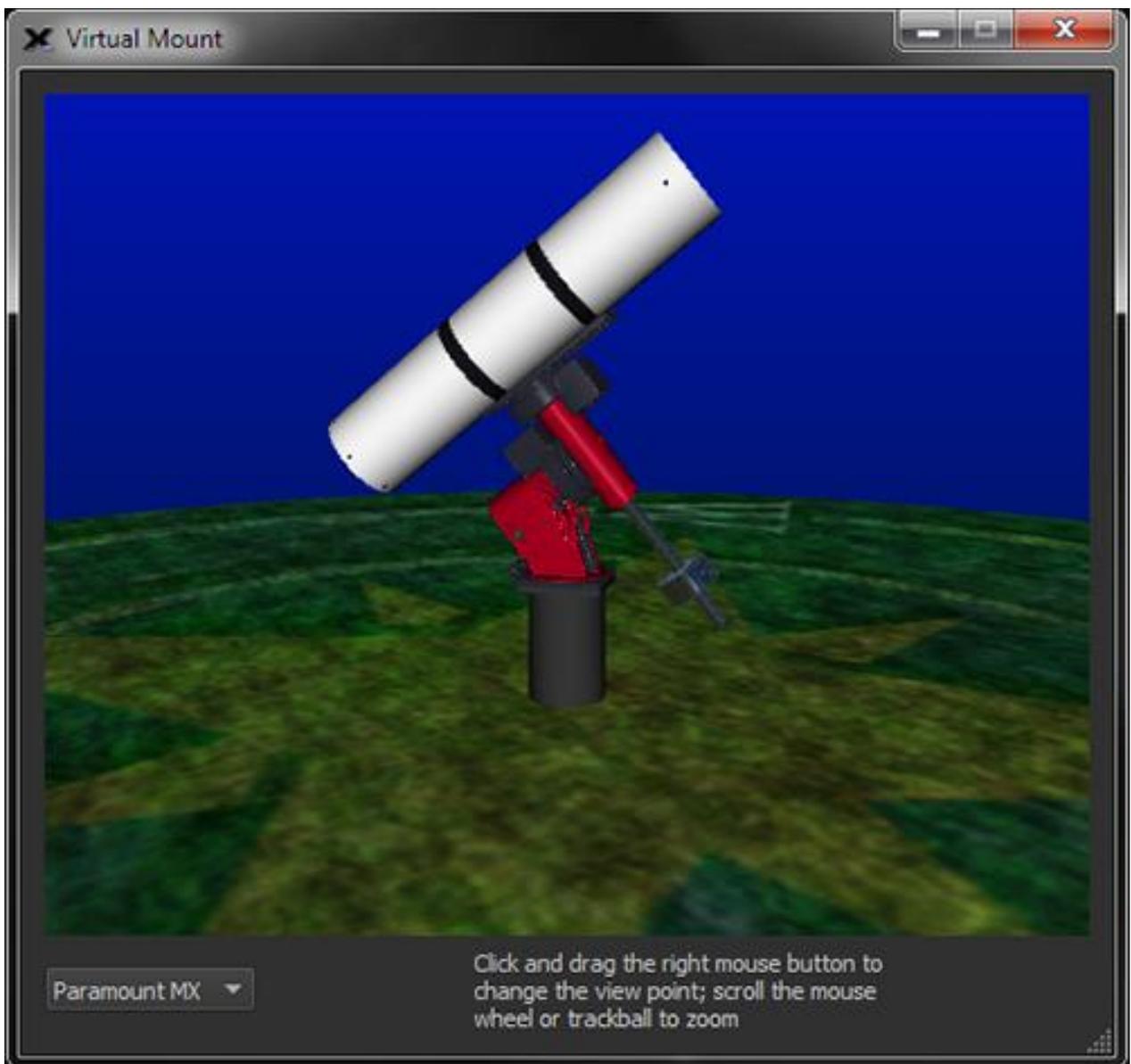


Figure 168: The simulated Paramount MX.

Right-click and drag on the **Virtual Mount** window to change the point of view. Place the mouse cursor over this window and use the mouse scroll wheel to zoom in and out.

The pop-up menu on the bottom of the **Virtual Mount** window allows you to select the simulated telescope mount.

## Move and Jog Controls

Use the controls on the **Move** and **Jog** tabs to manually slew or move, by discrete increments, the telescope.

### **Move Tab**

Click and hold the **Move** arrow buttons on the **Telescope** window to direct the telescope in a specific direction. The **Rate** pop-up menu controls the speed of the slew. The **Rate** options in this list change depending on the currently selected mount.

The **Move** window offers eight different direction controls: north, east, south, west, and the “diagonal” directions in between. Diagonal direction buttons are hidden for mounts that do not support dual-axis moves.

### **Jog Tab**

Use these arrow buttons to slew the telescope by the angular distance shown in the **Distance** list, and using and equatorial (**RA/Dec**) or horizon (**Azm/Alt**) coordinates.

### **Orientation Options**

The direction a button moves the mount is configurable. This is useful, for example, when the optical tube on a German equatorial mount changes sides from East to West, the relative motion of the telescope in the right ascension axis is reversed. Changing the orientation for the right ascension axis makes the buttons work “as expected” for the opposite side of the mount.

- **Normal** sends the standard commands to the mount for moving in this direction.
- **Swap Axes** changes the left/right direction buttons to up/down, and up/down to left/right.
- **Flip Left/Right** swaps the left and right buttons. Left moves right, and right moves left.
- **Flip Up/Down** swaps the up and down buttons. Up moves down and down moves up.

Alice, welcome to Wonderland.

## Shut Down Procedure

At the end of the night, you’ll want to make sure to park the telescope so it will be in the correct orientation to close the observatory roof. Note that some telescope control systems cannot park the telescope. For these telescopes, *TheSkyX* uses a “built-in” park feature that slews the mount to the park position (a fixed altitude/azimuth coordinate) that you define and turns off the

mount's sidereal tracking. When communication with the mount is established again, *TheSkyX* can unpark the mount and initialize the mount's control system.

### **Set Park Position**



Use this command to specify the altitude and azimuth coordinates to slew the mount before parking. The current position of the telescope cross hairs is used as the park position.

### **Clear Park Position**



Use this command to delete the previously defined park position. After clearing the park position, a new one must be defined with the ***Set Park Position*** command before the telescope can be parked.

## **Park**



The Park command slews the telescope to the park position, and then turns the mount's sidereal tracking off (where possible).

## **Unpark**



Once a mount has been parked, it may have to be unparked to initialize the telescope control system to restore normal operation.

## **Disconnect Telescope**

Terminates communication with the mount. This command is the same as selecting the Connect command from the Telescope menu when there is a connection. See “Linking To and Synchronizing the Telescope” for more information about this command.

## **Focuser**

Controls the focus and focus speed of a pulse focuser that is connected to the telescope's focuser port. This feature is especially useful when viewing CCD images on a monitor while focusing.

## Software Synchronization



Star synchronization (or “sync” for short) a mount with *TheSkyX* initializes the mount’s control system to an equatorial position on the celestial sphere. Mount synchronization may be performed using the mount’s hand paddle, if one is available, or through *software synchronization*.

### **To synchronize a mount using TheSkyX**

1. For telescopes that employ an external hand paddle that can control the mount independently, make sure that *TheSkyX*’s location, date, time, time zone and Daylight-Saving Time settings (DSO) match the telescope’s hand paddle settings. See “Entering Your Location” on page 33 for information about how to configure *TheSkyX* for your location on earth. See “Location, Date, Time” on page 370 for details how to use *TheSkyX* to configure the mount’s site and time settings.

If your mount does not have a hand paddle, or the **Location, Date, Time** command is not available for your telescope, consult the owner’s manual for your mount for details how to initialize the control system before using *TheSkyX* to control it.

2. From *TheSkyX*, manually center a known star in the telescope’s eyepiece (or other detector) using the mount’s hand controller or *TheSkyX*’s telescope move control commands (see “Move and Jog Controls” on page 374).
3. Find or identify this star in *TheSkyX Professional Edition*. (See “Finding and Identifying Celestial Objects” on page 59).
4. Choose the **Star Synchronization** command from the **Start Up** pop-up menu on the **Telescope** window.
5. Click the **Sync** button.

The following procedure applies if your telescope can be synchronized through software like *TheSkyX*. Some control systems do not support software synchronization and must be configured to operate “standalone” first. If your telescope mount does not support software synchronization, following the manufacturer’s initialization instructions now. *TheSkyX* can control the mount only after it has been initialized using the hand paddle.

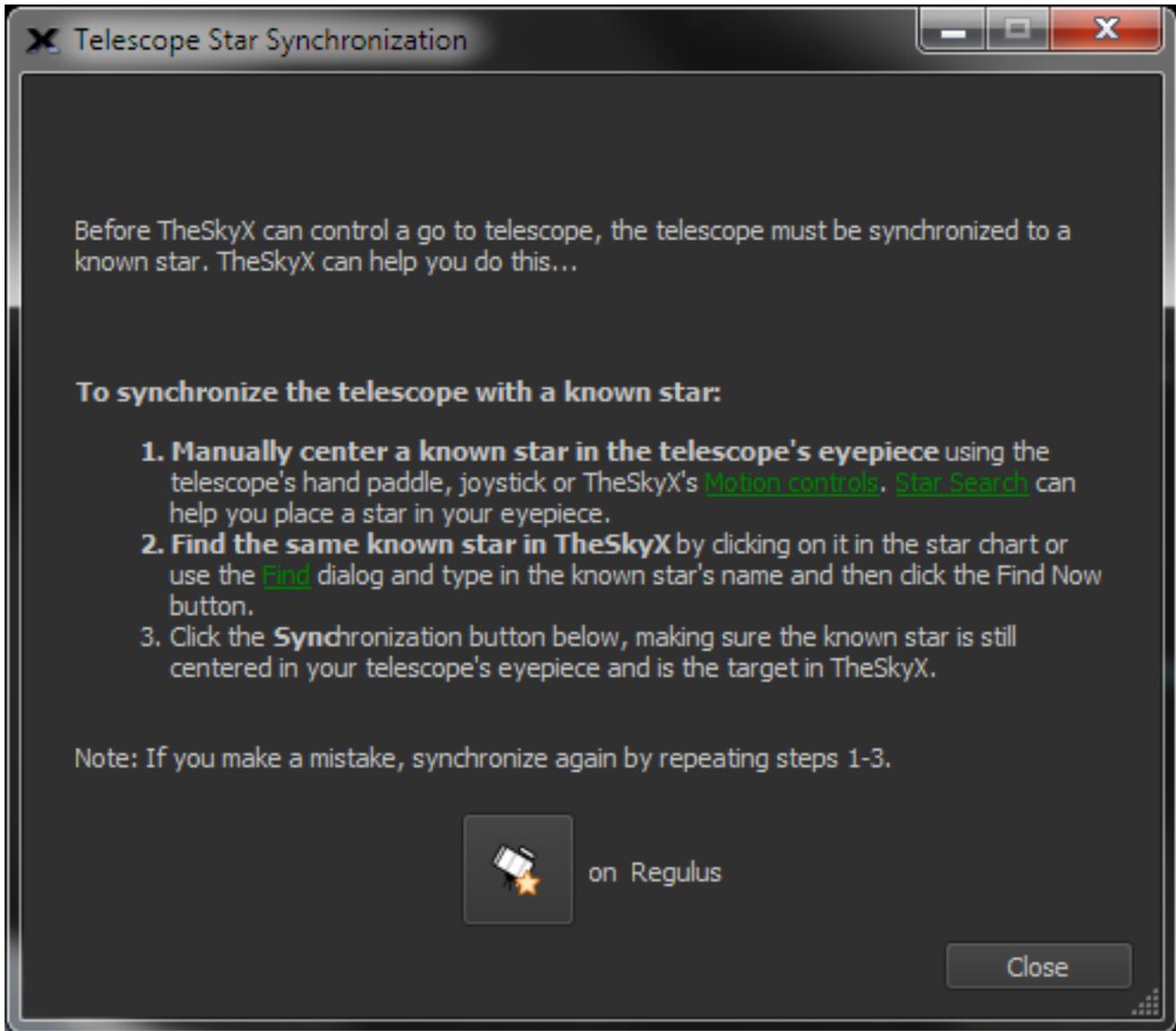


Figure 169: The *Telescope Star Synchronization* window (*Synchronize* command in the *Start Up* pop-up menu on the *Telescope* window).

1. Select the **Connect** command from the **Telescope** menu. Cross hairs appear on the Sky Chart, showing the position the telescope “thinks” it is pointing.
2. If you haven’t set the telescope’s time and coordinates, do so now (page 370).
3. Position the center of the telescope’s field on a known star. In general, do not select a planet, nebula, galaxy or other “extended object” for synchronization; star coordinates are typically more accurate, and a star is a true “point source.”
4. Click on the same star if it is visible on the Sky Chart or use the **Find** command to locate it.
5. Click the **Star Synchronization** command in the **Start Up** pop-up menu on the Telescope window.
6. On the **Star Synchronization** window, click the **Sync** button.

The Sky Chart's cross hairs should jump to and overlay the star that was used for synchronization, or be centered on the star used during the hand paddle initialization.

The telescope is now aligned on, or synchronized with, the target object and can be controlled by *TheSkyX*. See "Slewing to a Specific Object or Target" on page 381 to get started slewing the telescope.

### ***A Faster Way to Synchronize***

Use the **Sync** command to perform a synchronization on the current target object. This command bypasses the **Star Synchronization** window.

The **Sync** action should not be performed unless you are sure of the consequences.

- Once a permanently mounted Paramount-class mount is polar aligned and a working TPoint model established, further synchronization should not be necessary. A "bad" synchronization can cause the mount to lose its orientation with the celestial sphere.
- Telescopes that employ TPoint should only be synchronized before pointing calibration data is acquired. Subsequent observing sessions should recalibrate the model rather than re-synchronize the mount. See the *TPoint Add On User Guide* for more information about recalibration.
- If there is no TPoint model, then you may wish to "single-click" synchronize the mount multiple times during a single observing session to minimize pointing errors in a small area of the sky.

To add the **Sync** command to a toolbar:

1. On the **Preferences** window, click the **Toolbars** icon (page 202).
2. Click the **Customize** button to show the Customize Toolbars window.
3. Select the toolbar to add an action.
4. Select the **Sync** command from the **Actions** list, under **All Other Commands**.
5. Click the right arrow to add this action to the selected toolbar.
6. Click **OK**.
7. Click **Close**.

The single-click **Sync** command is now accessible on the selected toolbar.

### ***Image Link and Sync***

If you are familiar with *TheSky6 Professional Edition*, you may have used the **Image Link and Sync** feature, where the coordinates of a photo determined by Image Link are used to synchronize the telescope. *TheSkyX Professional Edition* can do the same.

### ***Synchronizing on an Image Link Photo***

Follow the steps below to use a photo from a previous session to reestablish the telescope's position.

1. Use the **Image Link** command to overlay a photo on the Sky Chart and determine the astrometric coordinates for every position in the photo (page 312).
2. Click on the Sky Chart anywhere “inside” the boundaries of the Image Link photo. The first object in the **Related Search Results** list on the **Details** tab of the **Find** window is named < **OBJECT FITS Keyword** > **Image Link Photo**, where < **OBJECT FITS Keyword** > is the text from the OBJECT keyword in the photo’s FITS header. The coordinates of the Image Link photo are the 2000.0 astrometric RA/Dec of the center of the photo. Synchronizing on the Image Link photo restores the telescope’s position to these coordinates.
3. Synchronize the telescope on this target (page 377).

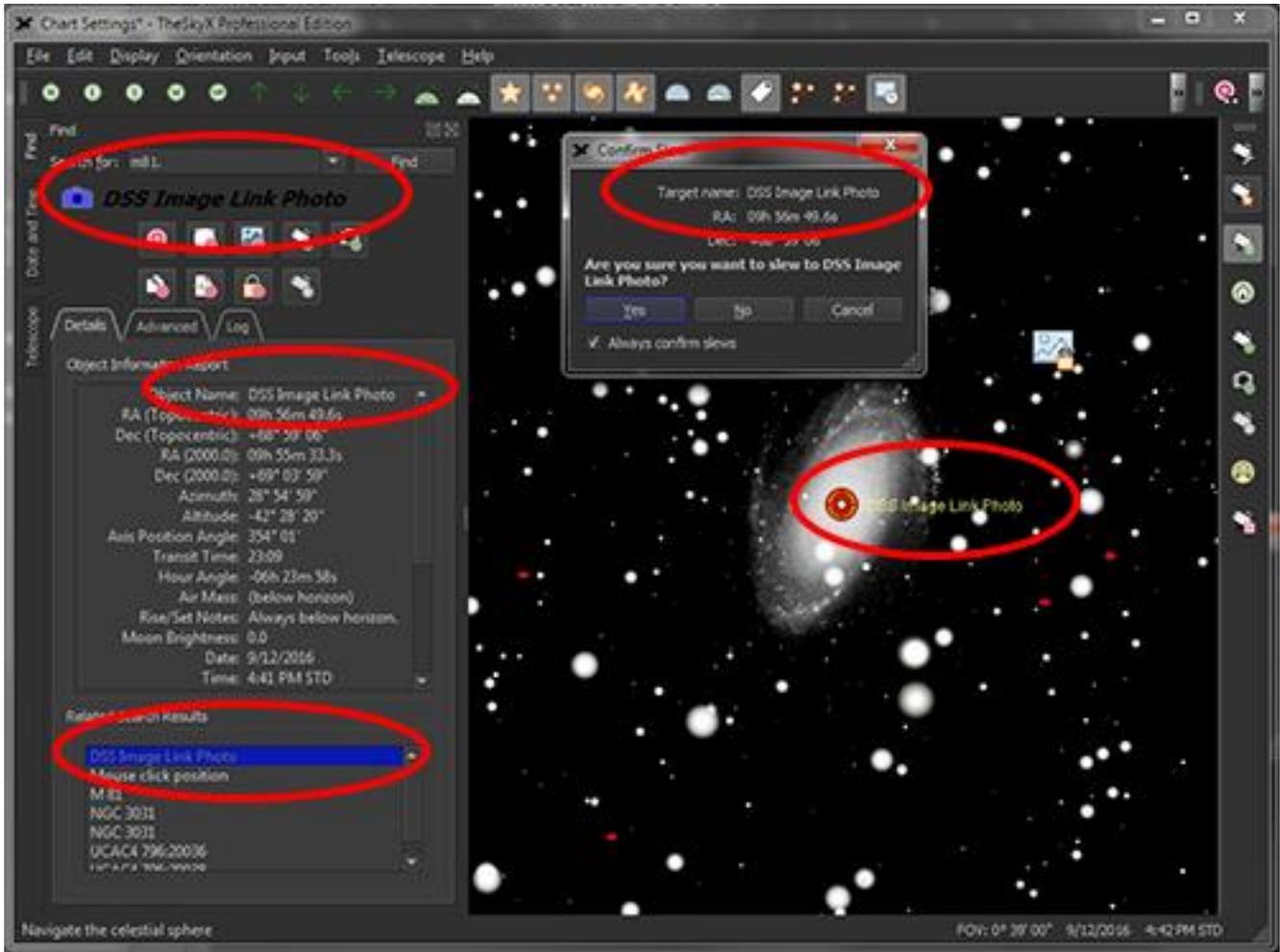


Figure 170: Clicking the Image Link photo on the Sky Chart displays the photo’s **OBJECT** name in the FITS header, plus **Image Link Photo** in the **Related Search Results** of the **Find** window.

## Slewing to a Specific Object or Target



1. Click on the object in the Sky Chart. If the desired object is not visible on the current chart, click the **Find** command from the **Edit** menu, enter the object's name (**Crab Nebula**, for example) or its catalog number (**M1**) into the **Search For** text input and click the **Find** button.
2. Click the **Slew** button. One is located on the **Telescope**, **Find** and the **Observing List** windows and on the **Telescope** toolbar.

The **Search For** text input and **Find** button are also available on the **Telescope** window.

There's another way slew the telescope...

1. Right-click an object in the Sky Chart.
2. Select the **Slew** command from the Sky Chart's pop-up menu.

## Slewing to a Specific Coordinate

Astronomers know better than to claim stars do not move. Proper motion, precession, nutation, aberration and other phenomena cause astronomical bodies to move over time when observed from earth.

While *TheSkyX* makes every effort to hide the complexities involved with coordinate transformations in cataloged data, and generally uses the object's topocentric coordinates, you may still need to slew a telescope to coordinates that were recorded at a different time. For example, older astronomical catalogs may have recorded in equinox 1950. Slewing the telescope to equatorial coordinates that are from 1950, when *TheSkyX* is expecting positions from a different equinox, means the telescope will point to the wrong position.

Use the **Slew To Coordinates** command from the **Tools** menu on the **Telescope** window to display the **Enter Coordinates** tab of the **Navigate** window. From here, enter the right ascension, declination or azimuth, altitude coordinates, then click the **Slew To RA/Dec** or **Slew To Az/Alt** button, respectively.

When using coordinates from historical observations, make sure to specify the equinox of the coordinates by entering the year into the **Equinox** list box, or choosing one of the default options: **Apparent**, **2000.0**, or **B1950.0**. Or, manually enter a different value if the coordinated are from a different equinox.

## Slewing to the Prior Target



Use the **Slew Prior** command to slew the telescope to the previous target. This command is not accessible on the **Telescope** window, but can be added as a button to any tool bar. See “Customizing Toolbars” on page 202 for details about adding buttons to toolbars.

## Slewing to an Image Link or All Sky Image Link Target

A telescope can be slewed to the coordinates that match the center of an Image Link photo so that its position can be restored from night to night.

### To Slew to an Image Link Photo

1. Use Image Link or All Sky Image Link to find the astrometric solution for a photo. After a successful Image Link, the photo will be overlaid on the Sky Chart, precisely matched against the background stars. Make sure to turn on the **Show Linked Photo** checkbox on the **Image Link** window to make the photo visible.
2. Click within the Image Link photo on the Sky Chart to identify it. This target object appears in under **Related Search Results** on the **Object Information** window with the name **<OBJECT FITS Keyword> Image Link Photo**, where **<OBJECT FITS Keyword>** is the text from the OBJECT keyword in the photo’s FITS header (or **DSS Image Link Photo** when the photo was obtained from the Digitized Sky Survey data).
3. Select the Image Link Photo text to make it the current target object, then click the **Slew** button to slew the telescope to J2000.0 RA/Dec of the photo’s center.

## Closed Loop Slew

PROFESSIONAL



Imagine, while observing objects visually with your go to telescope, slewing the telescope to a star cluster (the “target”) in a different part of the sky. Chances are, the telescope’s inherent pointing inaccuracies mean the cluster will not fall “dead center” in the eyepiece. At this point, you will most likely grab the telescope’s hand paddle to manually find and center the object in the eyepiece before enjoying the view.

A *Closed Loop Slew* automates this target centering process using the astrometric position of a photo acquired with a camera, instead of the human eye. Image Link (page 312) replaces the observer’s interaction with the telescope to automatically center the target object. The result of a closed loop slew is that, using a single button click, a go to telescope with a camera attached can be slewed to any target, or equatorial coordinate, and the object will fall squarely in the center of the frame.

This feature can be used, for example, to precisely slew the telescope to a specific star so that it falls on a spectrographic slit each night. Or, to precisely slew the mount to the center of a previously acquired photograph.

#### ***How does Closed Loop Slew work?***

The Closed Loop Slew command incorporates automated telescope control, automated Image Links and automated camera control to ensure the target object is centered.

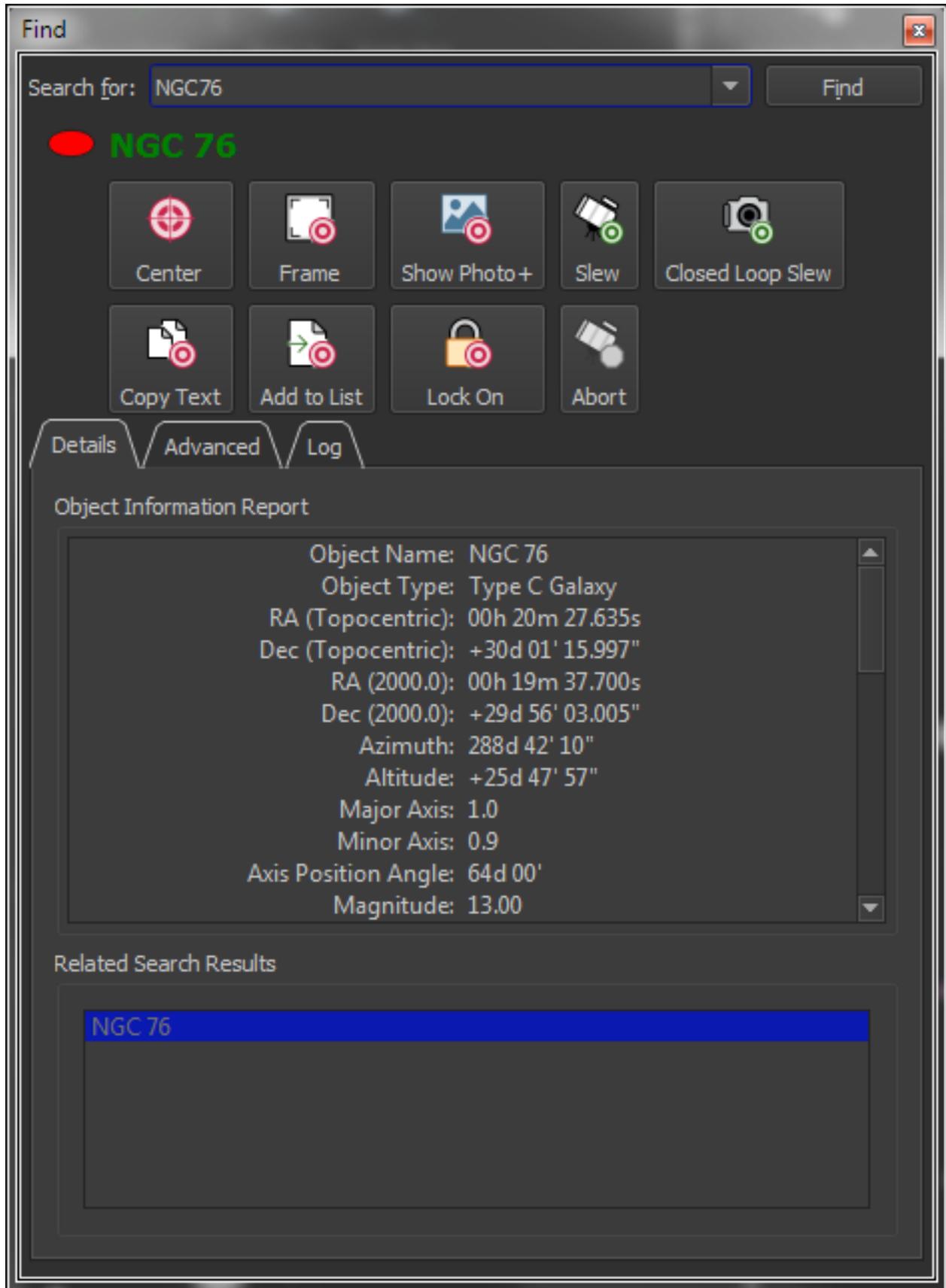


Figure 171: The Closed Loop Slew button on the Find window.

Figure 172 shows what happens “behind the scenes” when the **Closed Loop Slew** button is clicked.

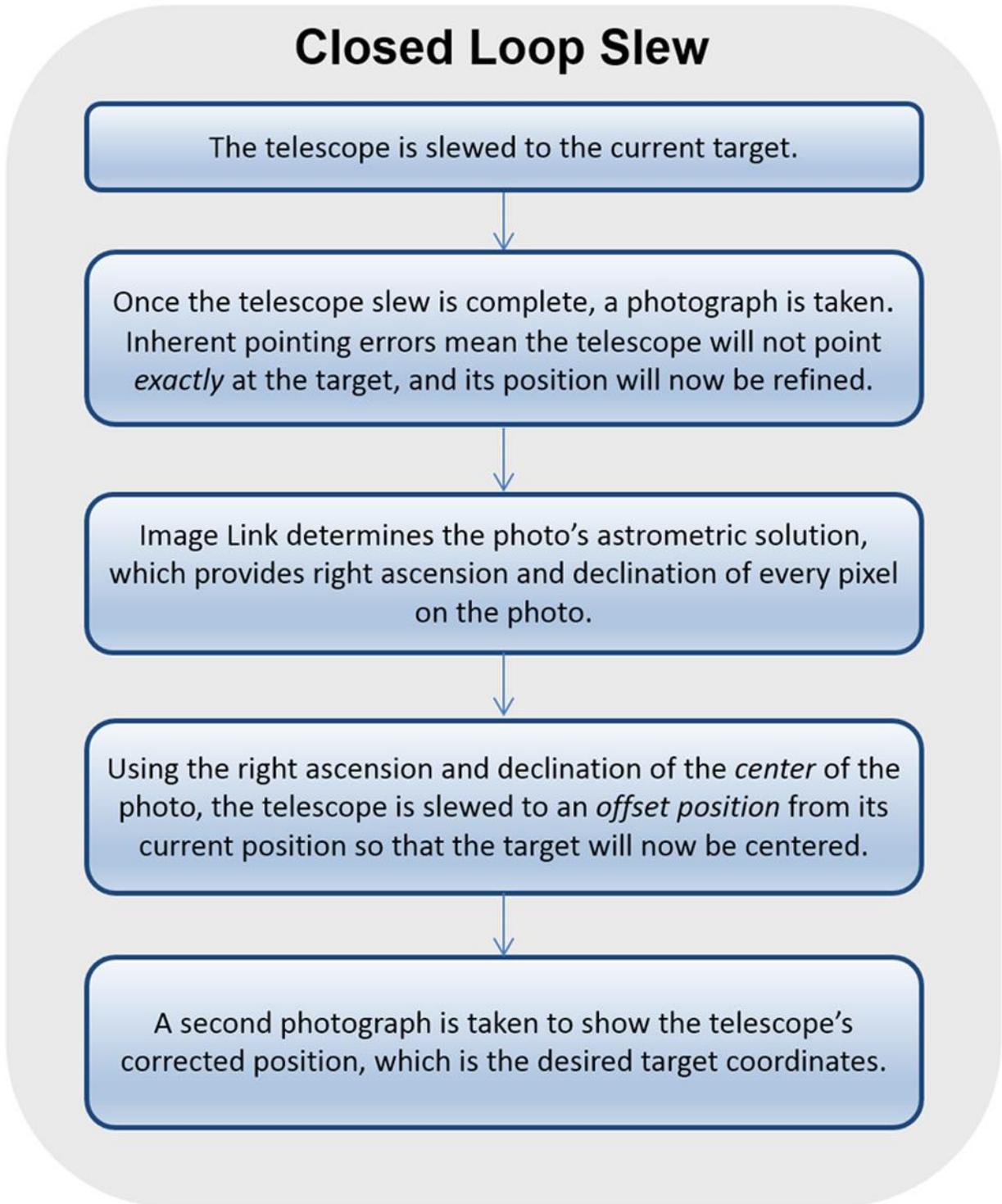


Figure 172: Flow chart showing each step of a Closed Loop Slew.

Acquiring multiple photos, and determining the astrometric solution *necessarily* requires more time than the typical “open loop slew”, however, the result of a Closed Loop Slew means the target object should be centered on the photo to within a few arcseconds of the target’s right ascension and declination coordinates.

### **Closed Loop Slew Setup**

To access the Closed Loop Slew settings,

1. Click **Tools > Image Link** and open the **Setup** tab.
2. Click the **Automated Image Link Settings** button to display the Automated Image Link Settings window.

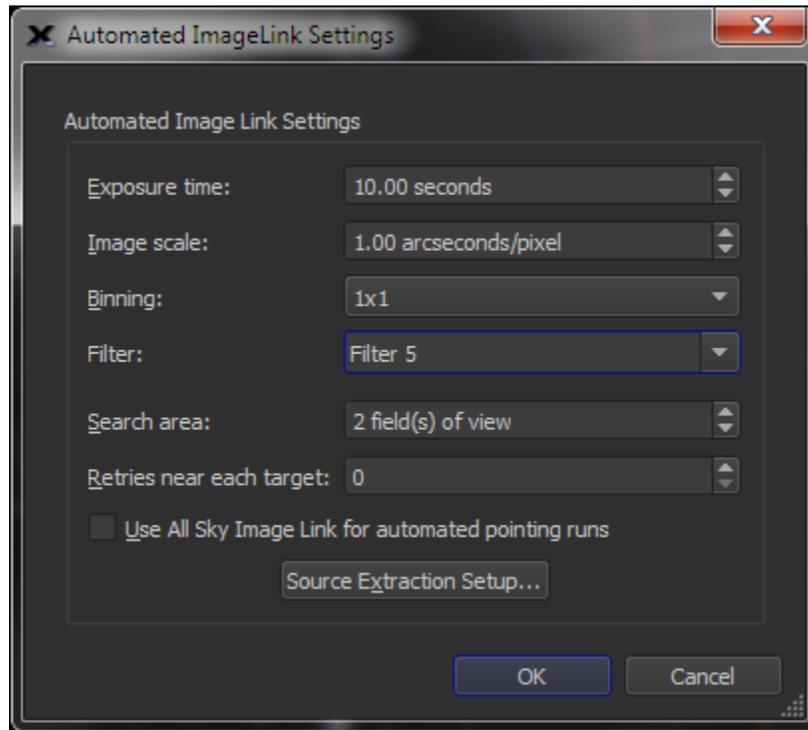


Figure 173: The Automated Image Link Settings window.

#### **Exposure Time**

Enter the length of the exposure, in seconds of time, to use when performing a Closed Loop Slew.

#### **Image Scale**

Enter image scale, in arcseconds per pixel, of the camera and optical system used to perform the Closed Loop Slew.

#### **Binning**

Select the camera's bin mode during Closed Loop Slews.

#### **Filter**

Select the filter to use during Closed Loop Slews.

#### **Search Area**

Enter the size of the sky region to search for an Image Link match during the Closed Loop Slew.

### **Retries Near Each Target**

Specify the number of times to retry performing a Closed Loop Slew at a given position before displaying a failure error message.

### **Use All Sky Image Link for Automated Pointing Runs**

When this check box is turned on, Closed Loop Slews use All Sky Image Link instead of the classic Image Link (See page 336 for a comparison of these technologies) to determine the astrometric solution.

### **Source Extraction Setup**

Click is button to specify the Source Extraction settings (page 319) to use for Closed Loop Slews.

All other camera-specific settings used when acquire photos from the imaging camera during a Closed Loop Slew (including bin mode, image calibration, etc.) can be configured from the **Camera** tab (page 436). Closed Loop Slews *do not* use the autoguider settings.



When the camera's binning (page 452) is changed, the value of the **Image Scale** on the Automated Pointing Calibration Run window must be changed accordingly.

For example, if the image scale produced by the optical system at 1x1 binning is 1 arcsecond per pixel, and the binning is changed to 2x2, then the value in the **Image Scale** text box must be changed to 2 arcseconds per pixel. Failure to do so will cause the Closed Loop Slew's Image Link to fail.

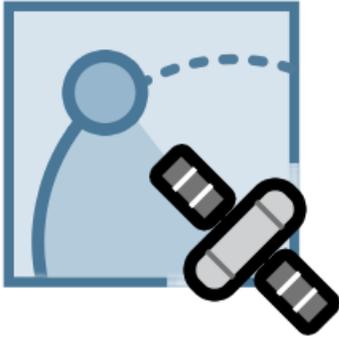
### **Performing a Closed Loop Slew**



The **Automatically Save Photos** checkbox must be turned on *before* performing a closed loop slew. If this option is turned off, the initial photo is not saved automatically, and the Image Link portion of the closed loop slew process will fail with the error message: "Error 507. Please save the photo."

Once *TheSkyX Professional Edition* has been configured for your mount (page 358) and imaging camera (page 445), click the **Closed Loop Slew** button to connect to the mount and the camera, then slew to the telescope to the target (using the Closed Loop Slew process described above).

## Tracking Spacecraft



*TheSkyX Professional Edition* can slew the telescope to, and track spacecraft. The first step is to locate the satellite to track (by clicking its symbol on the Sky Chart or using the **Find** command), then click the **Track Satellites** button on the **Telescope** window (which is otherwise hidden). If the satellite is currently above the horizon, mount is slewed to intercept the satellite's path, then the mount's tracking rates are set to match satellite's rates. If the satellite is currently below the horizon, *TheSkyX* waits until it is visible (specifically, above the local horizon) then begins the *slew to and track satellite* process.

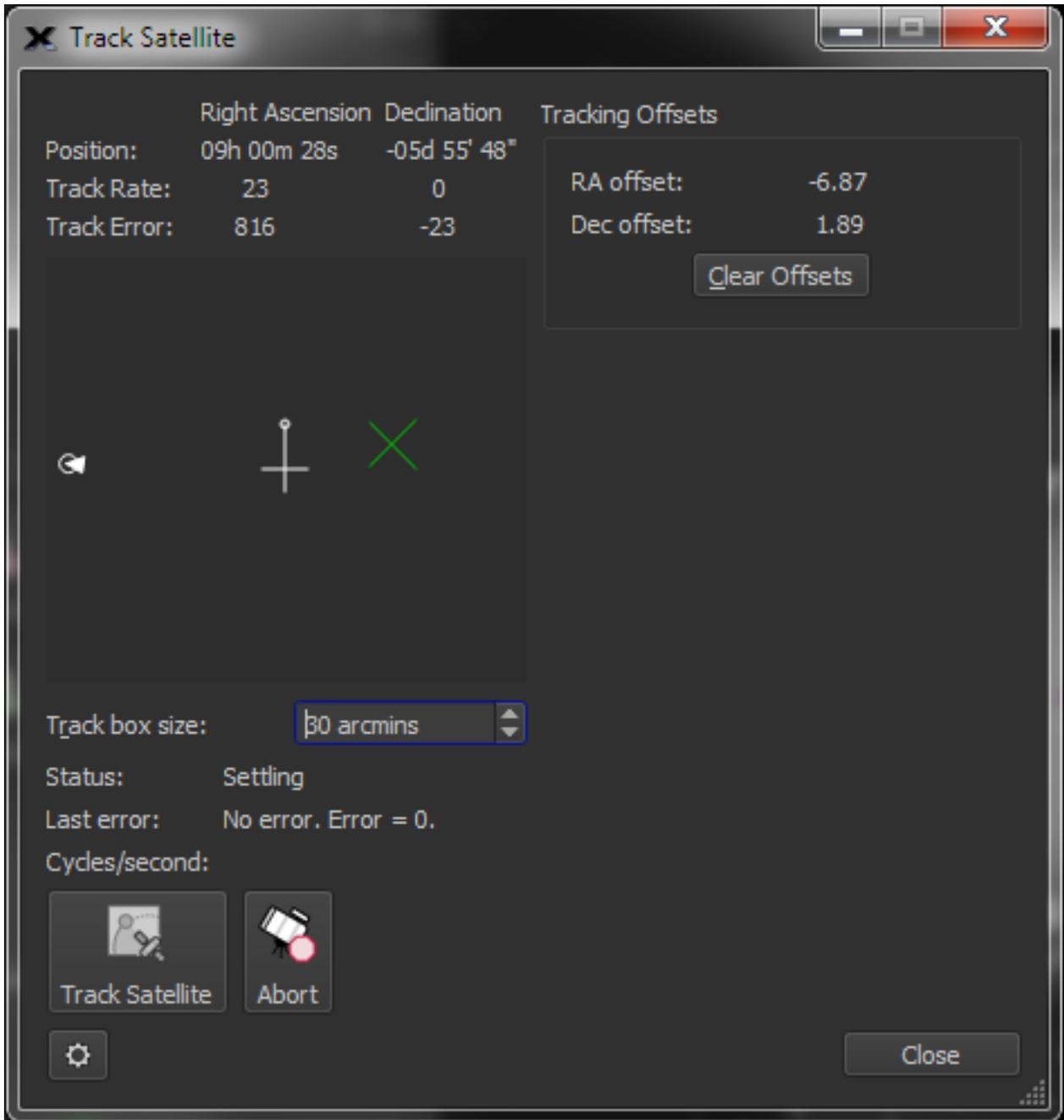


Figure 174: Tracking initiated, but not yet “stable”.

When the satellite appears above the *theoretical* local horizon, the mount slews to the satellite and begins tracking it. The satellite’s **Position**, relative **Track Rate** and **Track Error** in **Right Ascension** and **Declination** are displayed at the top of the window.

The black region represents the background sky. The white circle represents the satellite, the white arrow drawn through this circle shows the magnitude of the satellite’s tracking rate and its current trajectory. The gray cross hairs show the center of the field. The green X represents the current **Tracking Offset** that is applied to the mount’s position.

Optimal tracking is achieved when satellite is centered in the field. Mechanical errors and uncertainty in the satellite two-line elements may cause the satellite to fall away from the center. To adjust the position of the satellite, click in the black region away from the satellite's current position. The green X shows this new offset, and, when the correct offset is applied, the satellite will slowly move to the center of the field.

A larger number in the **Track Box Size** text box allows a larger maximum tracking offset. Click the **Clear Offsets** button to set the offset to zero in each axis.

If for any reason the mount cannot continuously track the satellite, the message "Target lost, unable to maintain tracking. Error = 7501." is displayed, and the mount's tracking rates will be turned off.

## **Satellite Tracking Controls**

Each control on *TheSkyX Professional Edition's* standard Satellite Tracking window is described below.

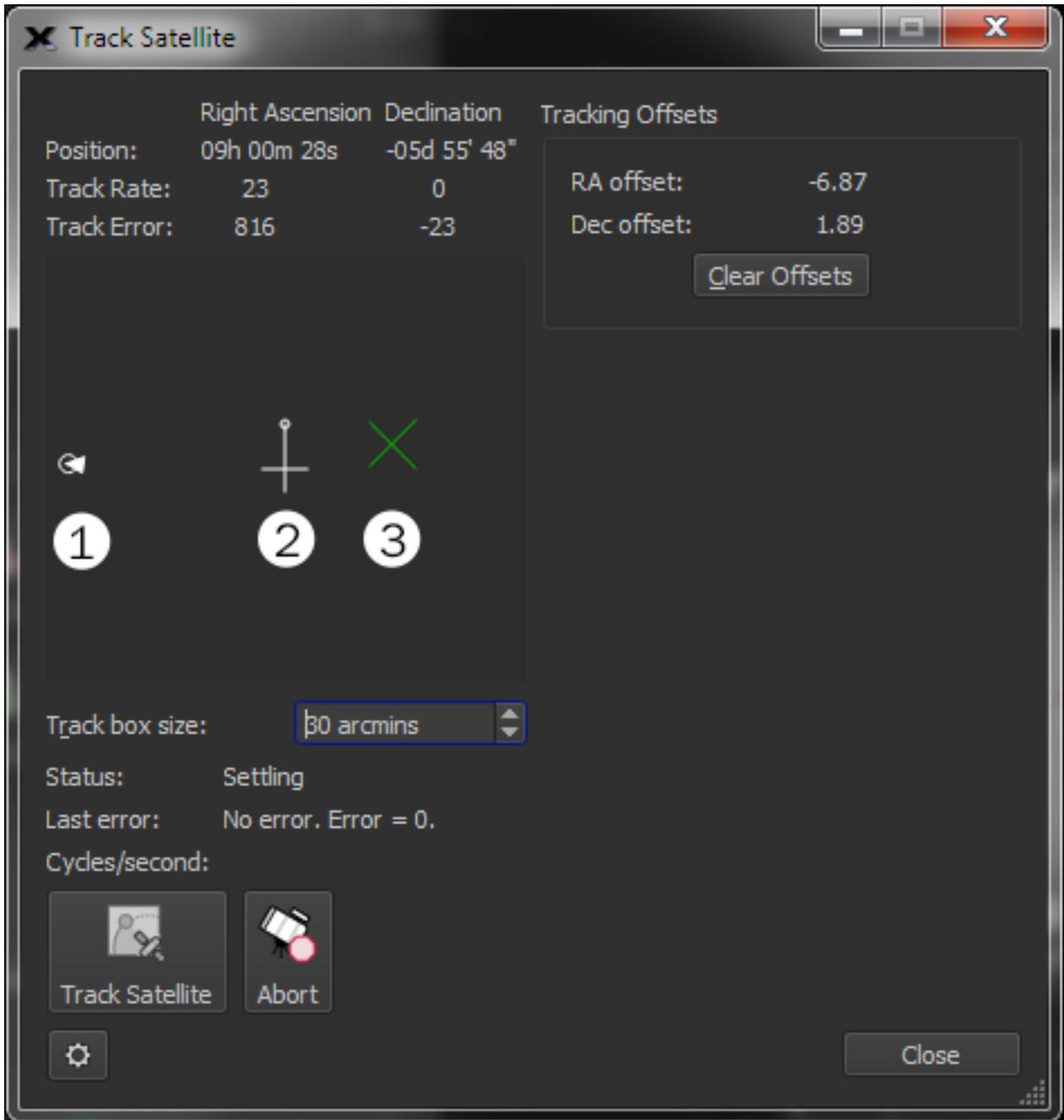


Figure 175: The Satellite Tracking window's graphical controls.

Figure 175 shows numbers next to each graphical element, and each is described below:

- The white arrow (1) shows the relative position of the satellite in the field of view and points in the direction of the satellite's motion.
- Click and drag the small circle at the end of the cross in the center of the graphic (2) to rotate the field (so that the satellite path can be oriented to match the video or detector).
- Click anywhere inside the black region (which represents a "satellite tracking field of view" or track box) to apply an offset to the telescope's current tracking position, which is represented by a large green "X" (3).

Advanced satellite tracking capabilities for Paramount-class mounts are available in the optional *Advanced Satellite Tracking Add On*; contact Software Bisque for details.

***Position (RA/Dec)***

Shows the right ascension and declination coordinates of the telescope.

***Track Rate (RA/Dec)***

Shows an internal tracking rate for the satellite.

***Track Error (RA/Dec)***

Shows the magnitude of the tracking error in each axis. The minimum “acceptable” average tracking error that is allowed to start tracking can be configured from the ***Satellite Tracking*** options in the ***Advanced*** pane on the ***Preferences*** window (page 225).

***Tracking Offsets (RA/Dec)***

Shows the offsets in right ascension and declination, in arcminutes that are applied to the satellite’s position during tracking. The offset is represented by the green X graphic. To change the offset, click the mouse within the black region.

***Clear Offsets***

Click this button to set the tracking offsets to zero.

***Track Box Size***

Enter the relative size of the satellite tracking box. The size of the track box can be adjusted to match the field of view of the optical system. The track box size can be up to two (2) arcminutes, so that relatively large “position offsets” to the telescope’s current track position can be introduced by clicking on the track box graphic.

***Status Message (Status Text Box)***

Shows the current state of satellite tracking.

- ***Idle*** – No satellite tracking.
- ***Begin*** – TheSkyX has initiated satellite tracking.
- ***Start Slew*** – Telescope slewing is about to start.
- ***Waiting for Target to Rise*** – TheSkyX is monitoring the satellite’s position, and will begin tracking when it rises.
- ***Slewing to Target*** – Telescope is being slewed to the satellite.
- ***Settling*** – The position of the telescope is being adjusted to match the satellite’s position.
- ***Tracking*** – The mount is successfully tracking the satellite.

***Last Error Message (Last Error Text Box)***

Shows the most recent error message to occur.

**Update Frequency (Cycles Per Second)**

Shows the frequency at which the satellite's position is being updated.

**Track Satellite Button**

Click this button to start tracking the selected satellite.

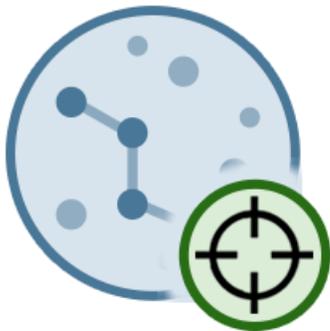
**Abort Button**

Click this button to stop tracking the satellite.

**Satellite Tracking Notes:**

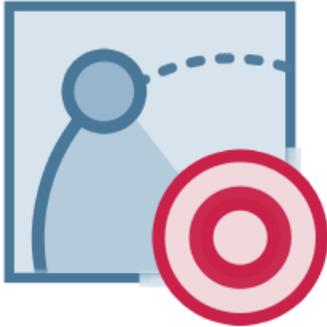
- *TheSkyX Professional Edition* does not use a "leap frog" or "successive slews" method to track satellites. Instead, *TheSkyX* sets the mount's *tracking rate* in both RA and Dec to match the current satellites current tracking rate.
- Many commercial mounts do not allow tracking rates to be configured in both RA and Dec axis, so these mounts cannot be used to track satellites with *TheSkyX*.
- For mounts that can set dual axis tracking rates, many still do not have the required dynamic range to track very slow or very fast-moving satellites. Trying to use a mount that does not have configurable tracking rates from zero to several degrees per second may not result in satisfactory results.
- *TheSkyX Professional Edition's* satellite tracking has been optimized for, and extensively tested with both the Paramount ME and Paramount MX mounts and works quite well to accomplish this task. The Paramount control system allows tracking rates to be configured for both the RA and Dec axes and can track virtually any satellite (or any object that tracks at any rate from 0.0 arcseconds per second up to several degrees per second).

**Center Cross Hairs**



Click this button to center the telescope cross hairs on the Sky Chart.

## Set Track Rates



Solar system objects, including the Sun, Moon, planets, comets and asteroids each move at rates that can vary greatly compared to sidereal rate.

- **Important Note:** To track objects at non-sidereal rates using *TheSkyX*, the mount's control system must be able to set tracking rates for both the right ascension axis and declination axis based on the computed rates of the object.
- See "Tracking " on page 388 for details about tracking satellites with *TheSkyX*. Many commercial mounts either cannot set the tracking rates in both axes, or do not have sufficient dynamic range to track relatively slow moving or relatively fast-moving objects.

To configure the mount to track at the non-sidereal rate for one of these objects:

1. Locate the object on the Sky Chart (using either the **Find** command or by clicking the object on the Sky Chart).
2. Click the **Slew** button to slew the telescope to the object. This step is optional, but, if the object is a "faster mover", it's better to position the telescope close to its current position first.
3. Click the **Set Track Rates** button on the **Telescope** window. The **Confirm Set Track Rate** window shows the current right ascension and declination rates for the selected target, in arcseconds/second.

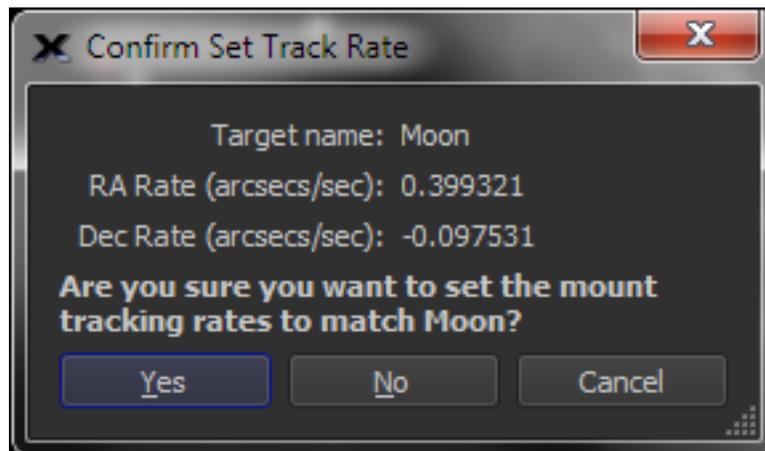


Figure 176: The Confirm Set Track Rate for solar system objects.

Clicking the **Yes** button sets the mount's right ascension and declination tracking rates.

**Important Note**

Slewing to a star automatically resets the right ascension's axis to the sidereal rate and sets the declination rate to 0.0.

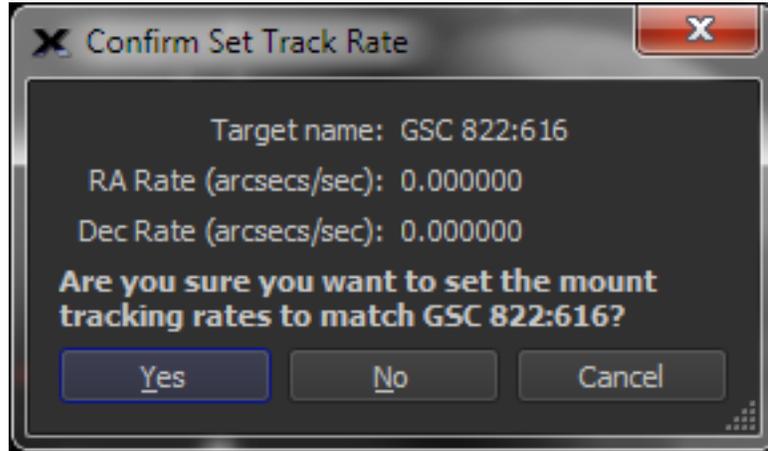


Figure 177: Set tracking rate to the sidereal rate.

Clicking the **Set Track Rate** button when the target object is a star shows 0.0 for both the right ascension and declination tracking rates, which, although perhaps confusing, is *TheSkyX's* convention. The right ascension tracking rate is *relative to the sidereal rate*, so, setting a tracking rate of 0.0 in right ascension means "track at the sidereal rate". As expected, the declination axis' tracking rate is set to 0.0.

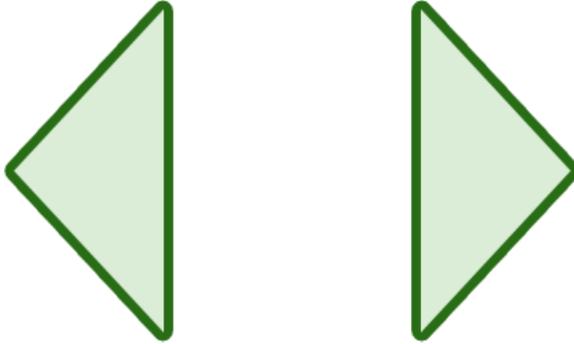
**Add Pointing Sample**



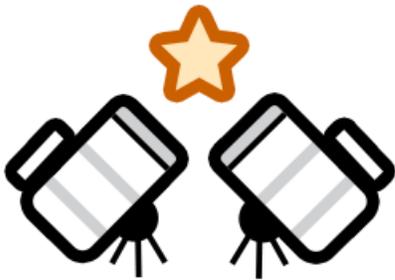
Click this button to add a TPoint Add On pointing calibration sample to calibration data. See "TPoint Add On" on page 363 for details about telescope modeling using the *TPoint Add On* software.

## Search for Targets

Enter the name of a target object into the **Search For** text box then click the **Find** button. Or, click the mouse on the Sky Chart to select the target. If there is more than one object near the mouse cursor, click the forward or backward buttons to scroll through them.



## Flip Mount Now



Click the **Flip Mount Now** button to slew the telescope to the opposite side of the pier and still point to the same object. This can be convenient when a German equatorial mount is pointing to an object near the meridian and the telescope is on the west side of the pier.

## Terminating the Telescope Link



Select the **Connect** command on the **Telescope** menu to stop communicating with the telescope, and close the communications port.

## Using the Telescope Simulator

The telescope simulator allows you to simulate the process of connecting to, synchronizing and slewing a go to telescope without connecting to a physical telescope mount. This can be useful to become familiar with how to operate a telescope from *TheSkyX* or practice an observing session during daylight.

1. Select the **Telescope Setup** command from the **Telescope** menu.
2. In the **Telescope Setup** window, click the **Select Mount** button.
3. Choose the **Telescope Mount Simulator** option from the **Simulator** list.
4. Click **OK**.
5. Click the **Connect** button on the **Telescope Setup** window to establish a virtual connection to the simulated telescope mount.

## Digital Setting Circles



*TheSkyX's* Digital Settings Circles window displays a status report that contains, for example, the telescope's RA/Dec coordinates. The text size is also configurable so that it can be more easily read at a distance.

This feature is available with both encoder-based systems and telescopes having full computer control.

To use it, select the **Digital Setting Circles** command from the **Telescope** menu.

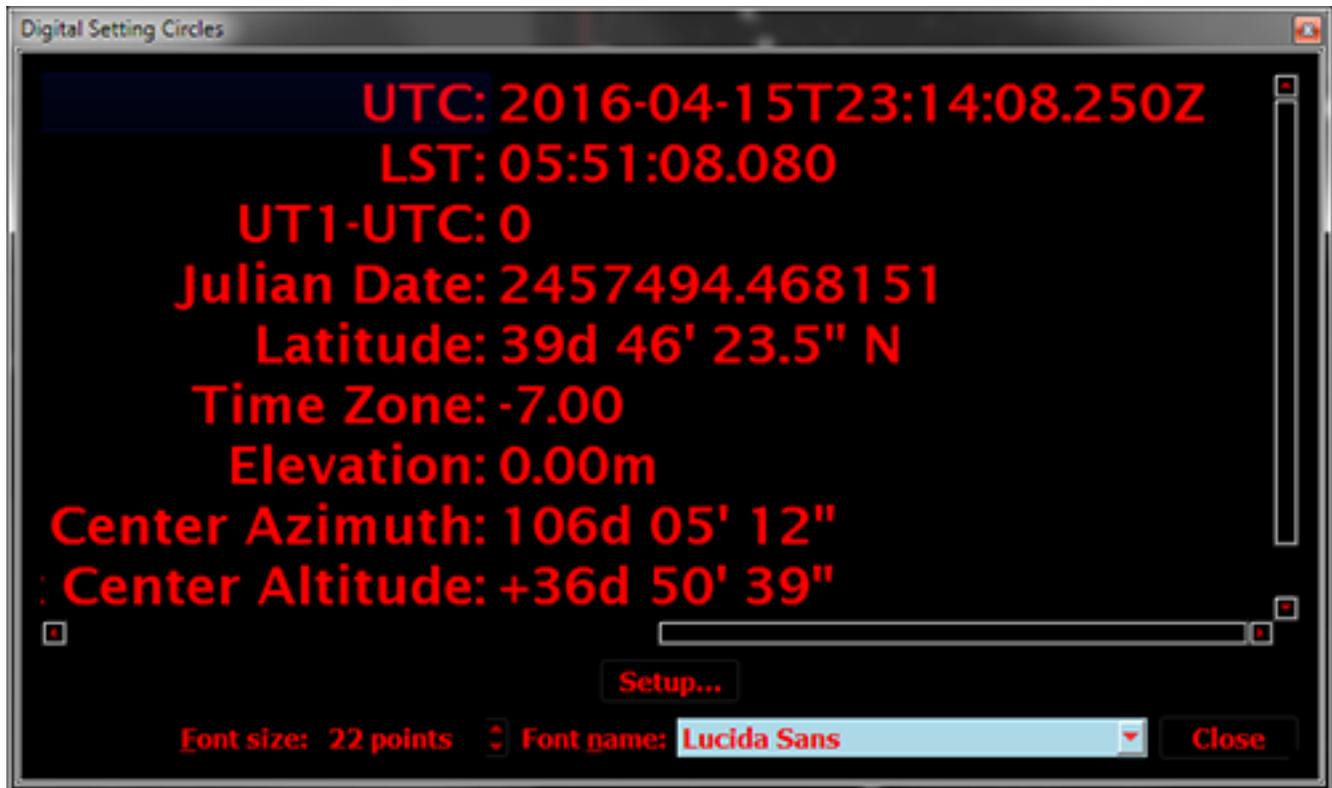


Figure 178: Digital Setting Circles window.

### **Configuring the Digital Settings Circles Report (Report Setup button)**

By default, the report shows universal time (UT) and local sidereal time (LST). Click the Report Setup button to show the Digital Setting Circles report in the Preference window.

Select the attributes you wish to display in the report, and then click Close.

## **Telescope Troubleshooting**

Physically connecting a hardware device to computer software is not always a simple task. Things can, and often do, go wrong. Below is a checklist of items to consider before contacting the Software Bisque support desk.

- Both the software and the hardware must be correctly configured. Communication ports, cables, connectors and telescope control systems all must be plugged in, turned on, connected properly using the correct telescope interface cable and initialized before attempting to be “linked” to the computer.
- Connection cables must be wired correctly. *TheSkyX* uses “bi-directional” serial communication with most devices. This means that the connecting cable must be wired

properly to send *and* receive commands. You can verify that a serial cable is functioning by measuring resistance between pins 2, 3 and 5 on each end of the telescope cable.

- The communication port must be operational. If you are using a USB to serial adaptor, make sure that you have the latest software drivers installed for the device.
- The proper telescope firmware (that is, the software that is run by the telescope's control system) must be correct before *TheSkyX* can control the telescope. Contact the manufacturer to obtain firmware updates.

## Astro-Physics GTO German Equatorial Mounts



Figure 179: Astro-Physics GEM (© Astro-Physics)

### AP GTO Minimum System Requirements

*TheSkyX* can control any mount that employs the Astro-Physics GTO control system running firmware version G or later (including the GTOCP1, GTOCP2 and GTOCP3). If you have an older version of the firmware, contact Astro-Physics for details about upgrading. *TheSkyX* will successfully connect to and control earlier firmware versions (for example, Software Bisque has successfully tested *TheSkyX* using the GTO model controller with firmware version D from May 2001 with the GTO model controller). However, we *strongly recommend* using the latest firmware version.

#### **Hardware Requirements**

- Astro-Physics GTO German Equatorial control system with firmware G or later.
- A standard RS232 serial cable. Serial cables can be purchased from most any computer store.
- A [USB to serial adaptor](#).

### Step-by-Step AP GTO Setup Procedure

1. Using a standard DB9 M/F RS232 serial cable, connect the male end of the cable to the port labeled COM1 on the GTO Control Panel and the female end to the [USB to serial adaptor](#).
2. Click the **Telescope Setup** command from the **Telescope** menu.
3. Select **Mount** in the **Imaging System** list on the left side of the **Imaging System Setup** window.
4. On the **Choose Mount** window, select your model telescope and click **OK**. If the *exact* model of your telescope is not listed, don't worry; just select a similar model

telescope. The underlying serial communication protocol is the same for similar models.

5. Click the **Settings** command on the **Mount Setup** pop-up menu and then select the correct **COM** port (Windows) or the correct **Serial Device** (Mac).
6. On the **Imaging System Setup** window, turn on the desired preferences and then click **Close**.
7. Select the **Connect** command from the **Telescope** menu.

The telescope cross hair will now display the current coordinates of the telescope. If the mount has not been parked, or has not been initialized with the location, date and time from another application, the coordinates of the telescope will be RA: 0h 0' 0" Dec: 90° 0' 0".

AP mounts are automatically initialized using *TheSkyX's* time, date, location and Daylight-Saving Time adjusted time zone, the mount's tracking is started, and the control system is configured to use the more accurate long format mode when sending and receiving equatorial coordinates to and from the mount.

### **Synchronization vs. Recalibration**



Synchronizing a GEM when the telescope is pointing to a position in the sky that is on the same side of the pier as the telescope (for example, when the telescope is on the east side of the pier and is pointing to a star on the east side of the meridian) can result in unexpected behavior and possibly damage your equipment. Please carefully read the most recent version of the Astro-Physics Keypad Manual for details how to use synchronization and recalibration.

The Astro-Physics command protocol provides two different methods that planetarium software like *TheSkyX* can use to initialize the mount's control system.

- The Calibrate mount or Sync command (:*CM#* is sent to the control system) defines both the equatorial coordinates of the telescope and on which "side of the pier" the optical tube assembly resides.

The normal or expected orientation of a GEM is when the optical tube assembly is on one side of the pier (for example, the east side of the pier) and points to a position on the **opposite** side of the pier (in the west). Always make sure the mount is this normal orientation before using the synchronization command.

If you are unsure about which side of the pier the control system "thinks" the telescope is on, click the **Get Current Settings** button under **Hand Paddle Status** on the **Miscellaneous** tab of the **Astro-Physics** window.

- The Re-calibrate or Re-Cal command (:*CMR#* is sent to the control system) is used to update the control system with the telescope's current position only, and does not define

the telescope's side of pier. Astro-Physics highly recommends using the command instead of using the Synchronization command.

When Astro-Physics mounts are controlled by *TheSkyX*, by default, *TheSkyX* uses the Astro-Physics command protocol's Recalibration command instead of the Calibration command. See page 377 for details about *TheSkyX*'s telescope **Synchronization** command.

If you need to use the Astro-Physics Calibrate command to initialize the telescope's position and side of pier information, turn off the **Convert Sync to Re-Cal (highly recommended)** checkbox on the Astro-Physics window. Don't forget to turn this checkbox back on once the calibration has been performed.

### **Astro-Physics GTO Control System Notes**

- *TheSkyX* always places the Astro-Physics control system into the "long format" mode upon establishing a link.
- Click the **Location, Date, Time** command from the **Tools** pop-up menu on the **Telescope Setup** window (**Display** menu) to compare *TheSkyX*'s date, time, latitude, longitude and time zone settings to the mount. Click the >> button to reset the AP GTO's values to match *TheSkyX*'s.

### **Astro-Physics Specific Commands**

Select the **Astro-Physics Specific** command from the **Display** menu to show commands that are specific to this control system. This command is only available when an Astro-Physics model mount is selected **Telescope > Telescope Setup** window.

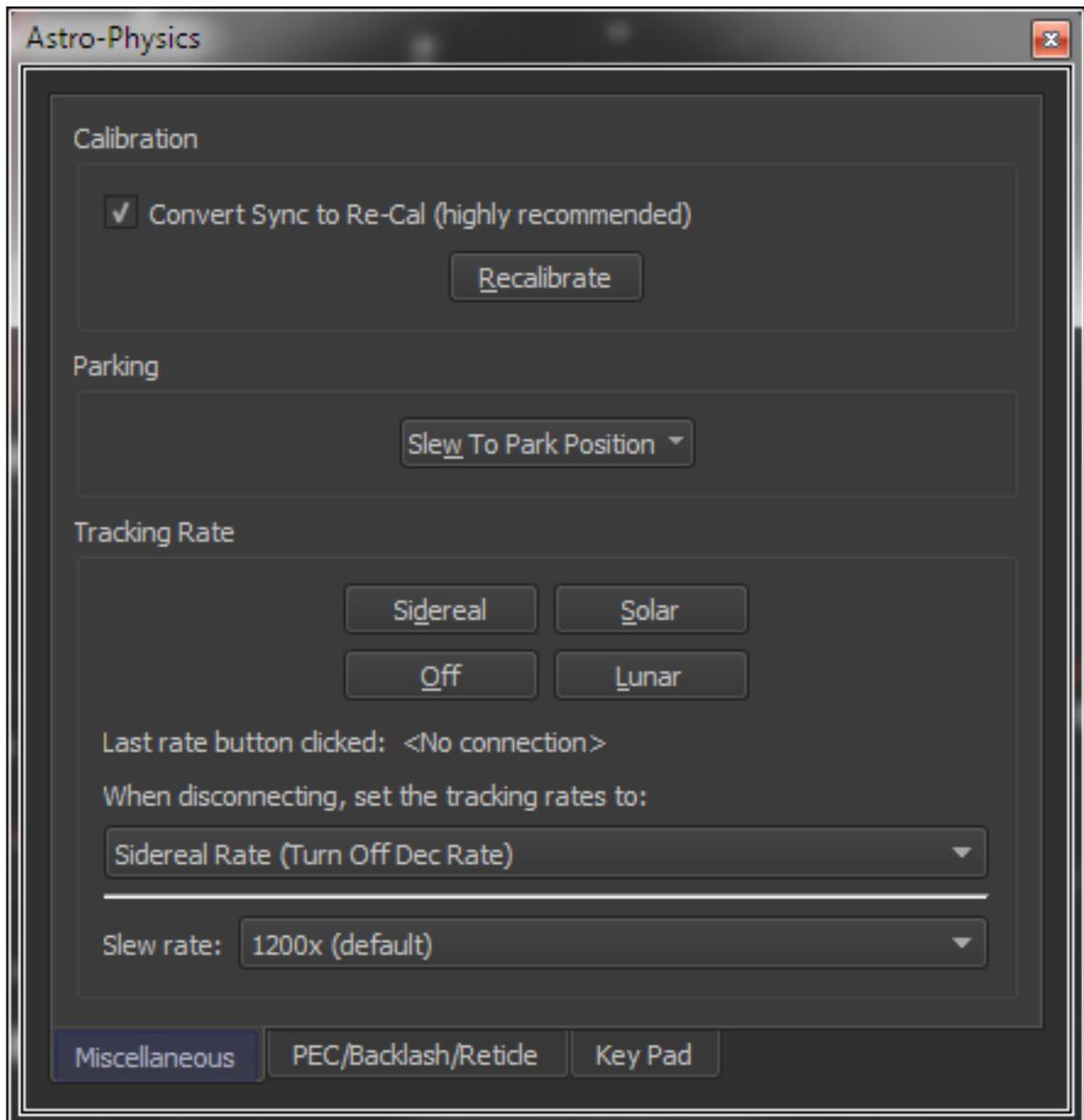


Figure 180: The Astro-Physics window's Miscellaneous pane.

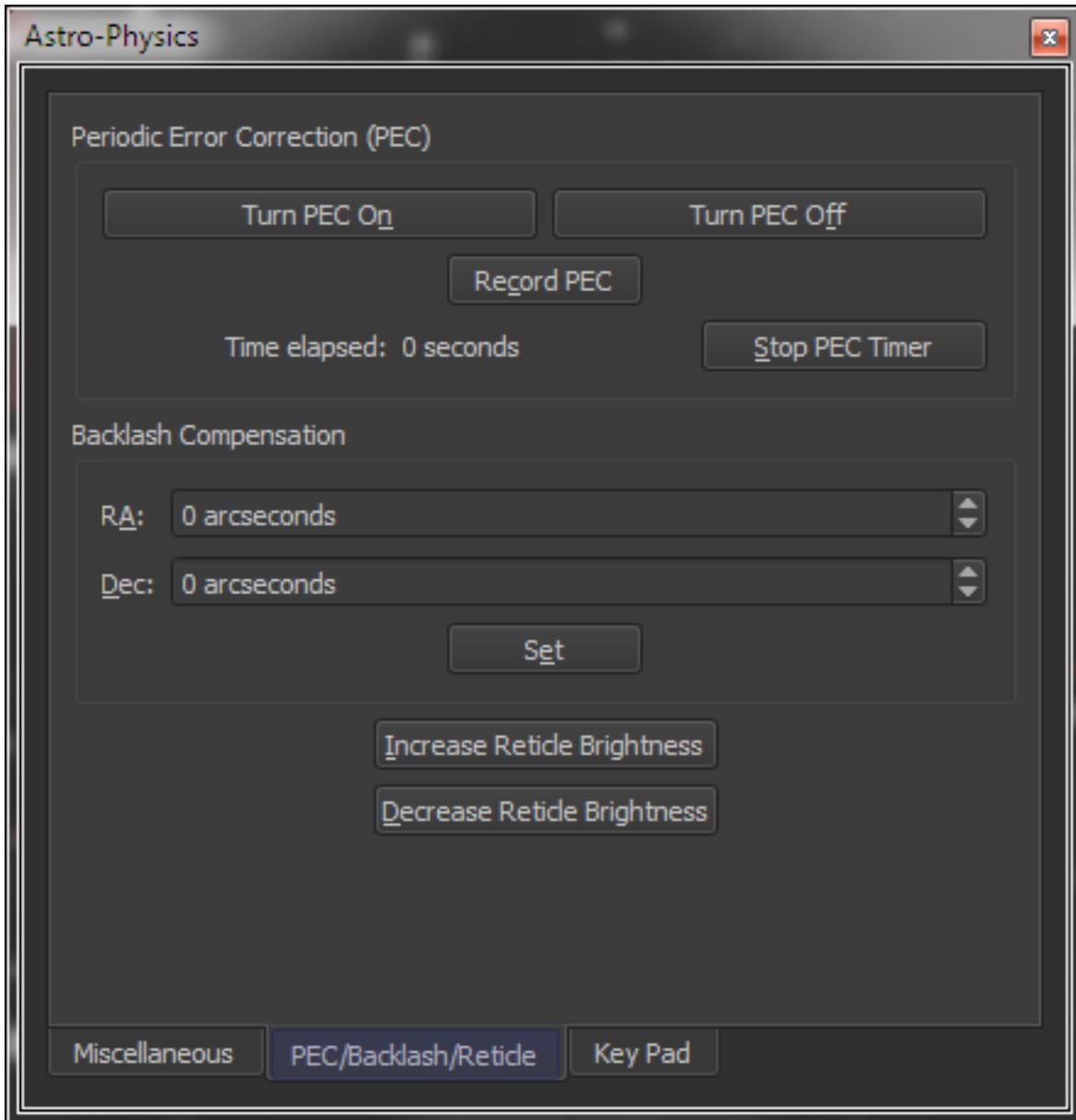


Figure 181: The Astro-Physics window's PEC/Backlash/Reticle pane.

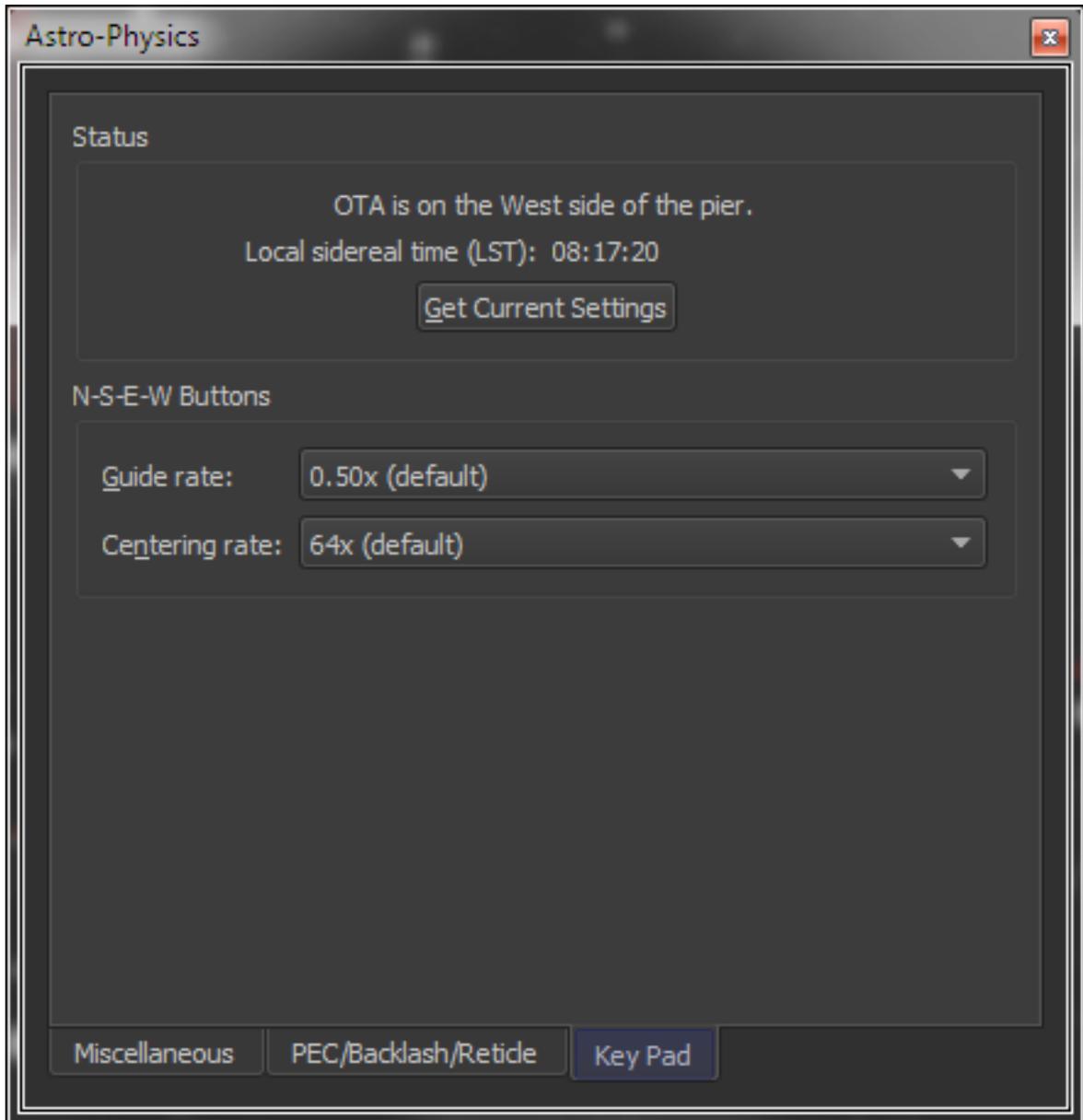


Figure 182: The Astro-Physics window's Key Pad pane.

Most of the AP-specific commands are self-explanatory. Details about each command can be found in AP RS-232 Command Language document which is available from Astro-Physics web site.

### ***Convert Sync to Re-Cal (Highly Recommended)***

When this checkbox is turned on (and is by default), the Astro-Physics Re-Cal command is used in place of the Astro-Physics Calibrate command whenever the **Star Synchronization** command (page 377) is issued from *TheSkyX*. Turn this checkbox off to use the Astro-Physics **Calibrate** command instead of the **Re-Cal** command.



The **Communications Log** (page 368) can be used to verify that *TheSkyX* is sending the appropriate commands to the mount.

## ***Celestron and NexStar-Compatible Mounts***



**Figure 183: The Celestron C11-SGT (XLT) Computerized Telescope (NexStar-compatible). © Celestron International.**

*TheSkyX* controls most NexStar-compatible telescopes manufactured by Celestron International, including:

- Celestron™ Advanced Series (all models)
- Celestron™ NexStar (all models)
- Celestron™ CG Series (all models)
- Celestron™ CGE Series (all models)
- Celestron™ CPS Series (all models)
- Celestron™ GT Series (all models)
- Celestron™ SLT Series (all models)
- Celestron™ NexStar i Series (all models)

The NexStar control system is also used on telescopes from other manufacturers, including:

- Orion Telescopes and Binoculars go to telescopes

- Sky-Watcher SkyScan go to telescopes
- Tasco go to telescopes

## **Celestron Minimum System Requirements**

*TheSkyX* can control telescopes that employ the NexStar control system using firmware version 1.6 and later and motor controller version 4.2 or later. If you have an older version of the firmware, contact the manufacturer for details about upgrading.

### ***NexStar-Compatible Telescope Hardware Requirements***

- A NexStar-compatible telescope.
- A NexStar Telescope Interface Cable. This cable can be purchased from Software Bisque, or the manufacturer.
- A [USB to serial adaptor](#).

### Important Notes

- The NexStar firmware version 1.6 and later, and motor controller version 4.2 and later are required to support high precision (24-bit) slewing and variable tracking rates.

To determine the NexStar firmware version for your mount, when the hand paddle LED reads **NexStar GPS**, press the **Menu** button, then press the button labeled UP or DOWN (6 key or 9 key) until the **Utilities** menu appears. Press the UP or DOWN arrows on the keypad until the **Version** option appears, then press the **Enter** button. The versions for different firmware components are listed in the following order: hand controller, motor controller version for each axis, GPS version and then the bus control version.

Contact [Celestron International](#) for details about obtaining updated firmware for your NexStar.

- NexStar GT Series telescopes using firmware version 1.6 and earlier and motor controller version 4.2 and earlier must use the **Ultima 2000** model mount.
- The NexStar command protocol version 4.1 or later supports software synchronization (that is, the telescope's position can be defined by external software like *TheSkyX*). See page 377 for details about synchronizing your mount with *TheSkyX*.



*TheSkyX* does not require third-party software, such as Celestron's NexRemote application, or virtual serial port drivers, to control NexStar mounts.

## **Step-by-Step NexStar Setup Procedure**

1. Turn off both the computer and the telescope (always a good idea when connecting devices).
2. Connect the telescope interface cable to the serial port of the computer and the hand paddle of the NexStar (RJ22 end connector).

3. After the telescope interface cable is plugged into the NexStar's hand paddle and into the USB to serial adaptor, turn both the computer and the telescope on (the order does not matter).
4. Click the **Telescope Setup** command from the **Telescope** menu.
5. Select **Mount** in the **Imaging System** list on the left side of the **Imaging System Setup** window.
6. On the **Choose Mount** window, select your model telescope and click **OK**. If the *exact* model of your telescope is not listed, don't worry; just select a similar model telescope. The underlying serial communication protocol is the same for similar models.
7. Click the **Settings** command on the **Mount Setup** pop-up menu and then select the correct **COM** port (Windows) or the correct **Serial Device** (Mac).
8. On the **Imaging System Setup** window, turn on the desired preferences and then click **Close**.
9. Select the **Connect** command from the **Telescope** menu.
10. Click the **Star Synchronization** command on the **Start Up** pop-up menu (page 377), then follow the on-screen instructions to complete the initialization.

The telescope cross hairs show the current position of the telescope should appear on the Sky Chart.

#### ***For NexStar models 4, 5, 8 (non-GPS), 60, 80 and 114***

Before connecting *TheSkyX* to the NexStar models 4, 5, 8 (non-GPS), 60, 80 and 114, make sure that the hand paddle is in the **RS 232 mode**. That is, the NexStar hand paddle must display the text **RS-232** on the top line, and **Undo to Exit** on the bottom line, **at all times** so that the hardware's serial port is operational; otherwise a connection cannot be established to the device through software. If the hand paddle does not remain in **RS232** mode at all times, *TheSkyX* will not be able to communicate with the telescope.

#### ***NexStar/TheSkyX Communication Notes***

- Make sure so set the correct Daylight-Saving Time setting on the NexStar hand paddle, otherwise *TheSkyX*'s positions for solar system object, and object rise/set times, will differ from the NexStar hand paddle's values by one hour.
- The NexStar models 4, 5, 8 (non-GPS), 60, 80 and 114 hand paddle must be in **RS232** mode in order to communicate with *TheSkyX*.
- The NexStar models 4, 5, 8 (non-GPS), 60, 80 and 114 must be initialized and aligned in order to communicate with *TheSkyX*.
- The NexStar models 8 GPS and 11 GPS hand paddle *does not need to be in any specific mode or show a specific menu* to communicate with *TheSkyX*.
- The NexStar firmware version 1.6 and later supports Motion Control buttons.
- The NexStar firmware version 1.6 and later has built-in slew limits. If a slew from *TheSkyX* fails, check the LED readout from the hand paddle to make sure these limits have not been exceeded.

## Gemini Astronomical Positioning System



Figure 184: The Losmandy Gemini astronomical positioning system. © Losmandy Instruments.

### Gemini Minimum System Requirements

*TheSkyX* can control any mount that employs the Gemini Astronomical Positioning System firmware version 1.05 or later. If you have an older version of the firmware, contact the manufacturer for details about upgrading.

#### **Hardware Requirements**

- Gemini Astronomical Positioning System with firmware version 1.05 or later.
- A Gemini telescope cable. (Contact Losmandy Instruments to purchase this cable.)
- A [USB to serial adaptor](#).

### Step-by-Step Gemini Setup Procedure

1. Using the Gemini telescope serial cable, plug the male RJ22 end of the cable into the port labeled RS-232 on the Gemini controller and the female end to the [USB to serial adaptor](#).
2. Click the **Telescope Setup** command from the **Telescope** menu.
3. Select **Mount** in the **Imaging System** list on the left side of the **Imaging System Setup** window.

4. On the **Choose Mount** window, select your model telescope and click **OK**. If the *exact* model of your telescope is not listed, don't worry; just select a similar model telescope. The underlying serial communication protocol is the same for similar models.
5. Click the **Settings** command on the **Mount Setup** pop-up menu and then select the correct **COM** port (Windows) or the correct **Serial Device** (Mac).
6. On the **Telescope Setup** window, turn on the desired preferences and then click **Close**.
7. Select the **Connect** command from the **Telescope** menu.
8. If the telescope has not been initialized, click **Tools > Locate, Date, Time** command on the **Telescope** window (**Display** menu). This window shows *TheSkyX's* settings, and the Gemini's. Click the >> button to set the Gemini's values to *TheSkyX's*.
9. Click the **Star Synchronization** command on the **Start Up** pop-up menu (page 377), then follow the on-screen instructions to complete the initialization.

The Gemini should now be initialized and ready to use.

### ***Gemini Specific Commands***

Select the ***Gemini Specific*** command from the **Display** menu to show commands that are specific to this control system.

Note that this command is only available when the ***Gemini*** is selected in the Mount pop-up menu on the **Telescope > Setup** window.

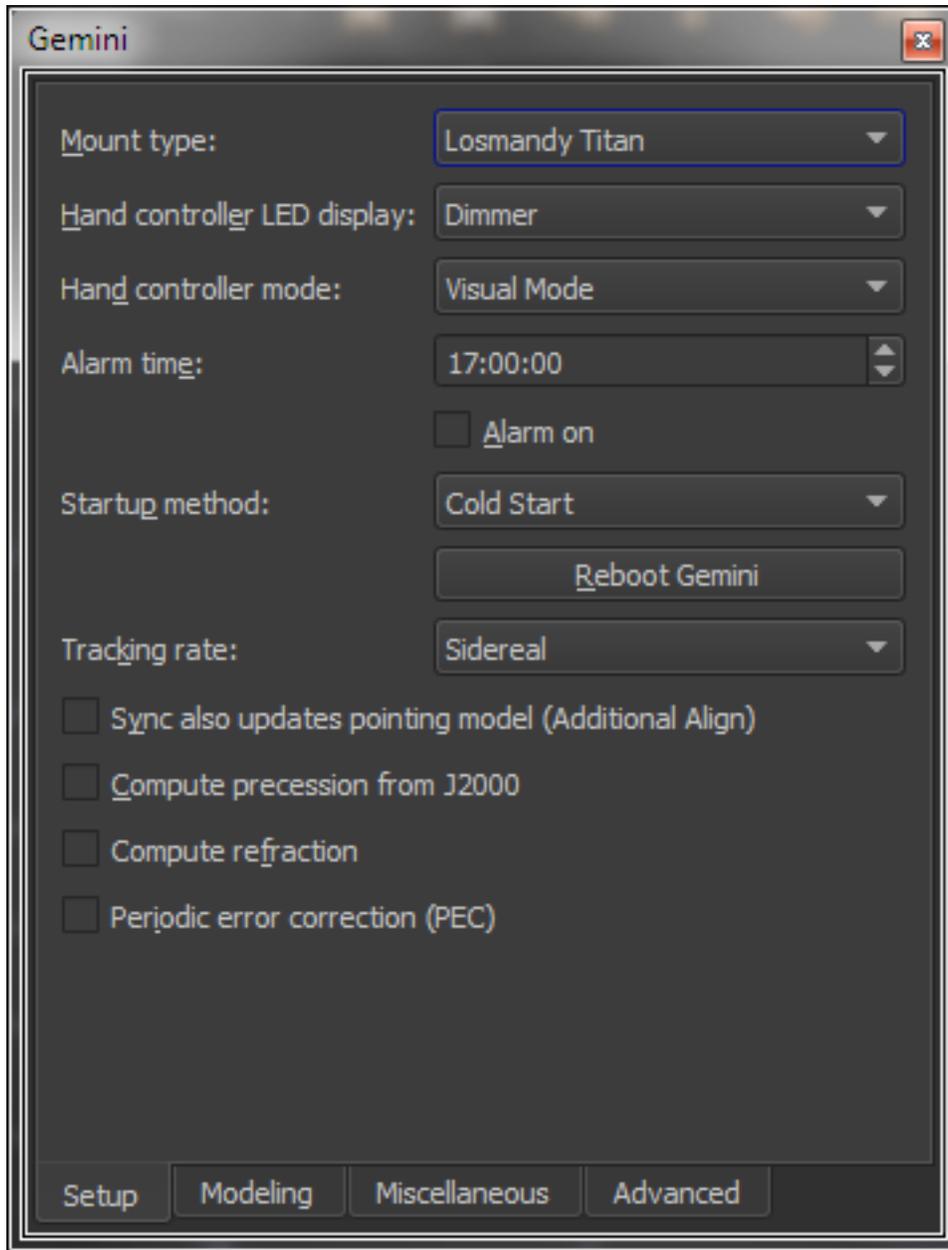


Figure 185: The Gemini window's Setup pane (Display menu).

Details about Gemini window options can be found in Gemini User Manual; this document is available on the Losmandy web site (<http://www.losmandy.com>).

## ***iOptron Mounts***



Figure 186: The iOptron EQ45 Pro German Equatorial Mount. © iOptron.

### **iOptron Minimum System Requirements**

*TheSkyX* can control iOptron model altitude/azimuth and equatorial mounts that use the iOptron firmware dated after February 2014. Please contact iOptron support to obtain the latest firmware for your model telescope.

#### ***iOptron Hardware Requirements***

- iOptron mount.
- A standard RS-232 cable (supplied with the mount).
- A Mac or Windows computer running *TheSkyX* Professional Edition or *TheSkyX* Serious Astronomer Edition.

#### ***iOptron Software Driver Requirements***

- No software driver is required for iOptron mounts that use a serial (RS232) interface.
- iOptron mounts that use a USB interface require an operating system-specific *Virtual Serial Port Driver* that must be installed before *TheSkyX* can communicate with this mount. The SmartStar uses the Silicon Labs CP210X USB to UART Bridge computer chip for serial communications, and the driver can be downloaded from the Silicon Laboratories' web site: <http://www.silabs.com>.

The USB to UART Bridge product page (and drivers) is:

<http://www.silabs.com/products/mcu/pages/usbtouartbridgevcpdrivers.aspx>

Download and run the above appropriate installer for your operating system to install the VCP driver.

## Step-by-Step iOptron Setup Procedure

1. If necessary, install the virtual serial port drivers for the iOptron for your operating system (see iOptron Software Driver Requirements on page 413).
2. From *TheSkyX*, click the **Telescope Setup** command from the **Telescope** menu.
3. Select **Mount** in the **Imaging System** list on the left side of the **Imaging System Setup** window.
4. Click the **Choose** command in the **Mount Setup** pop-up menu.
5. On the **Choose Mount** window, select your model telescope and click **OK**. If the *exact* model of your telescope is not listed, don't worry; just select a similar model telescope. The underlying communication protocol is usually the same for similar models.
6. Click the **Settings** command on the **Mount Setup** pop-up menu and then select the correct **COM** port (Windows) or the correct **Serial Device** (Mac).
7. On the **Telescope Setup** window, turn on the desired preferences and then click **Close**.
8. Select the **Connect** command from the **Telescope** menu.
9. On the **Telescope Setup** window, select the **Location, Date, Time** command and verify *TheSkyX's* location, date, time, and time zone settings match the mount's settings. Click the right pointing green arrow button to update the mount's settings to match *TheSkyX's* settings if they don't match.
10. Click the **Star Synchronization** command (page 377) on the **Start Up** pop-up menu, then follow the on-screen instructions to complete the initialization.

The iOptron should now be initialized and ready to use.

## iOptron-specific Settings

Settings specific to iOptron mounts can be accessed from the **iOptron** window. By default, this window appears as a pane on the left side of the Sky Chart and is displayed automatically when a connection to the mount is established (). Choose the **iOptron** command from the **Display** menu to show this window if it is hidden.

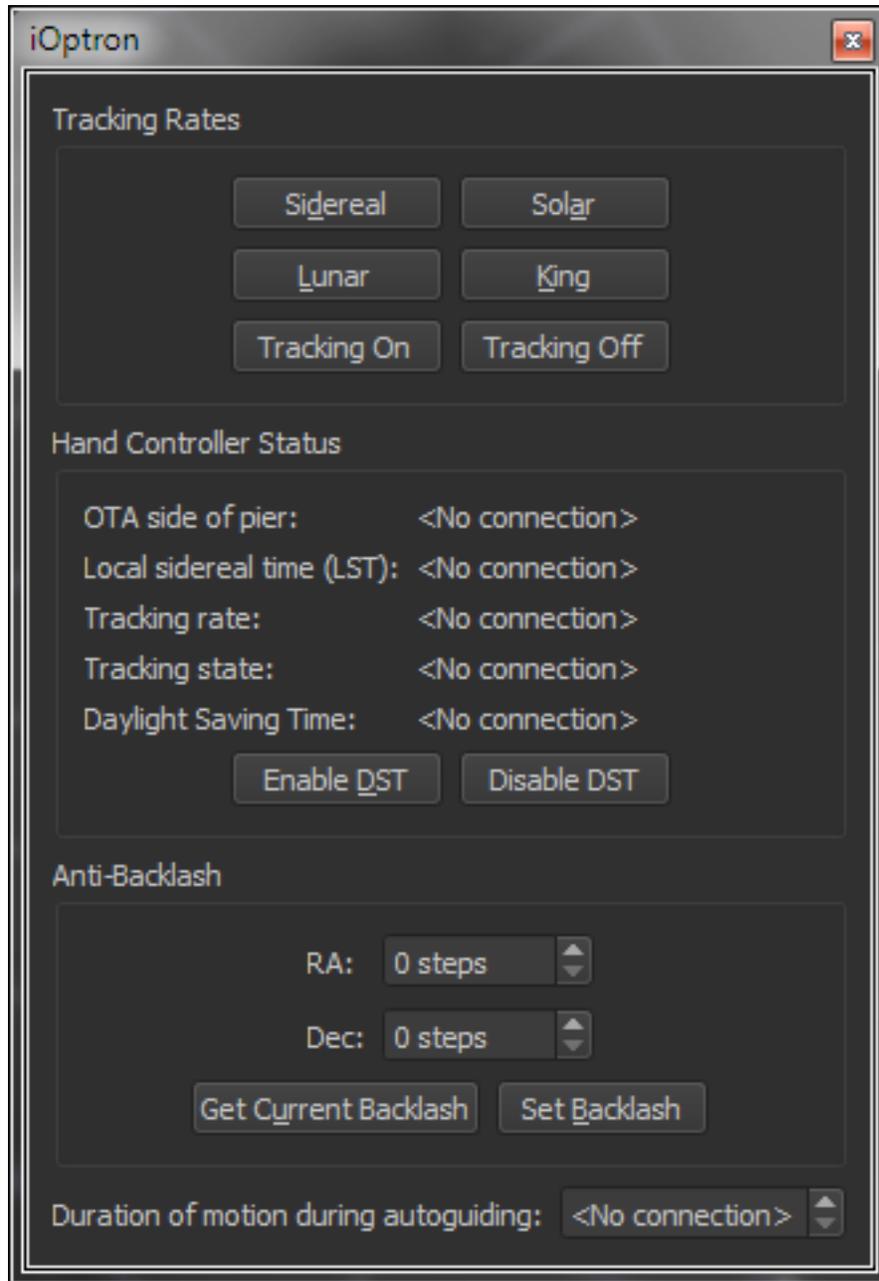


Figure 187: The iOptron settings window.

Use this window to access settings specific to your model mount.

### **Tracking Rates**

iOptron mounts support four different tracking rates:

- Sidereal
- Solar
- Lunar
- King

And tracking at the selected rate can be turned on by clicking the Tracking On button, or off by clicking the Tracking Off button.

### ***Hand Controller Status***

These controls can be helpful to double-check that the mount is initialized properly for your site.

### ***OTA Side of Pier***

For a German equatorial mount, the optical tube assembly normally resides on the *west* side of the pier when observing objects on the *east* side of the meridian. Likewise, the optical tube assembly normally resides on the *east* side of the pier when observing objects on the *west* side of the meridian.

However, German equatorial mounts can be oriented such that the counterweight shaft is “above horizontal”. In this orientation, the OTA is on the *east* side of the pier, and observed objects are on the *east* side of the meridian. In this orientation “atypical” orientation, synchronizing the mount to a star causes the telescope to think the OTA is on the opposite side of the pier, and subsequent mount slews will end up at the wrong equatorial position. Before synchronizing, orient the mount such that that the counterweight shaft is in a “below horizontal” position, then choose a bright star on the appropriate side of the meridian.

### ***Local Sidereal Time***

Displays the local sidereal time that is computed by the hand paddle. The hand paddle’s LST must closely match *TheSkyX*’s LST; if they do not, reset the mount’s location, date, and time to match *TheSkyX*, as described above. If the LSTs differ by one hour, make sure the hand paddle’s Daylight-Saving Time setting is correct for your site and for the current date.

### ***Tracking Rate***

Shows the hand paddle’s current tracking rate.

### ***Tracking State***

Shows the hand paddle’s current tracking state, either on or off.

### ***Daylight Saving Time***

Shows if the hand paddle’s Daylight-Saving Time option is in effect or not.

### ***Enable DST/Disable DST***

Click the appropriate button to enable or disable Daylight Saving Time.

### ***Anti-Backlash***

To minimize the effects of backlash between the worm and gear, the hand paddle can be configured to rotate the right ascension or declination axis by a small amount, in the opposite direction of the slew, after a slew is completed. The amount of rotation is defined by the step size in each axis. Use the hand paddle to determine the angular size, in arcseconds, of each step. For example, the Anti-Backlash setup screen on the iEQ30 model states: “One step equals to [sic] 0.11 arc seconds”.

***RA/Dec Backlash Step Size***

Enter the number of backlash compensation steps for each axis, then click the ***Set Backlash*** button to save these values to the hand paddle's permanent memory.

***Get Backlash***

Click this button to retrieve the current RA and Dec steps from the hand paddle's permanent memory.

***Set Backlash***

Click this button to save the current RA and Dec steps to the hand paddle's permanent memory.

***Duration of Motion during Autoguiding***

Enter the length of time, in milliseconds, the telescope is moved when guider corrections are applied.

## Meade Instruments Mounts



Figure 188: The Meade Autostar ETX-90PE telescope. © Meade Instruments.

### Meade Mount Minimum System Requirements

*TheSkyX* can control LX200 Classic, Autostar, Autostar II, Autostar III and Autostar-compatible mounts, including the RCX400 series and telescopes that use the LX200 protocol (including the Vixen SkySensor 2000).

#### ***LX200 Classic Hardware Requirements***

- LX200 “classic” model by Meade Instruments Corporation telescope (or a control system that uses the LX200 command protocol).
- An LX200 telescope cable. This cable can be purchased from the Software Bisque Store or the manufacturer.
- A [USB to serial adaptor](#).

#### ***Autostar and Autostar II Hardware Requirements***

- Autostar, Autostar II-compatible telescope by Meade Instruments Corporation telescope (or a control system that uses the LX200/Autostar serial communications protocol).
- An Autostar telescope cable. This cable can be purchased from the [Software Bisque Store](#) or from the telescope’s manufacturer.
- A [USB to serial adaptor](#).

#### ***Autostar III Hardware Requirements***

- A standard USB cable for the Autostar III controller. The Autostar III controller (for example, the ETX-LS) has an integrated USB to serial adaptor so the square end of a USB cable can be plugged into the mount’s port labeled USB-B, and the other end connected directly to your personal computer’s USB port.

The integrated USB to serial adaptor requires installation of a software driver before *TheSkyX* can communicate with the mount. Consult the user guide for your mount for instructions on how to install the Meade mount’s USB to serial adaptor driver for the Windows operating system (32-

and 64-bit operating systems require a different driver). You might also check the [Meade USB to Serial Downloads](#) page for the most recent drivers.

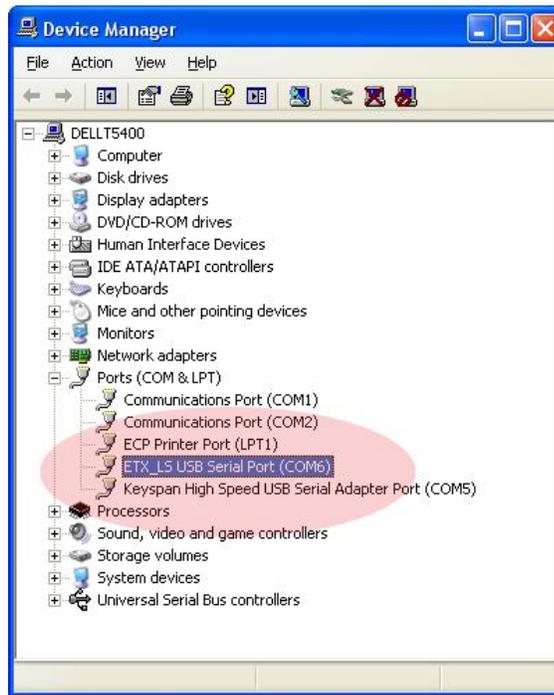


Figure 189: Windows Device Manager showing the ETX LS USB serial port driver's COM port number assignment.

The authors have not found a Mac-compatible driver for Meade eFinder Serial Emulator.

### ***Installing Windows 64-bit Autostar III Drivers***

Use the following procedure to install the latest Autostar III Meade eFinder Serial Emulator drivers.

1. Run the Autostar Update application (by choosing the Product Updates command on the Telescope menu of the Autostar Suite app), then click the Download My Autostar button. This will download the latest version of Autostar Update that includes the Windows 64-bit compatible LS drivers (this step does not actually install the LS drivers, it just updates the installer).
2. Plug the Autostar III telescope into the computer's USB port.
3. From Windows Device Manager, under **Unknown Devices**, right-click on the **Meade eFinder Serial Emulator** and click the **Update Software Driver** command. IMPORTANT NOTE: Meade eFinder Serial Emulator is the USB device's name (not the actual USB driver name) and the Autostar III device will be listed under **Unknown Devices** until the actual driver has been installed.
4. From the Update Driver Software window, click the **Browse My Computer for Software** option.
5. Choose the folder where the Autostar Suite is installed and turn on the **Include Subfolder** checkbox then click **Next**.

6. After the driver is installed, the name of the device is ETX\_LS USB Serial Port (COMN) and the location of the driver is listed under Ports (COM & LPT).

### **Meade RCX400 (Autostar II) Hardware Requirements**

- Meade RCX400 by Meade Instruments Corporation telescope.
- An LX200-compatible telescope cable. This cable can be purchased from the Software Bisque Store or the manufacturer.

## **Step-by-Step Meade Mount Setup Procedure**

*TheSkyX* must be properly configured before it can communicate your mount.

1. Turn off the telescope.
2. If your mount has a USB port, insert the square end of the USB cable into the port labeled *USB-B* and the rectangular end into a USB port on your computer. If the mount has a serial port, insert the phone-type connector of the telescope cable into the bottom of the hand paddle, and the DB9 connector to the [USB to serial adaptor](#).
3. Turn on the telescope.
4. Click the **Telescope Setup** command from the **Telescope** menu.
5. Select **Mount** in the **Imaging System** list on the left side of the **Imaging System Setup** window.
6. On the **Choose Mount** window, select your model telescope and click **OK**. If the *exact* model of your telescope is not listed, don't worry; just select a similar model telescope. The underlying serial communication protocol is essentially the same for similar models.
7. Click the **Settings** command on the **Mount Setup** pop-up menu and then select the correct **COM** port (Windows) or the correct **Serial Device** (Mac). If your mount has a built-in USB to serial adaptor, and you've installed the drivers for it, use the Windows Device Manager to see the COM port number that is assigned to the mount's USB port.
8. Click **Close**.
9. Click Telescope > Connect.
10. Click the **Star Synchronization** command (page 377) on the **Start Up** pop-up menu, then follow the on-screen instructions to complete the initialization.

## **Meade Control Window**

Meade specific telescope controls can be accessed from the Meade window. By default, this window is docked to the left side of the Sky Chart and is turned on when you select a Meade Instruments mount from the mount list. Select the **Meade** command in the **Display** menu to show or hide this window.

### **German Equatorial Mount**

Turn this option on if your mount is a German equatorial mount. This setting is used by the *TPoint Add On* so that it can correctly determine and record which side of the pier the OTA end of the declination axis is on when collecting pointing calibration data.

### ***Parking a Meade Telescope Mount (Park button)***

Press the **Park** button on the Meade window to send the mount to the park position. The handbox LED display will show the **Turn the Mount Off Now** message once parking complete. The next time the mount is powered on, no initialization is required.

Note that *TheSkyX's* software-based parking is not compatible with Meade mounts due to the protocol limitations discussed below. Therefore, do not use the **Park** and **Unpark** commands on the Telescope window to park your Meade mount.

See the following section for details on how to set a Meade mount's park position using the simulated handbox controls.

### ***Simulated Meade Handbox (Autostar Handbox)***

These controls can be used to simulate button presses to the Autostar handbox. Any command that can be accessed by pressing buttons on the handbox can also be accessed through software.

Simulated handbox control is particularly useful to perform certain features that are either not supported or inaccessible through the mount's serial communication protocol. For example, according to the published Meade protocol, the command to set the park position using the current position of the telescope (:hS#) is supported for LX200 GPS/RCX400 and LX16 models only.

If your Meade handbox includes the **Select Item: Setup > Select Item: Preferences > Select Item: Parking Place > Select Item: Park Scope Here > Yes/No** option, then you can navigate to this command using the simulated handbox control buttons to manually set the mount's park position. (The Autostar I and Autostar III we tested allow the mount's park position to be configured this way.)

When the mount is subsequently parked using the **Park** button on the Meade window, the mount will dutifully slew to this park position before shutting down.

### ***Allow Handbox Control***

Turn this checkbox on to allow handbox simulation. (The Autostar I and III mounts we tested allow simulated handbox control. The LX200 Classic handbox has not been tested.)

### ***Hand Control Display Text***

When the **Allow Handbox Control** checkbox is turned on, and the telescope is connected, the text that is displayed on the handbox LED display is also shown in here.

### ***Enter/Back/Go To/Mode/Media/Up Arrow/Down Arrow Buttons***

These buttons perform the same operation as the equivalent button on the handbox. The up/down arrow buttons represent the buttons on the bottom of the handbox, not the direction buttons. The **Media** button is found on the Autostar III handbox only.

### ***Troubleshooting the Meade Telescope***

*TheSkyX* will successfully establish communications with the Meade mounts, provided all of the following are true:

- The device is turned on and functioning.
- The hand paddle is plugged into the telescope's base panel.
- The hand paddle is in Polar or Alt/Az mode and not in Land Mode. See the documentation for setting this mode.
- For mounts that require a serial telescope cable, the telescope cable is wired correctly for bi-directional communications.
- For mounts that require a serial telescope cable, the telescope interface cable is plugged into the correct serial communications port or USB to serial adaptor.
- The telescope cable is plugged into the RS232 port on the LX200 base panel.
- The telescope cable is not plugged into a modem port (Windows).
- The COM port or USB to serial adaptor is functional, the software drivers are installed, and the functioning USB serial port appears in Windows Device Manager.
- For mounts that require a serial telescope cable, the telescope serial cable (the one sold by Software Bisque) is using the DB9 end connector labeled "LX200" not "BBox and Compatible".
- The correct model mount is selected on the ***Telescope Setup*** window.
- The selected serial device (Mac) or COM port (Windows) is correct. Click ***Telescope > Telescope Setup > Settings*** to check this setting.

If all the above is correct, *TheSkyX* will successfully communicate and control the telescope.

## Software Bisque Paramount Robotic Telescope Systems

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Figure 190: The Software Bisque *Paramount* Robotic Telescope Mounts. © Software Bisque, Inc.

The documentation for setting up and using Software Bisque Paramount Robotic Telescope Systems with *TheSkyX Professional Edition* is found in the *Paramount User Guide* for the following models:

- Paramount ME GEM
- Paramount ME II GEM
- Paramount MX GEM
- Paramount MX+ GEM
- Paramount MYT GEM
- Paramount Taurus 400 Equatorial Fork Mount
- Paramount Taurus 500 Equatorial Fork Mount
- Paramount Taurus 600 Equatorial Fork Mount
- Bisque TCS/MKS 4000 Dual Axis Motion Control System-controlled mounts
- Bisque TCS/MKS 5000 Dual Axis Motion Control System-controlled mounts

A printed copy of *Paramount User Guide* is included with the mount. A digital copy, in PDF format can be downloaded by clicking the **Downloads** link on the Software Bisque web site. From there, click the **Documentation** link in the left column, then click on the desired user guide. The URL of this page is: <http://www.bisque.com/sc/media/p/75568.aspx>.

### Paramount ME and Mac OS X

The Paramount ME can be controlled by *TheSkyX Professional Edition for Mac* using the mount's RS 232 port in conjunction with a USB to serial adaptor. The [USA 19-HS High-Speed USB Keyspan Adaptor by Tripp Lite](#) is one USB to Serial Adaptor that works well on both Windows and Mac.

## StellarCAT

The StellarCAT hardware permits “go to” functionality for Dobsonian-class telescopes.

### Computer Assisted Telescope Innovations



Figure 191: ServoCAT and ServoCAT Jr. Track/GOTO. © StellarCAT.

### StellarCAT Minimum System Requirements

*TheSkyX* can show the position of your telescope that uses the StellarCAT and StellarCAT Jr. control system, as well as issue slew commands to point the telescope to any object.

#### **StellarCAT Hardware Requirements**

- StellarCAT or StellarCAT Jr. Track/GOTO system
- Sky Commander or Argo Navis DSC. (See the “ServoCAT Quick Start and Troubleshooting Guide” for details about setting up the Digital Setting Circle or DSC.)
- A [USB to serial adaptor](#).

### Step-by-Step StellarCAT Setup Procedure

*TheSkyX* must be configured correctly before it can communicate with the StellarCAT. Please consult the StellarCAT User’s Manual for details about setting up and configuring the system before attempting to connect it to *TheSkyX*.

1. Turn off the control system.
2. Using the appropriate cable, connect the serial port from the serial interface box to the computer’s [USB to serial adaptor](#) (or serial port).
3. Turn on the control system.
4. Select the **Telescope Setup** command from the **Telescope** menu.
5. Select **Mount** in the **Imaging System** list on the left side of the **Imaging System Setup** window.
6. Select the **Choose** command from the **Mount Setup** pop-up menu.
7. On the **Choose Mount** window, select your model telescope and click **OK**. If the *exact* model of your telescope is not listed, don’t worry; just select a similar model telescope. The underlying serial communication protocol is the same for similar models.

8. Click the **Settings** command on the **Mount Setup** pop-up menu and then select the correct **COM** port (Windows) or the correct **Serial Device** (Mac).
9. Click **Close**
10. Click Telescope > Connect.

### ***Troubleshooting the StellarCAT Connection***

*TheSkyX* will successfully establish communications with the StellarCAT, provided all of the following are true:

- The device is turned on and functioning.
- The DSC serial cable is wired correctly for bi-directional communications. See the ServoCAT User's Manual for details about this cable.
- The ServoCAT serial cable is plugged into the correct serial communications port or USB to serial adaptor (PC side).
- The ServoCAT telescope cable is plugged into the RS232 port on back of the unit.
- The telescope cable is not plugged into a modem port (Windows).
- The COM port or USB to serial adaptor is functional and the software drivers are installed.
- The telescope interface cable (the one sold by Software Bisque) is using the DB9 end connector labeled "LX200" and *not* "BBox and Compatible".
- Autostar/LX200 is selected as the **Mount**.
- The selected serial device (Mac) or COM port (Windows) is correct. Click **Telescope > Telescope Setup > Mount Setup > Settings** to check it.

If the all the above is correct, and *TheSkyX* will successfully communicate and control the telescope.

## Takahashi Temma Mounts



Figure 192: Takahashi Temma mounts. © Takahashi.

### Temma Minimum System Requirements

*TheSkyX* can control Takahashi Temma model altitude/azimuth and equatorial mounts, including:

- EM-10 Temma PC Jr. (USD2)
- EM-200 Temma PC Jr. (USD2)
- EM-200 Temma PC
- NJP Temma PC
- EM-500 Temma PC
- EM-10 Temma2 Jr. (USD3)
- EM-200 Temma2 Jr. (USD3)
- EM-11 Temma2 Jr. (USD3)
- EM-200 Temma2
- EM-400 Temma2
- EM-500 Temma2

#### **Hardware Requirements**

- Any Takahashi Temma or Temma2 mount.
- A Takahashi telescope cable (supplied with the mount).
- A [USB to serial adaptor](#).

### Step-by-Step Temma Setup Procedure

*TheSkyX* must be configured correctly before it can communicate with the Temma mount. Make sure to set *TheSkyX's* location, date, time, time zone and Daylight-Saving Time correctly before proceeding.



Figure 193: Temma PC Jr. Control Panel

1. Turn off the Temma telescope mount.
2. Using the gray Temma telescope cable (supplied with your mount), connect the round end to the port labeled RS-232C on the Temma mount, and the DB9 end to the USB to serial adaptor.
3. Turn the MOTOR and COMPUTER STAND BY switches to the ON position. When the Temma control system is powered on, it is initialized with the following default parameters.
  - The control system “thinks” the optical tube assembly end of the declination axis is on the West side of the mount.
  - The control system “thinks” telescope is pointing at right ascension 0.0 and declination 0.0.
  - The right ascension and declination correction speeds are set to 90.
  - The control system’s tracking direction is for the Northern Hemisphere.

These default parameters will not match the actual position of the optical tube assembly. *TheSkyX* allows you to correctly initialize the Temma’s control system to match the position of the OTA. See the steps below to do so.

1. Select the **Telescope Setup** command from the **Telescope** menu.
2. Select **Mount** in the **Imaging System** list on the left side of the **Imaging System Setup** window.

3. Select the **Choose** command from the **Mount Setup** pop-up menu.
  4. On the **Choose Mount** window, select your model telescope and click **OK**. If the *exact* model of your telescope is not listed, don't worry; just select a similar model telescope. The underlying serial communication protocol is the same for similar models.
  5. Click the **Settings** command from the **Mount Setup** pop-up menu and then select the correct **COM** port (Windows) or the correct **Serial Device** (Mac).
  6. Click **Close**.
  7. Click the **Connect** command from the **Telescope** menu. The Temma's local sidereal time and latitude are set based on *TheSkyX's* values. The telescope cross hairs appear on the Sky Chart at 0,0 right ascension/declination. The Temma's tracking direction is automatically set based on *TheSkyX's* **North** or **South** latitude setting.
  8. Click the **Star Synchronization** command (page 377) on the **Start Up** pop-up menu, then follow the on-screen instructions to complete the initialization. See "Temma Synchronization" below for more information.

## Temma Synchronization

When the Temma mount is powered off, then on, the Temma control system's right ascension/declination coordinates are always 0.0, 0.0.

At this point, you must point the telescope to a known position, and then synchronize *TheSkyX* at that position.

| Synchronization Method   | Procedure   |
|--|---|
| To synchronize when the optical tube assembly end of the declination axis is on the <i>West</i> side of the mount. | <ol style="list-style-type: none"> <li>1. Loosen the clutches on the mount and orient the telescope so that the optical end of the declination axis is on the West side of the mount.</li> <li>2. Keeping the OTA end of the declination axis on the West side of the mount, center a known star that is on the <i>opposite</i> side of the meridian.</li> <li>3. Identify this star in <i>TheSkyX</i> (either by clicking on it or using <i>TheSkyX's</i> Find command from the Edit menu.)</li> <li>4. On the <i>Telescope</i> window, select the <b>Synchronize</b> command in the <b>Start Up</b> pop-up menu and follow the on-screen instructions.</li> </ol> |
| To synchronize when the optical tube assembly end of the declination axis is on the <i>East</i> side of the mount. | <ol style="list-style-type: none"> <li>1. Loosen the clutches on the mount and orient the telescope so that the optical end of the declination axis is on the East side of the mount.</li> <li>2. Keeping the OTA end of the declination axis on the East side of the mount, center a known star that is on the <i>opposite</i> side of the meridian.</li> <li>3. Identify this star in <i>TheSkyX</i> (either by clicking on it or using <i>TheSkyX's</i> Find command from the Edit menu.)</li> </ol>   |

| Synchronization Method   | Procedure   |
|--|---|
|  | <p>4. On the <i>Telescope</i> window, select the <b>Synchronize</b> command in the <b>Start Up</b> pop-up menu and follow the on-screen instructions.</p>   |
| <p>To synchronize by pointing the telescope at the zenith.</p> | <ol style="list-style-type: none"> <li>1. Loosen the clutches on the mount and orient the telescope so that the optical tube assembly is pointing straight up (that is, the OTA is vertical).</li> <li>2. Select the <b>Temma</b> command from the <b>Display</b> menu to show the Temma window if necessary.</li> <li>3. Click the <b>Settings</b> tab on the Temma window.</li> <li>4. Click the <b>Sync At Zenith</b> button on the Temma window.</li> </ol> |
| <p>No synchronization.</p>                                     | <p>If the Temma has been initialized using other software, or is still initialized from a previous observing session (that is, you did not turn off the Computer Stand By switch on the mount).</p> <p>Click the <b>Connect</b> command from the <b>Telescope</b> menu.</p>   |

### **Built-in Backlash Compensation**

The Temma control system has a built-in “backlash compensation” feature that attempts to minimize the effects of gear slop. When the mount is commanded to slew from *TheSkyX*, it slews past the object a small amount, then slews back to it in the direction of sidereal tracking.

### **Temma Mount Specific Commands (Temma Window)**

Select the **Temma** command from the **Display** menu to show commands that are specific to this control system.

Note that this command is only available when the **Temma** is selected in the Mount pop-up menu on the **Telescope > Setup** window.

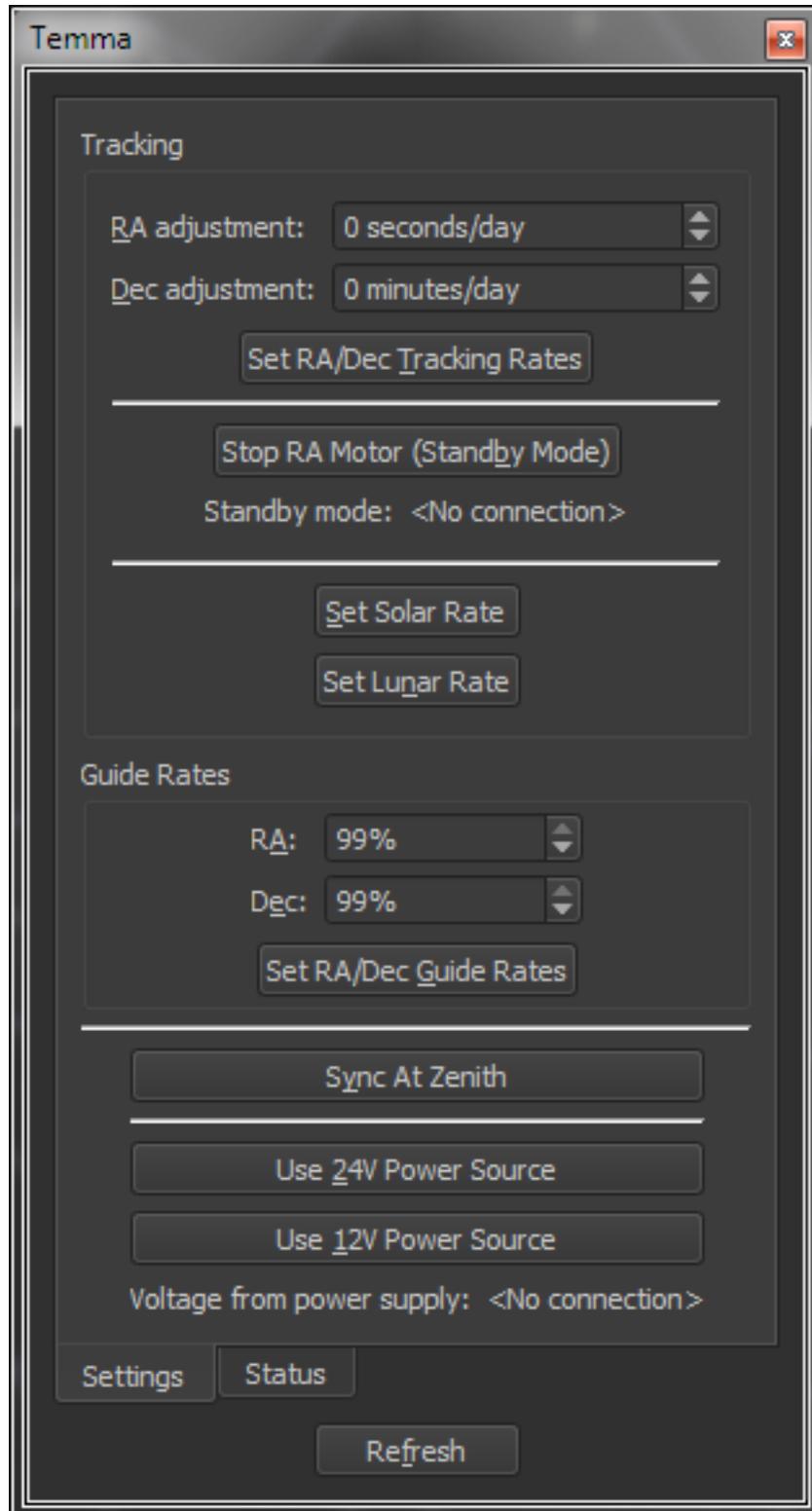


Figure 194: The Temma window's Settings pane (Display menu).

### Settings Tab

The Settings tab provides Temma-control system specific mount settings for adjusting tracking rates, guide rates, and provides control system status.

### **Set Solar Rate**

Click this button to set the mount's tracking rate to approximate the Sun's rate of motion across the sky.

### **RA Adjustment (sidereal seconds/day)**

Enter the adjusted tracking rate for the right ascension axis in *sidereal* seconds per day. There are 86,164 seconds in one *sidereal* day (1 "earth day" = 1.002738 "sidereal day"). See the tracking rate example below.

### **Dec Adjustment (min/day)**

Enter the adjusted tracking rate for the declination axis in minutes per day. See the tracking rate example below.

### **Tracking Rate Example**

The following example shows how to set the Temma's tracking rates to match (approximately) the Moon's reported rate. This same procedure can be used for any solar system object.

1. From *TheSkyX*, click the **Find** command from the **Edit** menu.
2. Type **Moon** in the Find text box, and then click the **Find** button.
3. On the Object Information window report, note the **RA Rate (arcseconds/sec)** and the **Dec Rate (arcseconds/sec)**. For this example, suppose RA = 0.4334 and Dec = 0.2567.
4. Compute the RA adjustment using the following equation: (*TheSkyX*'s RA Rate × -5760). The value is -2496.
5. Compute the Dec adjustment using the following equation: (*TheSkyX*'s Dec Rate × -1440). The value is -370.
6. Enter both values and click the **Set Tracking Rates** button.

### **Stop RA Motor (Standby Mode)**

Click this button to turn tracking off. Note that this command is not supported by all Temma models. You may wish to verify that the mount's motor stops tracking before relying on this command to enter standby mode.

### **Guide Rates**

#### **RA**

Enter the right ascension correction speed (as a percentage of the sidereal rate). This setting is used for the slow speed when using the Motion Controls.

#### **Dec**

Enter the declination correction speed (as a percentage of the sidereal rate).

### **Set RA/Dec Guide Rates**

Click this button to set the current tracking rate using the number entered in the **New** text box.

### **Sync At Zenith**

Click this button to synchronize the Temma mount when the OTA is pointing at the zenith.

### **Use 12V Power Source Button**

Click this button to configure the Temma control system to use 12-volt power supply.

### **Use 24V Power Source Button**

Click this button to configure the Temma control system to use 24-volt power supply.

- Issuing these commands when the Temma is slewing will cause the mount's motors to stop.
- Even when a 12-volt power supply is used, clicking the 24V Power Source Button results in higher slew rates.

### **Status Tab**

#### ***Temma's Local Sidereal Time***

Displays the local sidereal time reported by the Temma control system, in hours, minutes and seconds.

#### ***OTA is on this Side of Mount (East/West)***

For German equatorial mounts, the optical tube assembly (OTA) end of the declination axis can be located on the East or West side of the mount. The Temma reports which side of the mount it "thinks" the optical tube assembly is on. Select the appropriate side from the pop-up menu.

#### ***Voltage From Power Supply***

The Temma mount can use either 12V or 24V power. The *actual* voltage that is being supplied to the control system is shown here.

#### ***Hemisphere Tracking Direction***

*TheSkyX's* North/South latitude setting in the **Input > Location** window is used to configure the Temma's direction of tracking.

#### ***Standby Mode***

Reports whether the Temma mount is in "standby mode," which means the mount's MOTOR switch (Figure 193 on page 427) is turned off. When this switch is in the off position, the mount's right ascension axis will not track at the current tracking rate.

## **Parking the Temma PC Jr.**

Temma PC Jr. mounts do not allow the mount's tracking rate to be turned off through software (the Motor Power switch must be turned off to stop the motors from tracking at the current rate). Therefore, when the Park command is issued for this mount, *TheSkyX* still slews the mount to the park position, but it must then periodically slew back to the park position every few minutes (to undo the rotation of the right ascension axis that is the result of the mount tracking at the sidereal rate).

Note that “software-based parking and continuous rewinding” is a *poor workaround* to a *fundamental shortcoming* in the mount’s control system. Loss of communication between the mount and *TheSkyX* will prevent *TheSkyX* from correcting the mount’s park position, and will most likely result in the mount tracking into itself. This unfortunate event will most likely cause damage to the mount, equipment, cabling or all three. The Temma control system has no built-in software or hardware tracking limits and it will try to rotate the right ascension axis even after the mount has tracked into a fixed object like, such as the pier.

## Vixen HTTP Equatorial Mounts



Figure 195: The Vixen™ Sphinx HTTP mount. © Vixen Optics.

### Vixen Minimum System Requirements

*TheSkyX* can control Vixen Sphinx HTTP mounts using firmware version 1.2 build 35 and later. If you have an older version of the firmware, contact the manufacturer for details about upgrading.

#### **Hardware Requirements**

- Any Vixen Sphinx model German equatorial mount that uses the STAR BOOK™ Star-Chart Go To System.
- An Ethernet **crossover** cable for direct connection from the computer to the STAR BOOK or an Ethernet straight cable for network connection to the telescope through a router.

#### **Cabling Notes**

The Vixen HTTP mount uses standard network protocol rather than serial communications. In the **Settings** window, enter the URL of the mount on your network. The default URL is <http://169.254.1.1>. Use this address if the Vixen is connected directly to the computer's network port using with an Ethernet *crossover cable*.

If your mount is plugged into a network router, use a standard network cable instead.

## Step-by-Step Vixen HTTP Setup Procedure

1. Plug the network cable into the base of the Star Book and into the computer's network port; a network crossover cable is required for this configuration. Or, plug the cable into a network router or hub using a standard Ethernet cable.
2. Turn on the mount.



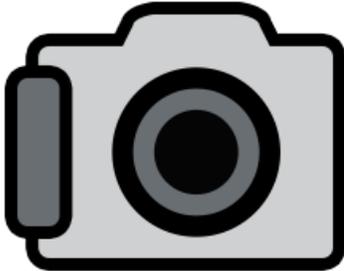
When connecting to an existing network, be sure to plug in the network cable into the base of the Star Book controller and into a network port *before* turning on the mount. Otherwise, the default URL of the IP address will be wrong, and TheSkyX will not connect.

3. Select the **Telescope Setup** command from the **Telescope** menu.
4. Select **Mount** from the **Imaging System** list on the left side of the **Imaging System Setup** window.
5. Select the **Choose** command from the **Mount Setup** pop-up menu.
6. On the **Choose Mount** window, select your model telescope and click **OK**. If the *exact* model of your telescope is not listed, don't worry; just select a similar model telescope. The underlying serial communication protocol is the same for similar models.
7. On the **Imaging System Setup** window, click the **Settings** button from the **Mount Setup** pop-up menu and enter the URL of the Vixen Star Book. When the mount is turned on and the network cable is plugged into both the Star Book hand paddle and the network router, the Star Book's About box shows the URL of this device on the network. Enter this address into the URL text input on the HTTP Port Settings window.
8. On the **Imaging System Setup** window, turn on the desired preferences and then click **Close**.
9. Select the **Connect** command from the **Telescope** menu. The telescope cross hair displays the current coordinates of the telescope.
10. Click the **Star Synchronization** command (page 377) on the **Start Up** pop-up menu, then follow the on-screen instructions to complete the initialization.

The Vixen mount should now be initialized and ready to use.

## Camera Control

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*TheSkyX Professional Edition* with the optional *Camera Add On* can be used to acquire photos from CCD, DSLR or video cameras. The [Camera Add On](#) can be purchased from the [Software Bisque Store](#) and activated using the serial number that is registered to your Software Bisque account when the product is purchased. (You do not need to download and install additional software to use the *Camera Add On*.) See “Activating the Camera Add On” below for more information.

### **Activating the Camera Add On**

When you purchase the *Camera Add On to TheSkyX Professional Edition* from the Software Bisque Store, the *Camera Add On* serial number is automatically registered to your Software Bisque account, and can be viewed by visiting your account’s [Subscriptions](#) page.

The *Camera Add On* serial number is used to activate the camera control features directly from *TheSkyX Professional Edition*. **No additional installers, software or software downloads are required to use the Camera Add On.**

To access your serial number and activate the *Camera Add On*:

1. Sign in to the [Software Bisque web site](#) by clicking the **Sign In** link in the upper right corner of the site. After you are signed in, your **Sign In Name** appears in the upper right corner of the site.
2. Navigate to your subscriptions page by clicking your **Sign In Name**, then click the [Subscriptions](#) link.
3. From *TheSkyX Professional Edition*, click the **Telescope Setup** command on the **Telescope** menu.
4. Highlight **Camera** on the **Imaging System** list.
5. Click the **Camera Setup** pop-up menu and select the **Enter Serial Number** command.
6. Manually enter your **Name** and your *Camera Add On Serial Number*.
7. Click **OK**.

The *Camera Add On to TheSkyX Professional Edition* is now activated and ready to use. You'll need to repeat the above procedure on each computer that is running a licensed copy of *TheSkyX Professional Edition* and the *Camera Add On*.

Before you attempt to link to the camera, run through this checklist to make sure you are ready to begin imaging:

- The camera should be securely attached to the telescope. If practical, attach a safety wire, cable, or strap to catch the camera if it works loose. The camera's power and other cables may tug on the camera as you move your mount, and if the camera isn't completely secure it can work loose, fall off the telescope and damage or destroy the camera.
- All electrical connections should be secure, and power to the camera should be turned on.
- The cable from the camera or control box to your computer should be securely attached, especially if you have a laptop that may get moved about during use.
- Double check the routing of all cables to make sure they will not catch on the mount, telescope, or other accessories. We suggest that you route your cables next to the mount, then along the telescope to the camera. This reduces the free-swinging weight of the cables and will provide a steadier imaging platform. If your mount provides internal routing for cables, make sure all cables attached to the mount are secure.

## Supported Cameras

The *Camera Add On* can natively control the cameras listed in the table below.

| Camera Manufacturer/Model   |  |  |  |  |
|---|--|---|---|---|
| Apogee Instruments Alta and later model cameras (Andor owns and distributes Apogee cameras) | -  | ✓   | -   | -   |
| ATIK cameras  | ✓  | ✓   | -   | -   |
| Canon/EOS models <sup>1</sup>   | ✓  | ✓   | -   | -   |
| DirectShow-compatible video cameras <sup>2</sup>  | -  | ✓   | -   | -   |
| Finger Lakes Instruments/All models   | ✓  | ✓   | ✓   | ✓   |
| Moravian Instruments cameras <sup>3</sup>   | ✓  | ✓   | -   | -   |
| Orion Starshoot Autoguider (SSAG)   | ✓  | -   | -   | -   |
| QHYCCD/All models   | -  | ✓   | -   | -   |

| Camera Manufacturer/Model  |  |  |  |  |
|--|---|---|---|---|
| Quantum Scientific Imaging (QSI)/All models                            | ✓   | ✓   | ✓   | ✓   |
| Santa Barbara Instruments Group/All models <sup>4</sup>                | ✓   | ✓   | ✓   | -   |
| Software Bisque/Camera simulator <sup>5</sup>                          | ✓   | ✓   | ✓   | ✓   |
| Starlight Xpress/Lodestar/CoStar/Superstar/Ultrastar/SXVR/Trius models | ✓   | ✓   | ✓   | ✓   |
| ZWO/All models   | ✓   | ✓   | ✓   | ✓   |

<sup>1</sup>The *Camera Add On* supports Digic III, IV and V model Canon EOS cameras, including:

- 5D Mark II
- 5D Mark III
- 50D
- 6D
- 60D(a)
- 7D
- 70D (via USB only; Wi-Fi interface not supported)
- 80D
- 100D Rebel SL1
- 450D Rebel XSi
- 500D Rebel T1i
- 550D Rebel T2i 600D Rebel T3i
- 650D Rebel T4i
- 650D Rebel T4i
- 700D Rebel T5i
- 1000D Rebel XS
- 1100D Rebel T3

<sup>2</sup>TheSkyX Pro Camera Add On for Windows can take photos from any video device that supports the Windows DirectShow media streaming architecture.

<sup>3</sup>A Windows X2 Plug In for [Moravian Instruments cameras](#) is distributed by Moravian Instruments, not Software Bisque, and must be downloaded and installed separately.

<sup>4</sup> **SBIG DEVICE SUPPORT ON MACOS DISCLAIMER:** At the time of this writing, the SBIG camera drivers are *not digitally signed*, so [System Integrity Protection \(SIP\)](#) prevents successful installation of the drivers on macOS El Capitan (macOS version 10.11) and later. Please [read this support post](#) for instructions how to disable SIP on macOS so that the SBIG driver can be installed to allow SBIG device control.

SIP web site: <https://support.apple.com/en-us/HT204899>

Software Bisque Community Post: <https://tinyurl.com/y95drrt9>

<sup>5</sup> Camera simulator can acquire photos from the Digitized Sky Survey (web-based, or from the 10x DSS on the [TheSkyX Pro Database Add On](#)).

The *Camera Add On* can also control any camera with an X2 Camera Plug In that adheres to the [X2 Standard](#) (page 440) on Mac or Windows, or any ASCOM-compliant cameras, Windows only.

Note that third-party vendors can develop, distribute and install third-party camera drivers independent of Software Bisque and *TheSkyX Professional Edition's* installers, so the above list may not be comprehensive.

To view the list of supported cameras by the *Camera Add On*:

1. Click the **Telescope Setup** command on the **Telescope** menu
2. Highlight **Camera** in the **Hardware List** on the left side of the **Imaging System Setup** window.
3. Click the **Choose** command from the **Camera Setup** pop-up menu.

If your model camera is not listed, check with the camera's manufacturer to find out if a *TheSkyX Professional Edition* Camera Add On or X2 Camera Plug In is available.

## X2 Camera Plug In and Camera Drivers

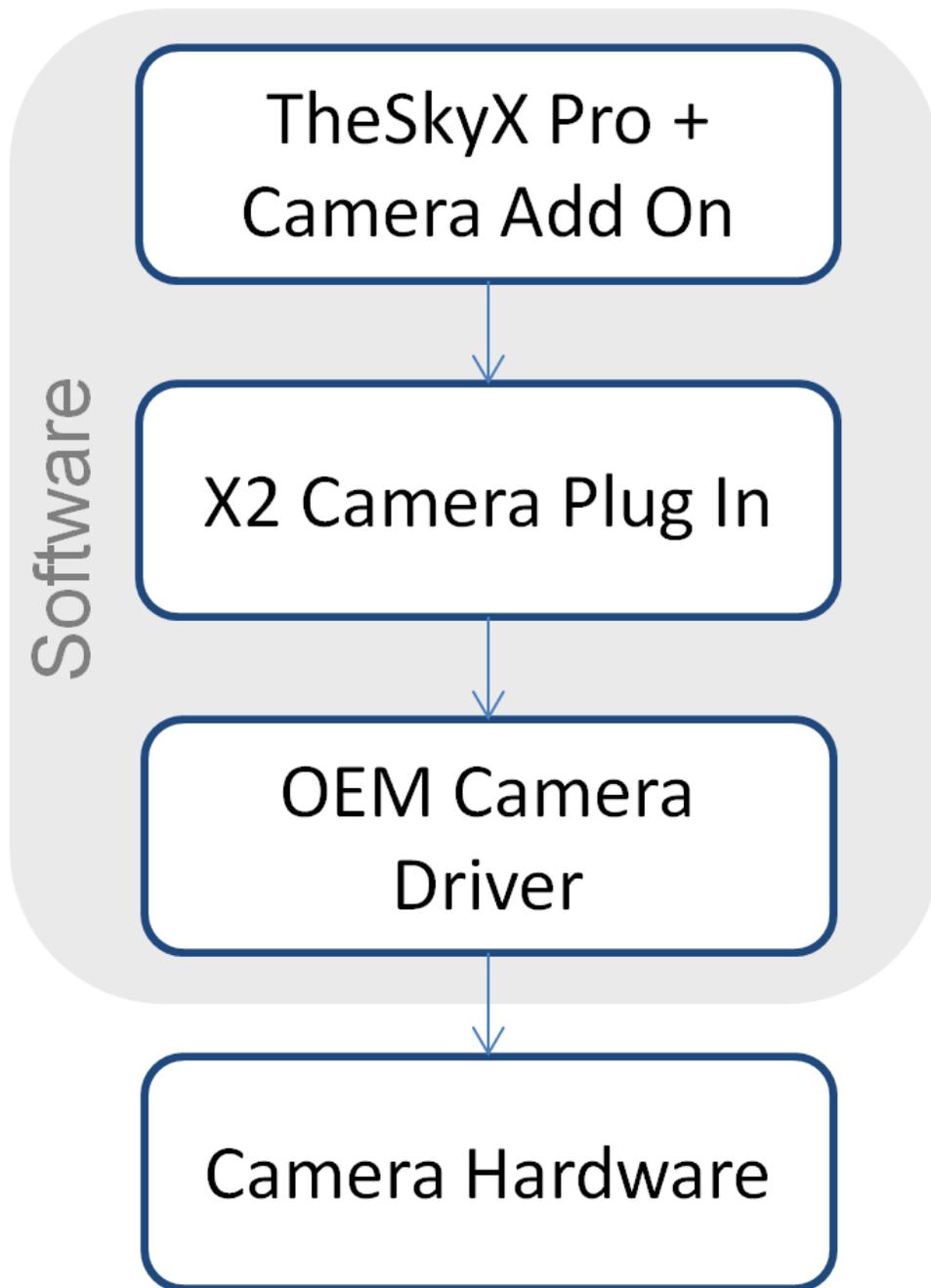


Figure 196: Minimum requirements for camera control.

Figure 196 shows the *minimum software and hardware components* that are necessary for the Camera Add On to “take a picture” with an astronomical camera. The top and bottommost components are obvious; the purpose of the less obvious middle two software components is described below.

### **Original Equipment Manufacturer (OEM) Camera Driver**

Camera hardware and firmware require a *camera software driver* (or *camera driver*) to send commands to, and receive commands from, a personal computer. This two way communication is usually performed using a USB, Ethernet, Wi-Fi, parallel port, or other standard communications interface.

The camera driver is normally developed, distributed and updated by the original equipment manufacturer (OEM), not Software Bisque.

For cameras that require a separate OEM driver, you must download and install the camera driver from the manufacturer's web site *before* the Camera Add On can control it. See the table under "X2 Plug In and Driver Distribution" on page 442 for a list of each camera manufacturer and the Mac/Windows OEM camera driver availability.

Like all software, camera drivers are periodically updated to fix bugs, or add new features. Software Bisque recommends that you keep your camera driver up to date by installing the latest drivers from the OEM's web site. Installing the latest camera driver is also an excellent first step when troubleshooting camera-related problems.

### **X2 Camera Plug In**

The Camera Add On communicates with a camera device driver through a software component called the X2 Camera Plug In. X2 Camera Plug Ins are based on Software Bisque's X2 Plug In Standard Interface ([www.bisque.com/x2](http://www.bisque.com/x2)).

## X2 Plug In and Driver Distribution

### X2 Camera and OEM Camera Driver Distribution Options

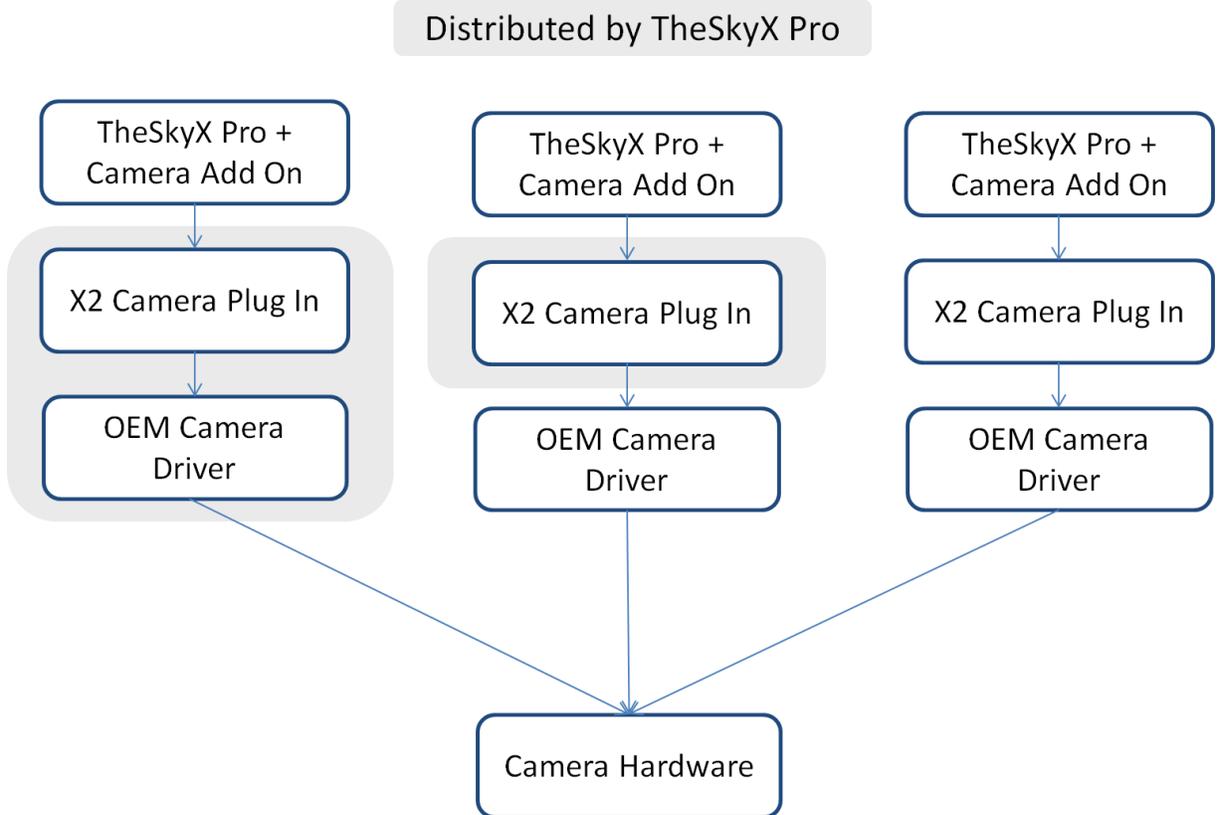


Figure 197: X2 Camera Plug In and OEM Camera Driver distribution options.

Figure 197 shows the three camera driver distribution options for the TheSkyX Professional Edition and the Camera Add On. The shaded regions indicate which component is distributed by TheSkyX Professional Edition.

The camera driver and X2 Plug In distribution options include:

- TheSkyX Pro distributes both the X2 Camera Plug In and the OEM Camera Driver.
- TheSkyX Pro distributes only the X2 Camera Plug In. The OEM Camera Driver must be downloaded and installed from the camera manufacturer’s web site.
- TheSkyX Pro does not distribute either the X2 Camera Plug In or the OEM Camera Driver. Both must be must be downloaded and installed separately from the camera manufacturer’s web site.

Cameras that can be controlled by the Camera Add On using an X2 Camera Plug In and the OEM Camera Driver are considered “natively supported.”

#### **To configure the Camera Add On to control a natively supported camera:**

1. If necessary, install the OEM camera driver from the manufacturer’s web site listed in the table above.

2. If necessary, install the X2 Camera Plug In from the manufacturer's web site listed in the table above.
3. From TheSkyX Professional Edition, click the **Telescope Setup** command from the **Telescope** menu.
4. Double-click **Camera** in the **Imaging System** list to display the **Choose Camera** window.
5. Expand and highlight your model camera, then click **OK**. If the exact model of your camera is not listed, choose a similar model camera.
6. Click the **Settings** command from the **Camera Setup** pop-up menu to display the ASCOM Chooser window then choose your camera.
7. Click the **Properties** button on the Chooser window to configure the camera and click **OK**.
8. Click **OK** to close the Chooser window.
9. Click the **Connect** command from the **Camera Setup** pop-up menu on the **Imaging System Setup** window to connect to the camera.

### **Third-Party Camera Drivers**

TheSky Pro Camera Add On for Windows can control cameras that have an ASCOM driver.

To configure the Camera Add On to control a camera that has an ASCOM camera driver:

1. Download and install the ASCOM platform. Details how can be found on the ASCOM web site.
2. Download and install the ASCOM-driver for your camera (visit the ASCOM web site, or the camera manufacturer's web site to download it).
3. From TheSkyX Professional Edition, click the **Telescope Setup** command from the **Telescope** menu.
4. Double-click **Camera** in the **Imaging System** list to display the **Choose Camera** window.
5. Expand **ASCOM** and highlight **ASCOM Camera**, then click **OK**.
6. Click the **Settings** command from the **Camera Setup** pop-up menu to display the ASCOM Chooser window then choose your camera.
7. Click the **Properties** button on the Chooser window to configure the camera and click **OK**.
8. Click **OK** to close the Chooser window.
9. Click the **Connect** command from the **Camera Setup** pop-up menu on the **Imaging System Setup** window to connect to the camera.

The ASCOM camera is now ready to be controlled from the Camera Add On.

#### **MaxIm DL Controlled Cameras**

In addition to native camera support and ASCOM camera support, the Camera Add On can acquire photos from any camera controlled through Cyanogen's MaxIm DL. Note that MaxIm DL is required for the Camera Add On to be able to communicate with cameras under the control of MaxIm DL.

To configure the *Camera Add On* to control MaxIm DL's camera:

1. Install the MaxIm DL Pro or MaxIm DL DSLR software and configure your camera based on the software's instructions.
2. From TheSkyX Professional Edition, click the **Telescope Setup** command from the **Telescope** menu.
3. Double-click **Camera** in the **Imaging System** list to display the **Choose Camera** window.
4. Expand **Diffraction Limited** and highlight **MaxIm DL's Camera**, then click **OK**.
5. Click the **Connect** command from the **Camera Setup** pop-up menu on the **Imaging System Setup** window to connect to the camera.

The Camera Add On will now use the MaxIm DL-controlled camera to acquire photos.

## **Controlling a Camera**

Once the camera and the computer are powered up, start *TheSkyX Professional Edition* and then choose the **Telescope Setup** command from the **Telescope** menu. This displays the **Imaging System Setup** window. In the **Hardware List** on the left side of this window, click on the **Camera** text to display the camera setup options shown in Figure 198.

Click the **Choose** command from the **Camera Setup** pop-up to select your camera from list (see Figure 200) and click **OK**.

If you have a filter wheel, focuser or rotator installed/attached to the camera, select the model from the hardware list.

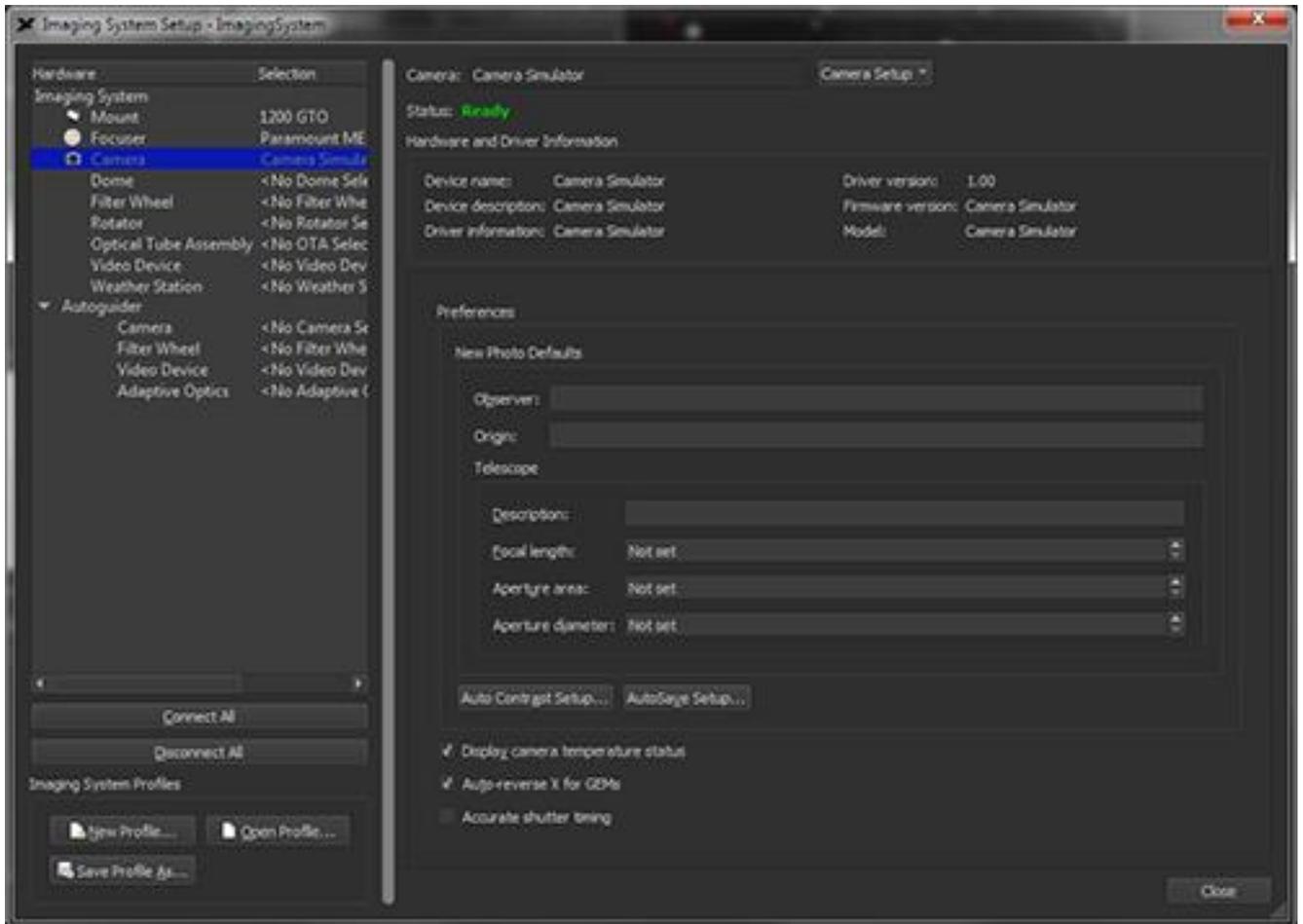


Figure 198: The Camera Setup options on the Imaging System Setup window.

Selecting **Camera** in the **Hardware** list displays camera driver details and other camera-specific preferences.

### **Currently Selected Camera (Camera text)**

The **Camera** text at the top of the **Imaging System Setup** window shows the manufacturer and model of the currently selected camera.

### **Camera Setup Pop-Up Menu**

The **Camera Setup** pop-up menu provides commands for choosing, setting up, connecting, disconnecting and entering the **Camera Add On** serial number.

#### **Choose**

Click this command to display the **Choose Camera** window. The **Camera** list shows all supported models.

#### **Settings**

Click this command to display camera-specific port setup and driver options.

### **Connect**

Choose this command to establish a connection to the camera.

### **Disconnect**

Choose this command to stop communicating with the camera.

### **Enter Serial Number**

Choose this command to enter your Camera Add On serial number. See “Activating the Camera Add On” on page 436.

After selecting your model camera, click the **Settings** command in the **Camera Setup** pop-up menu to configure the communication interface and other camera-specific options.

### **Camera Status (Status text)**

This text box displays the current camera status.

### **Hardware and Driver Information**

When **Camera** is highlighted in the **Hardware** list on the Imaging System Setup window, the following camera hardware and camera driver-specific information is displayed.

#### **Device Name**

This text box shows the name of the selected device.

#### **Device Description**

This text box shows an abbreviated description of the device.

#### **Driver Information**

This text box shows additional information about the driver for this device.

#### **Driver Version**

This text box shows the version of the software driver used to control this device.

#### **Firmware Version**

This text box shows the version of the device’s firmware, when available.

#### **Model**

This text box shows the hardware’s model as reported by the device’s firmware, when available.

## **Camera Preferences**

You can specify the default values that the Camera Add On will use when saving photos under the **Preferences** section of the **Imaging System Setup window**.

### **New Photo Defaults**

These values will be stored to the appropriate FITS keyword in the FITS header when new photos are acquired.

#### **Observer**

Enter the name of the observer. The value is saved to the OBSNAME FITS keyword in the FITS header.

#### **Origin**

Enter the place of origin of the photograph, typically the observatory name of observing site. This value is saved to the ORIGIN FITS keyword in the FITS header.

#### **Telescope**

Enter the physical characteristics of the telescope or optical tube assembly below.

#### **Description**

Enter a description of the telescope.

#### **Focal Length**

Enter the focal length of the telescope, in millimeters. This value is:

- Used to compute the AO **Wander** metric for the *autoguider camera*. When entering the telescope's focal length for AO **Wander**, be sure to set the *autoguider's preferences* by highlighting the camera listed under **Autoguider**, not the camera listed under **Imaging System**.
- Used to compute the image scale of a photo (in arcseconds per pixel) taken with the selected camera or autoguider. This image scale is displayed on the right side of the y-axis of autoguider graphs (see Figure 216).
- Saved as the value of the FOCALLEN keyword in the FITS header.

#### **Aperture Area**

Enter the area of the telescope's mirror, in square millimeters. The **Aperture Area** value is used to specify the area of the aperture, *minus any central obstruction*, and is saved as value of the APTAREA keyword in the FITS header.

#### **Aperture Diameter**

Enter the diameter of the telescope's mirror, in millimeters. This value is saved as the value of the APTDIA keyword in the FITS header.

#### **AutoDark Subtract Uses All Processors**

For computers that have more than one processor, turn this checkbox on to allow the Camera Add On to use all available processors when performing auto dark calibrations.

#### **AutoSave Setup**

Click this button to show the preferences to use when photos are automatically saved (page 462).

### **Display Camera Temperature Status**

When this checkbox is turned on, the camera's temperature-related settings, including temperature, set point, and the cooler's power usage are displayed below the Camera Status text on the Camera window. Turn the checkbox off to hide these settings.

### **Auto Reverse X for GEMs**

Turn this checkbox on to so that the direction of the x-axis guider corrections are automatically reversed when the telescope on a German equatorial mount changes sides of the pier.

### **Accurate Shutter Timing**

Turn this checkbox on to record accurate time stamps in the FITS header.



- This option is hidden by default, and is shown only when the appropriate time-source software is running when TheSkyX is launched.
- This option is compatible with TheSkyX for Windows, only.

## **SBIG Camera Settings**

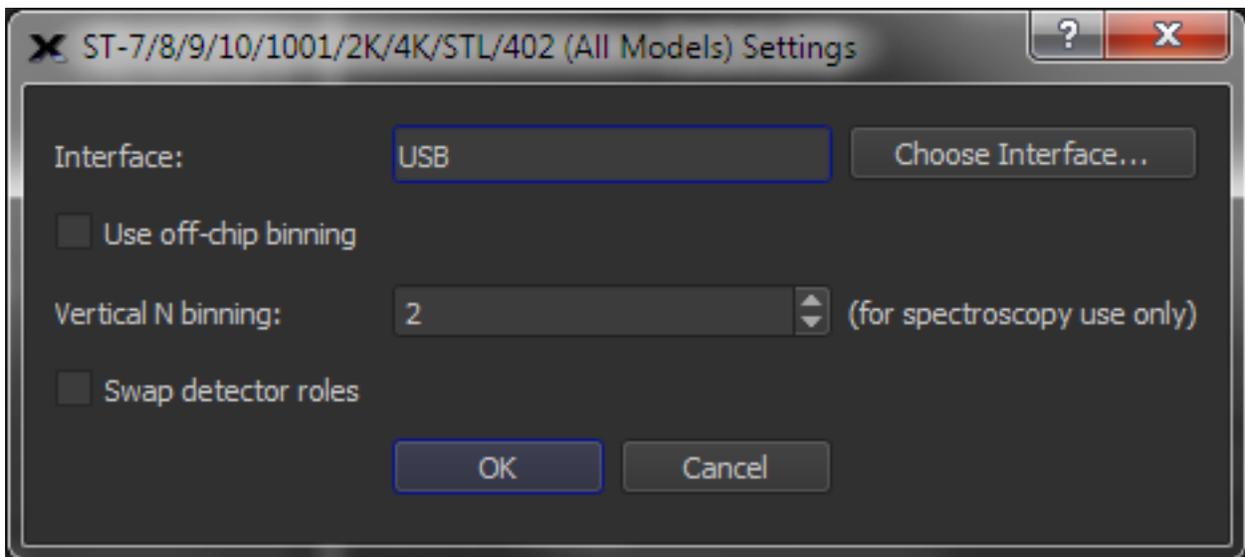


Figure 199: The SBIG Camera Settings window.

Use the **SBIG ST... Settings** window to set the communications interface, binning options and the roles of the camera's imaging and autoguiding sensors.

### **Camera Communications (Interface text box)**

SBIG cameras can be connected to a computer using one of the following communication interfaces.

| Interface Name  | Description  |
|-----------------|--|
| <b>Ethernet</b> | <p>SBIG offers an optional Ethernet communications box that uses TCP/IP network protocol to communicate with the camera.</p> <p>After selecting the Ethernet option, enter the IP Address assigned to the camera and click <b>OK</b>.</p>  |
| <b>USB</b>      | <p>The <b>USB</b> option applies to all “modern” SBIG cameras.</p> <p>Selecting the <b>USB</b> interface allows the SBIG camera driver to automatically locate the camera plugged into the USB port.</p> <p>If you own two SBIG cameras and want to assign a specific USB port to a specific camera, choose the <b>USB1, USB2, USB3</b> or <b>USB4</b> option and click <b>OK</b>.</p> |

The *Camera Add On* does not support legacy SBIG parallel port cameras.

### **Use Off-Chip Binning**

Turn this checkbox on to have the SBIG camera driver perform binning rather than the SBIG camera hardware.

### **Vertical N Binning (Spectroscopy Use Only)**

Enter the bin value (1-255) used when performing spectroscopy with the SBIG camera.

### **Swap Detector Roles**

Turn this checkbox on to use the camera’s main sensor as the guiding sensor and the guiding sensor for the imaging sensor.

## **Setting Up an SBIG Camera**

Follow the steps below to configure *TheSkyX Professional* to control an SBIG model camera.

1. Install the [SBIG camera drivers](#) for your operating system. If necessary, use SBIG’s free CCOPS software for your OS to make sure the driver is properly installed and you can take photos with the camera.
2. Make sure your camera is plugged in, turned on and connected to a USB port on your computer. Before attempting to connect to the camera, allow about 30 seconds or so for the SBIG camera to initialize.
3. From *TheSkyX*, select the **Telescope Setup** command from the **Telescope** menu.
4. Select the **Camera** text in the **Imaging System** list.
5. Click the **Choose** command on the **Camera Setup** pop-up menu to display the **Choose Camera** window. If you have not purchased the *Camera Add On*, click the **Run Trial** button to use begin the 90-day trial period.

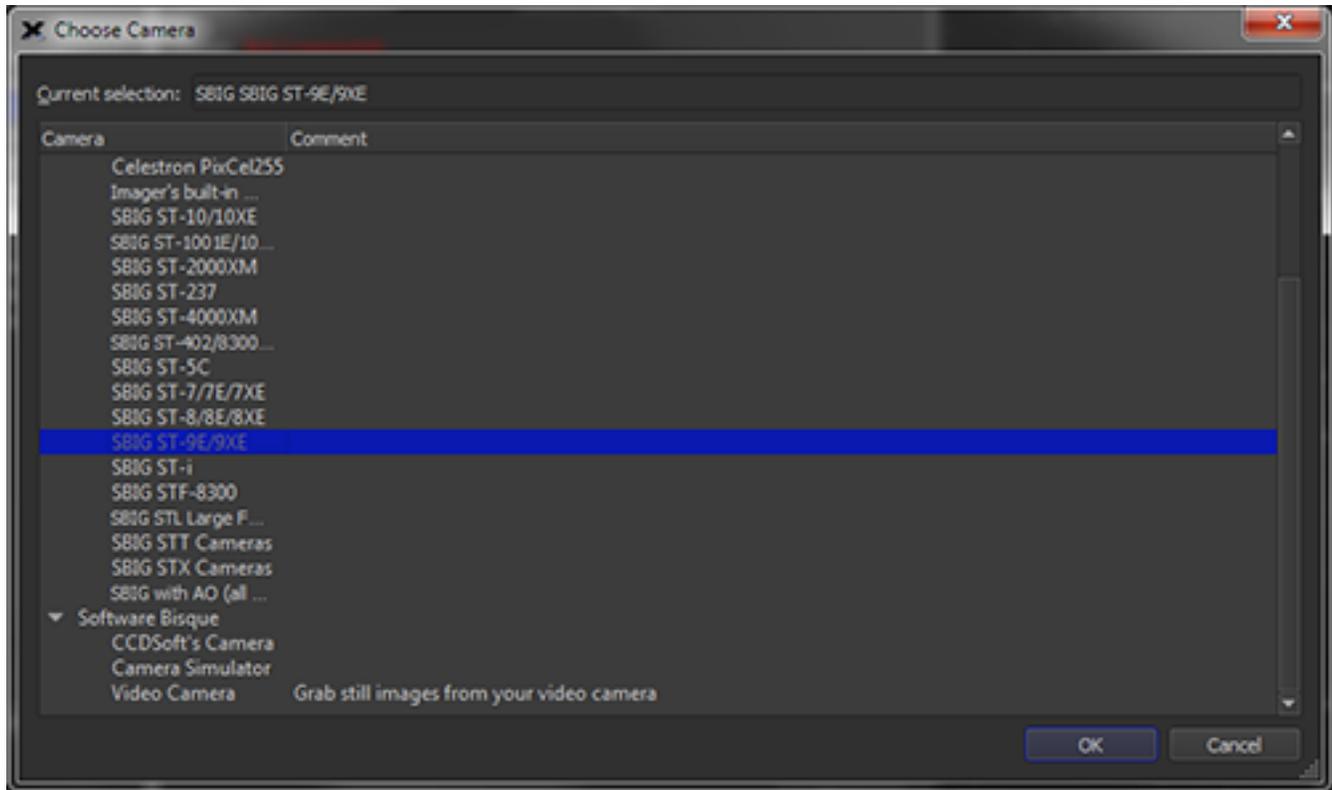


Figure 200: Figure 158: The Choose Camera window.

5. Expand **SBIG**, then select your camera model and click **OK**. The name of the selected camera will appear at the top of the **Camera** window (Figure 201).
6. Select the **Connect** command from the **Camera Setup** pop-up menu or click the **Connect** button on the **Camera** window. If the SBIG drivers are installed properly, after about fifteen seconds, the green **Ready** status text appears on the **Imaging System Setup** window and on the **Camera** window.

## Configuring the Remote Guide Head

SBIG offers a separate Remote Guide Head (RGH) for the STT, STXL and STX Series cameras. The RGH allows autoguiding using a separate guide scope, off-axis guider or camera lens. When plugged into the camera's Remote Head port, the RGH effectively replaces the functionality of the camera's built-in autoguider.

1. Click the **Telescope Setup** command from the **Telescope** menu.
2. Double-click **Camera** under **Imaging System** on the left side of the window.
3. Expand **SBIG**, then choose **SBIG <Your Model Imager Name>** and click **OK**.
4. Double-click **Camera** under **Autoguider** and choose **Imager's Built-in Autoguider**.



The SBIG RGH is considered a "built-in" autoguider and the SBIG driver will recognize this device **only after connection to the Imager is established**.

## Canon DSLR Cameras

Canon DSLRs are popular for astrophotography and the Camera Add On allows these cameras to be an integral part of your digital imaging workflow.

### Canon Camera Plug In Minimum Requirements

TheSkyX Professional Edition's Canon DSLR Plug In is intended to work with all Canon Digidig 4 or later DSLRs on the following operating systems.

#### Mac OS X Minimum Requirements

- An Intel-based Mac running Mac OS X 10.6 (Snow Leopard) or later. Attempting to connect to a Canon DSLR using Mac OS X 10.5 or earlier with this plug in will always result in the error message: "A necessary driver was not found."

#### Windows Minimum Requirements

- Windows 10, 8 or Windows 7, 32- or 64-bit operating system.



The Canon camera's mirror must be unlocked before the camera can be controlled from the Camera Add On. See the camera's documentation for details how to unlock it.

#### Canon Camera Minimum Requirements

The Camera Add On supports Digidig 3, 4, and 5 model Canon EOS cameras, including:

- 1D X
- 5D Mark II
- 5D Mark III
- 50D
- 6D
- 60D(a)
- 7D
- 80D
- 100D Rebel SL1
- 450D Rebel XSi
- 500D Rebel T1i
- 550D Rebel T2i
- 600D Rebel T3i
- 650D Rebel T4i
- 650D Rebel T4i
- 700D Rebel T5i
- 1000D Rebel XS
- 1100D Rebel T3
- 1200D Rebel T5

Choose **Universal/Generic for unlisted Digidig 3, 4, or 5 models** from the Canon camera list if your model is not listed.

The Digidig 4 processor was also used in some of the latest Canon PowerShot series cameras. However, the mechanics of connecting these model cameras to a telescope can be difficult and are beyond the scope of this document.

The Canon X2 Plug In may be compatible with older model cameras, but may not be able to take exposures over 30 seconds (which is a severe limitation for anything beyond automated TPoint calibration runs).

## Canon Camera Acquisition Modes

Canon cameras have the following methods for taking a photo (also known as “acquisition modes”).

1. **Luminance:** This mode works best for automated pointing calibration runs and Image Links. (This mode is a bit of a cheat for a one-shot color camera. It uses a standard RGB to Luminance formula to derive the luminance values from the RGB components. Not perfect, but works very well for these tasks.) ***THIS IS THE ONLY CURRENTLY FUNCTIONING MODE FOR THE CANON PLUG IN.***
2. **Canon Debayer:** For color images, this will use the built-in Canon debayer algorithms. (Under development.)
3. **RAW Color:** Better debayer routines. This mode may replace the Canon Debayer mode after further testing takes place.
4. **SuperPixel:** Converts a 2x2 RAW OSC pixel block (before debayering) into a single RGB pixel. This mode will provide good color results, at a lower reduced resolution.
5. **LiveView:** This mode has many potential applications, but is still under development.

### ***Binning***

Canon DSLR’s do not support hardware binning. This software binning mode simply sums neighboring pixels.

### ***Known Canon Driver Limitations***

- Luminance acquisition only.
- Mirror lock cannot be enabled. No error messages reported, the driver will just hang when attempting to take an exposure.
- Camera mode dial must be set to Manual.

## Setting Up a Canon Camera

Follow the steps below to configure *TheSkyX Professional* to directly control a Canon camera.

1. Download and install *TheSkyX Professional Edition* version 10.3.0 or later from the Software Bisque web site: <http://www.bisque.com/sc/media/p/47013.aspx>.
2. Make sure your camera is plugged in and turned on.
3. From *TheSkyX*, select the **Telescope Setup** command from the **Telescope** menu.
4. Select the **Camera** text in the **Imaging System** list.
5. Click the **Choose** command on the **Camera Setup** pop-up menu to display the **Choose Camera** window. If you have not purchased the *Camera Add On*, click the **Run Trial** button to use begin the 90-day trial period.
6. Expand **Canon**, click *Canon DSLR* and click **OK** (or double-click on the camera model to select it and close the window.)
7. Select the **Connect** command from the **Camera Setup** pop-up menu or click the **Connect** button on the **Camera** window. After about thirty seconds, the green **Ready** status text appears on the **Imaging System Setup** window and on the **Camera** window.

*TheSkyX Professional Edition* can now acquire photos from the Canon camera.

## **Orion Starshoot Autoguider**

The Camera Add On can autoguide telescopes via **Relays** (page 483) using the Orion Starshoot Autoguider (SSAG) on both Mac and Windows.

1. The SSAG's hardware relays *do not* adhere to the SBIG ST-4 standard, so you must use the autoguiding cable that comes with the guider, otherwise the telescope will not respond to guider corrections issued from the camera.
2. On the cameras the driver author tested, the first row of pixels in all full and subframes acquired with this camera are consistently "garbage" (that is, they contain random data). As a workaround to this behavior, the first two rows in the photo are ignored and appear all black.
3. Dark frames are automatically acquired to mitigate hot pixels while autoguiding with this model camera.

## Taking Photos

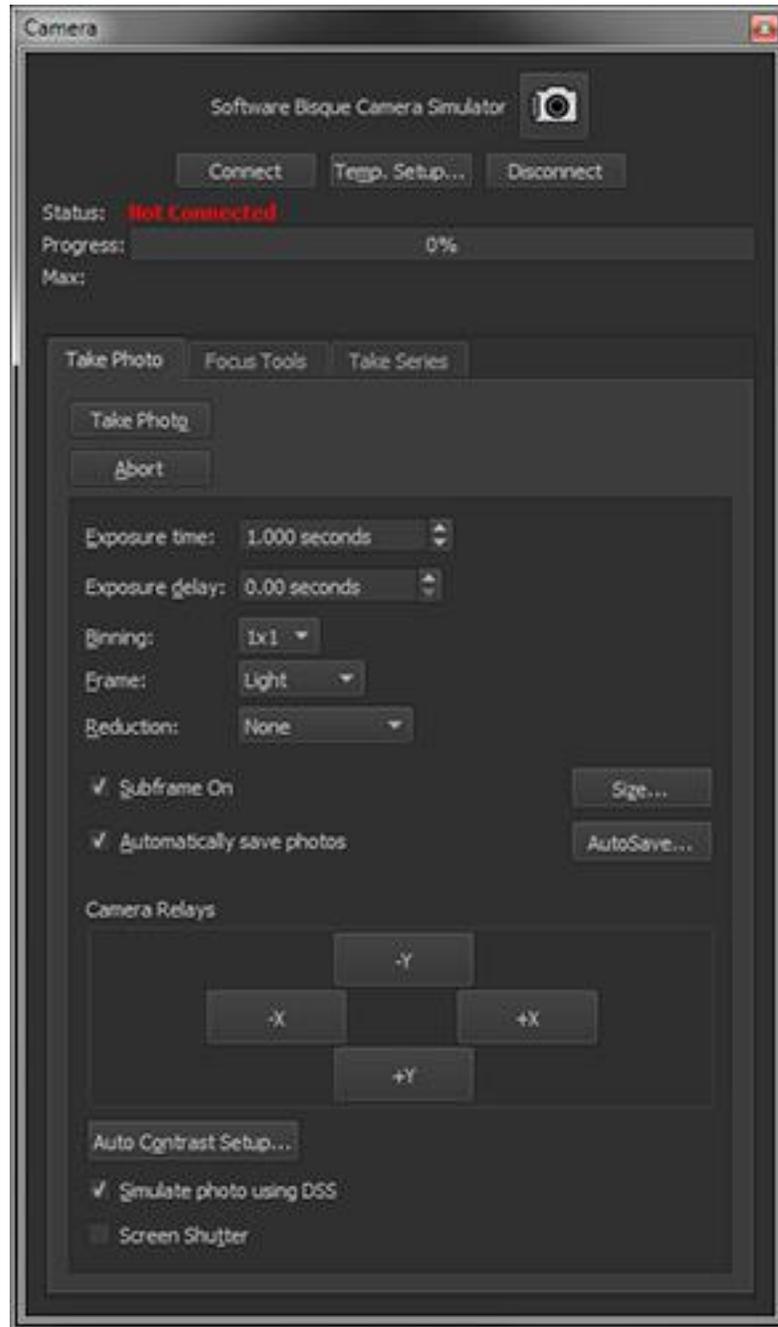


Figure 201: The Camera Add On window.

Once the camera is selected and communication established, take a photo using the default settings by clicking the **Take Photo** button on the **Camera** window.

When the exposure is complete, the photo is downloaded from the camera and displayed in the “FITS Viewer Window” (page 107).

**Establish Communication with the Camera (Connect button)**

Click the **Connect** button to establish a communication link between the camera and *TheSkyX*. The **Ready** status text indicates the camera is ready to acquire photos.

**Camera Cooling (Temp. Setup button)**

Click this button to specify the cooling point for the camera.

**Terminate Communication with the Camera (Disconnect button)**

Click the **Disconnect** button to end communication with camera. This step is usually performed at the end of the imaging session. The status text will show **Not Connected**.

**Take a Photograph (Take Photo button)**

Click this button to take a photo with the selected camera using the current camera settings.

**Abort Exposure Process (Abort button)**

Click this button to immediately end the process of acquiring a photograph from the camera.

**Select Exposure Length (Exposure Time)**

The maximum exposure length is determined by how good your polar alignment is, and by how accurately your mount tracks. If you see stars trailing into lines, shorten your exposure until this goes away (or take some time to improve your polar alignment or the accuracy of your mount's tracking). If you see wiggly lines on long exposures, then your mount's tracking error is too large for the current focal length. Use a focal reducer, or switch to a scope with a shorter focal length that better fits the capabilities of your mount.

The following table includes some recommended exposure times for various objects. The table assumes a focal ratio in the range of about f/7. Use longer exposures for longer focal ratios, and shorter exposures for shorter focal ratios. If you get blooming on a particular object, then go to a shorter exposure. If you don't get much detail in the image, or it seems washed out, go to a longer exposure. Generally speaking, unless you run into blooming, saturation, or other problems, longer exposures are generally better. Experiment to find the best exposures for your setup. You might want to keep a written record of successful exposures, which you can use as a guide for future imaging sessions.

| Object     | Suggested Exposure Range  |
|------------|---|
| <b>Sun</b> | Use a visual solar filter, plus any additional filters needed to cut the light. Polarizing filters, moon filters, or other specialized filters such as h-alpha filters can reduce the light so that your camera's shortest exposure will be sufficient for solar images. Do not use so-called photographic solar filters. These are intended for film, which is much less sensitive than your CCD detector.<br><br>Never attempt to photograph or view the sun without a proper solar filter! |

| <b>Object</b>                                  | <b>Suggested Exposure Range</b>   |
|--|---|
| <b>Bright planets</b>                          | Planets such as Venus, Jupiter, Saturn and Mars require surprisingly short exposures with most setups, as little as 5 to 10 thousandths of a second. However, if you use a Barlow or eyepiece projection to increase the focal ratio to f/20 or even f/30, longer exposures (up to a full second) may be required.  |
| <b>Moon</b>                                    | The moon is also very bright, especially around full moon, and may require some effort on your part to attenuate the light sufficiently for imaging. Polarizing filters and moon filters, or both, will get the job done. As with solar images, the shortest possible exposure of your camera should be tried first. Then add additional filtering if that isn't short enough, or increase the exposure if it's not long enough.  |
| <b>Open clusters, bright globular clusters</b> | These objects require relatively short exposures, and exposure length is usually limited by blooming if you don't have an anti-blooming camera. If you do have an anti-blooming camera, you can even image open clusters long enough to image background galaxies. For clusters with very bright members, or globular clusters with very bright cores such as M13, exposures under a minute should be enough. Dimmer clusters may require exposures longer than a minute. Very bright clusters, such as the Pleiades, may only work well with anti-blooming cameras. For color imaging, be careful not to saturate bright stars so you can get truer star colors. |
| <b>Galaxies</b>                                | Galaxies come in an enormous range of brightness levels. M31 will show up in an exposure of a few seconds; M101 may require 5 to 10 minutes or more. Generally speaking, edge-on spirals and elliptical galaxies are brighter and require shorter exposures. Face-on spirals are usually the dimmest galaxies and require longer exposures. When using a scope with a very long focal length, large pixels or binning may be required to get reasonable exposure times.   |
| <b>Nebulas</b>                                 | Nebulas come in an even wider range of brightness than galaxies do. Some, like M42, will yield excellent results in less than 20 seconds. Others, like the Rosette Nebula, may require 20-minute exposures to get good detail. A few trial exposures will help you determine the best exposure for any given nebula.  |

Generally speaking, longer exposures are better in most cases because they provide better-quality data. However, blooming, the risk of passing satellites or airplanes, and other factors usually limit the longest exposure time you can use. You can take multiple exposures and combine them in various ways to increase the quality of your photos.

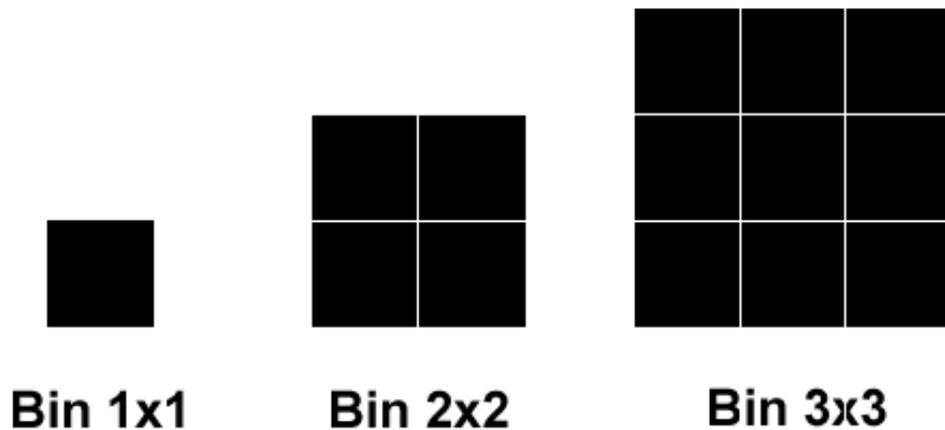
### **Delay before Taking Photo (Exposure Delay)**

Enter the number of seconds to wait before taking the next photo. This delay is useful to allow the telescope to settle, or to make sure everything is in order before taking a long exposure.

### **Select Bin Mode (Binning pop-up)**

Binning is an on-camera process that effectively combines the signal from a group of adjacent pixels into a single pixel on the photo to increase the sensitivity but decreases the photo's image scale. Binning pixels allows you to match pixel size to telescope focal length. Pixels that are small require longer exposures and provide higher resolution. Large pixels allow shorter exposures but provide lower resolution. For any given combination of camera and telescope, one bin mode or another will provide the optimal compromise between exposure duration and resolution.

Figure 202 shows how binning works. Binning 2x2 groups four pixels together, giving you virtual pixels that are made up of 4 actual pixels. Binning 3x3 yields virtual pixels made up of nine actual pixels.



**Figure 202: Bin modes group pixels together for greater sensitivity, at a cost of lower resolution.**

Figure 203 shows the relative sizes of image taken with 1x1 binning (larger image) and 2x2 binning (smaller image). Both images cover exactly the same area of sky, about 1 by 1.5 degrees in this example. The 2x2-binned image shows that the binned detector is more sensitive because there is more detail visible in the dim areas of M42. It also shows that the binned pixels bloom less quickly – four pixels can hold more energy than one before they spill over into adjoining pixels.

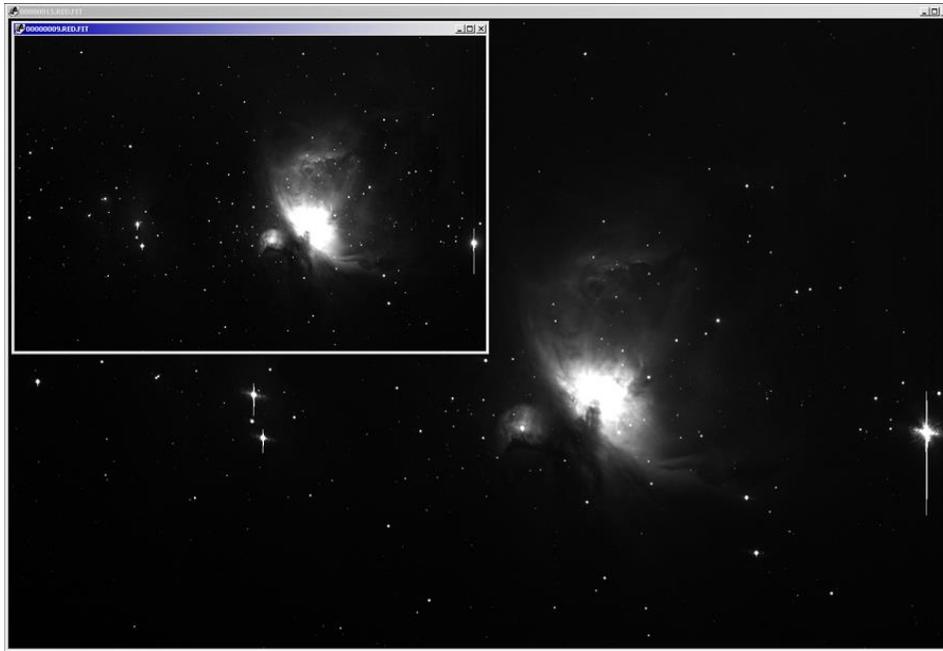


Figure 203: Relative sizes of a 1x1- and 2x2-binned image.

Generally speaking, you will most often use a bin mode that will delivers between 2 and 4 arcseconds per pixel. This is the most common range for general-purpose CCD imaging. When working in this range, each pixel in the image “sees” or covers 2 to 4 arcseconds of the sky. The seeing conditions on most nights allow approximately 2 to 4 arcseconds of detail, and that is the reason for this range of values. If you have better or worse seeing conditions, select a bin mode based on your local conditions.

High-resolution imaging provides fewer than 2 arc-seconds per pixel, and can only be done on nights when the seeing is exceptionally good. This type of imaging is used most often for planets, but can also yield very fine detail on galaxies. The key is to wait for exceptional seeing conditions that will support higher resolution.

Low-resolution imaging (more than 4 arc-seconds per pixel) allows you to image wide fields of view, and can be done with camera lenses or telescopes with very short focal lengths. Seeing is unlikely to affect low-resolution wide-field images, so you can do this kind of imaging on almost any clear night.

You can use various tools and web pages to determine arcseconds per pixel for your camera and telescope combination, or use the following formula:

$$\frac{(205 * \text{pixel\_size\_in\_microns})}{\text{telescope\_focal\_length\_in\_mm}}$$

If you are binning 2x2, be sure to double the pixel size to get the correct value. For example, if you have an ST-7E camera (9-micron pixels) and are using it unbinned on a Meade LX200 8-inch at f/10, this is:

$$\frac{(205 * 9)}{2000}$$

Or 0.93 arcseconds per pixel. That's very high resolution. Since a typical night offers 2-4 arcsecond seeing conditions, you would rarely be able to use all that resolution. Binning 2x2 yields 18-micron pixels, which gives you 1.86 arc-seconds per pixel. This is just under two arcseconds per pixel, and offers a good compromise on nights of typical seeing.

You can also approach this from another direction: using a 50% focal reducer will bring the focal length of this scope down to 1000mm, which provides 1.86 arcseconds per pixel unbinned.



- Binning also increases the sensitivity of your camera, as shown in Figure 203. Smaller pixel size means higher resolution, while larger pixel size means greater sensitivity.

When you bin 2x2, you are making the pixel size four times larger in area, so the virtual pixel is four times more sensitive to light. You are making a tradeoff between resolution and sensitivity whenever you select a bin mode for your image.

Try an experiment for yourself. Take a one-minute exposure of a galaxy using 1x1, 2x2, and (if available) 3x3. Note the differences in resolution and sensitivity.

- The range of available bin modes depends on the camera hardware. While the Camera Add On attempts to use information from the camera driver to list only the bin modes that are available for your camera, please consult the camera's documentation to determine the bin modes that your camera supports.

### **Set Frame Type to Light**

If you are just getting started, make sure that the **Frame** is set to **Light**. The Frame pop-up also includes settings for taking photo reduction frames. A CCD detector generates a certain amount of noise, and photo reduction removes a great deal of that noise. When you are taking a photo, always set the frame type to **Light**.

| <b>Frame Types</b> | <b>Description</b>  |
|--------------------|---|
| <b>Light</b>       | A normal photo, taken with the shutter open.  |
| <b>Bias</b>        | A frame of the shortest possible exposure, taken with the shutter closed. It represents the minimum noise in the CCD detector and camera circuitry. This frame is subtracted from Dark frames so that the dark frames can be scaled for time and temperature differences. |

| Frame Types       | Description  |
|-------------------|--|
| <b>Dark</b>       | A photo taken with the shutter closed. It is in effect a picture of the electronic noise in the camera. This noise can be subtracted from a Light image to create a cleaner image.   |
| <b>Flat Field</b> | A flat-field is an image taken of an evenly illuminated field, with the shutter open. Think of the flat-field as a photograph of the optical noise in the system, such as dust motes on glass surfaces or reflections off of the inside of the telescope. The <b>Flat Field</b> is applied to the Light frame to eliminate this source of noise. |

### Set an Appropriate Reduction Setting (Reduction pop-up)

When you select **Light** as the frame type, you can also choose the type of reduction to apply to the photo. Reduction is the process of applying bias, dark, and flat-field frames to your image to reduce system noise.

For your first images, choose the **AutoDark** reduction setting. After your exposure is finished, the software will automatically take a dark frame with the same exposure settings, and subtract it from the photo. This will give you a cleaner image with less thermal noise. When you gain more experience, you can explore the other reduction options:

| Dark Frame                       | Description   |
|----------------------------------|---|
| <b>None</b>                      | The software performs no photo reduction. Use this setting when you wish to manually apply your own bias, dark, and flat-field images; or when you simply want a quick image without any reduction.   |
| <b>AutoDark</b>                  | This will follow the first exposure with a single dark frame. The dark frame is saved in memory and will be applied to all subsequent exposures with the same duration and temperature. If you change the exposure duration, or the camera's cooled temperature changes several degrees, a new dark frame will be taken. For computers with more than one processor, see "AutoDark Subtract Uses All Processors" on page 447 to speed this process. |
| <b>Full Calibration</b>          | Photos are calibrated using a master frame from the selected calibration <b>Group</b> .   |
| <b>Group</b>                     | The <b>Group</b> pop-up appears when <b>Full Calibration</b> is selected from the <b>Reduction</b> pop-up and is hidden otherwise. Choose the name of the image calibration group to apply to each photo.   |
| <b>Image Calibration Library</b> | Click this button to open the <b>Image Calibration Library</b> window. The controls on this window can be used to define calibration groups and create master frames (page 550).  |

### **Acquire a Partial Frame (Subframe On checkbox)**

Turn on this checkbox to acquire a photo using only a portion of the detector, rather than the full frame. This can be useful, for example, to speed the photo download process when focusing on a star.

### **Define the Partial Frame Size (Size button)**

Click this button to show the **Subframe** window and define the position and of the subframe rectangle on the photo.

### **Subframe Window**

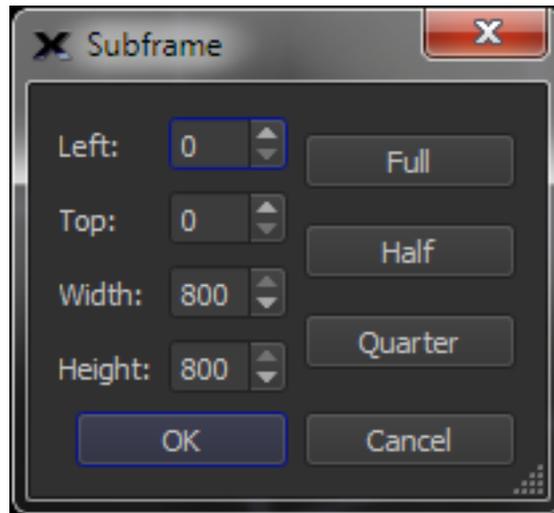


Figure 204: The Subframe window.

### **Left/Top Position**

Enter values to define the top and left position of the subframe rectangle on the photo.

### **Width/Height**

Enter values to define the width and height of the subframe rectangle on the photo.

### **Full**

Click this button to reset the dimensions of the subframe to match the size of the entire photo.

### **Half**

Click this button to define a subframe that covers the top half of the photo.

### **Quarter**

Click this button to define a subframe that covers the top, left quarter of the photo.

### **Automatically Save Photos**

Turn on the **Automatically Save Photos** checkbox to automatically save each acquired photo to the computer's hard drive.

On the **Imaging System Setup** window, highlight **Camera** in the **Hardware** list, then click the **AutoSave Setup** button to configure how photos are saved. The most common choice is to automatically save all photos. You can even save focusing photos if you so want. Photos from both the imager and autoguider can be saved automatically.

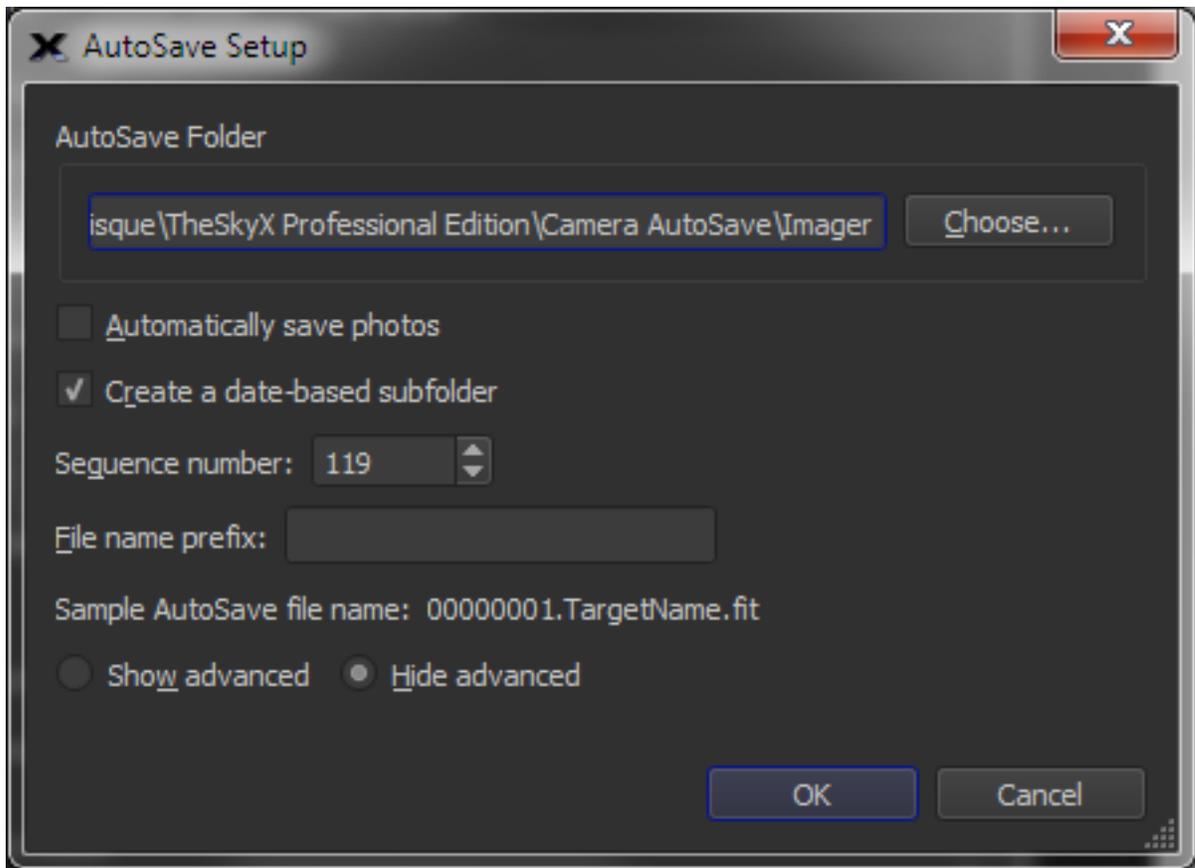


Figure 205: The AutoSave Setup window with the advanced settings hidden.

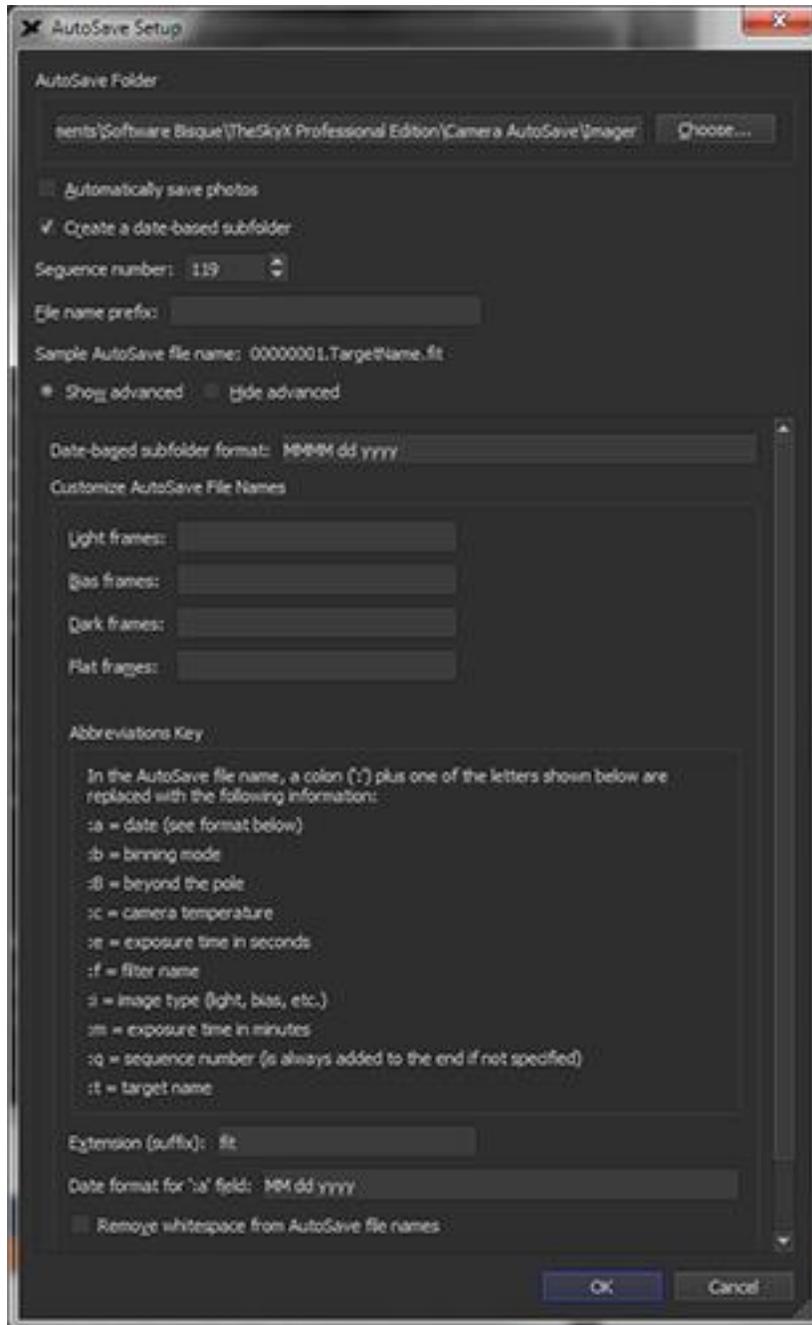


Figure 206: The AutoSave Setup window showing the advanced settings.

### **AutoSave Folder**

This text box shows the current folder where photos are saved. The default location is the AutoSave folder in the Application Support Files folder (page 26). Click the **Choose** button to select a different folder.

### **Automatically Save Photos**

Turn the checkbox on to save all photos.

### **Sequence Number**

Each time a photo is saved using AutoSave, this **Sequence Number** is incremented by 1. If you want to have a unique number for every photo, leave this value unchanged. Or, you can reset the sequence number back to 1 every observing session or every series of photos.

### **File Name Prefix**

Use this text box to define the text that will appear at the beginning of each file name.

### **Sample AutoSave File Name**

This text box shows what an automatically saved file name will look like based on the current settings.

### **Show/Hide Advanced**

File names for light, bias, dark and flat frames can be customized individually by turning on the Show Advanced radio button and defining the frame-specific file name “keys”. Each key defines specific information that is used to construct a unique file name.

### **Date-based Subfolder Format**

Autosave automatically creates a new folder for each observing session and uses the current date for the folder name. The text that appears in this text box defines the format and position of the month, day and year for the folder name.

For example, for photos created and auto-saved on January 1, 2030, the default text **MMM dd yyyy** will save files to the folder named **Jan 01 2030**. See “Date & Time Format Configuration” on page 224 for date formatting options, or hold the mouse cursor over this control to show a tool tip with this information.

### **Customize AutoSave File Names (Light, Bias, Dark, Flat Frames)**

For each frame type, enter a set of “abbreviations” to define the file name.

| <b>Abbreviation</b> | <b>Explanation</b>  |
|---------------------|---|
| :a                  | Enter the colon character followed by a lower case letter “a” to insert the date when the photo is acquired. For example, the text <b>01 31 2012</b> is inserted in the file name for photos acquired on January 31, 2012.<br><br>See “Date & Time Format Configuration” on page 224 for details how to format the date and time. |
| :b                  | Enter the colon character followed by a lower case letter “b” to insert text that defines the bin mode ( <b>1x1, 2x2, 3x3</b> ) used to acquire the photo.  |
| :B                  | Enter the colon character followed by an upper case letter “B” to insert text that defines the orientation of a German equatorial mount when the photo is acquired.   |

| Abbreviation | Explanation   |
|--------------|---|
|              | <p>The “beyond the pole” (Btp) convention is used to define the position of the optical tube assembly end of the declination axis with respect to the celestial pole.</p> <p><b>NoBtp:</b> The mount’s current orientation is not beyond the pole.<br/> <b>Btp:</b> The mount’s orientation is beyond the pole.</p> |
| :c           | Enter the colon character followed by a lower case letter “c” to insert the current temperature sensor. For example, <b>-5.02C</b> .  |
| :e           | Enter the colon character followed by a lower case letter “e” to insert the exposure time, in seconds. For example, <b>61.05secs</b> .  |
| :f           | Enter the colon character followed by a lower case letter “f” to insert the filter name used to acquire the photo. For example, <b>Green</b> .  |
| :i           | Enter the colon character followed by a lower case letter “i” to insert frame type. For example, <b>Light</b> .   |
|              | <p>Options:</p> <ul style="list-style-type: none"> <li>Light</li> <li>Bias</li> <li>Dark</li> <li>Flat</li> </ul>   |
| :m           | Enter the colon character followed by a lower case letter “m” to insert the exposure time, in minutes. For example, <b>1.02mins</b> .   |
| :q           | Enter the colon character followed by a lower case letter “q” to insert the current sequence number in the file name.   |
|              | <p>Note that a sequence number is <i>always included in AutoSave file name</i>. If no <b>:q</b> appears in the custom name, the sequence number appears at the end of file name, before the file name suffix. Otherwise, add a <b>:q</b> at the desired position of the sequence number.</p>                        |
| :t           | Enter the colon character followed by a lower case letter “t” to insert the name of the target object. For example, <b>Andromeda Galaxy</b> .   |

### **Extension (suffix)**

Enter an extension for the AutoSave file name that appears after the period character in the file name. By default, the three-letter extension **fit** is used when automatically saving Flexible Image Transport files.

### ***Small Mount Adjustments via Camera Relays, DirectGuide, or PulseGuide***

Click the **+X/+Y/-X/-Y** buttons to make small adjustments to the mount's position using the current autoguide method.

- **Camera Relays:** the camera's guider relays are activated which pulls to ground the appropriate lead(s) through a guider cable to the mount's guider port to move the telescope.
- **Direct Guide:** the mount's position is adjusted directly through the mount's control system (Paramount and Bisque TCS-controlled mounts, only).
- **PulseGuide:** the telescope is move by sending "small" telescope move commands directly to the telescope's control system (non-Paramount mounts).

### ***Digitized Sky Survey Photos (Simulate Photo Using DSS)***

Turn on the **Simulate Photo Using DSS** checkbox to take photos of Digitized Sky Survey objects, instead of collecting "actual" photons with the camera's detector and a telescope. See "Creating a FITS File of a Digitized Sky Survey Photo" on page 106 for more information about configuring *TheSkyX Pro* to retrieve photos from the Digitized Sky Survey.

You can control *where* in the sky the simulated camera is pointing by selecting a new target in the **Find** window (page 70), or connecting to a simulated (or actual) telescope, and then slewing the telescope to the target (page 381)

## **Taking a Photo**

To take a photo, click the **Camera** tab, enter the **Exposure Length, Binning** and click **Take Photo** button.

When the photo is ready, it is displayed in the **FITS Image Viewer** window (page 107).



## Autoguiding

The *Camera Add On* incorporates many powerful features for autoguiding using CCD, DSLR or video camera.

This chapter describes how to use the *Camera Add On* to autoguide using a camera with dual CCDs from SBIG (essentially two cameras in one, where autoguiding is called Self-Guiding) or autoguide using two independent cameras, one for imaging and one for autoguiding. We typically refer to the imaging camera or "main camera", the one that is capturing the resultant autoguided photo, as the "Imager" and the autoguiding camera as the Autoguider.

Here you will learn how to:

- Determine how well your mount can autoguide.
- How to fine-tune your mount for autoguiding.
- How to use the autoguiding features in the *Camera Add On* effectively.
- How to customize the autoguiding settings to meet your needs.

### Quick Start for Experienced Users

For this chapter, an experienced user is someone who is familiar with autoguiding a mount through software.

One important feature in the ***Camera Add On*** is the ability to continue autoguiding even after downloading an image. This allows you to take multiple, autoguided photos without restarting autoguiding. The autoguiding process runs independently of the imaging process. In fact, if you have a physically separate, independent autoguider, autoguiding is continuous (with an SBIG dual CCD the imager and autoguider share the same shutter so autoguiding is briefly paused while the imager is downloaded).

Another key feature: since the *TheSkyX Professional Edition* with the *Camera Add On* includes a complete framework for star charting and telescope control, the *Camera Add On* offers unsurpassed camera, guider, focuser, filter wheel, rotator, and mount integration.

Before you can autoguide, you must first *calibrate the autoguider*. Open the **Autoguider** tab (click **Display > Autoguider** if the window is not visible), and follow these steps:

#### **Autoguider Calibration**

1. From the **Autoguide** tab on the **Autoguider** window, click **Connect**.
2. Click **Take Photo** and use the mount's motion controls, or the camera's relay buttons, to position a bright calibration star on the autoguider photo, and not near an edge of the photo. For best results, the star should not be saturated and there should not be any stars of similar brightness on the photo so that the bright calibration star can be easily recognized.

3. Click **Calibrate**. While the calibration is in progress, the autoguider photo shows arrows on the photo to indicate the direction the calibration star moves as each relay is activated (that is, when the mount is moved). If calibration fails due to insufficient guide star movement, click **Settings** and increase the **X** and **Y** calibration times and or check the relay cable from the camera to the mount to make sure it is functioning properly.
4. When calibration is complete, the results are displayed (you can view the results any time by clicking **Setup** and going to the **Relay Calibration Results** tab).

### **Autoguiding**

From the **Autoguide** tab for the Autoguider:

1. With no sub-frame and **1x1** binning, click **Take Photo**. Adjust exposure time so that one or more guide stars are visible. See “Choosing a Good Autoguider Calibration Star” on page 476 for details.
2. Double click on the guide star. A *track box* is centered on the guide star and momentarily flashes to identify the guide star selection. You can also choose the guide star by clicking the **Auto Find Guide Star** button to scan the entire image for the brightest light source and place the track box on it.
3. Click **Take Photo** to confirm the brightness, location and presence of the guide star.
4. Click **Autoguide** to start the autoguiding process. Watch the **X** and **Y** errors; when they “settle down” and are at acceptable levels, from the **Camera** tab, click **Take Photo** to begin acquiring your “guided” photo.

### **Principles of Autoguiding**

The fundamental idea behind autoguiding is simple: For successive photos, the *Camera Add On* measures the exact position (the star’s *centroid*) of the guide star. If the star’s position deviates from one exposure to the next, the *Camera Add On* adjusts the telescope to keep the guide star at its original position. This process minimizes mount tracking errors that cause elongated stars.

The *Camera Add On* can control *two independent cameras* (one for autoguiding and the other for imaging), or an SBIG dual CCD that contains both an imaging CCD and an autoguiding CCD.

You can also configure the *Camera Add On* to use *either detector* as the imager or the autoguider. This means that every feature available to the imaging camera is also available to the autoguiding camera, and vice versa. To use this advanced capability, turn on the **Advanced Camera User Interface (Restart Required)** checkbox from the **Advanced** pane of the **Preferences** window (The **Preferences** command is accessed from **TheSkyX** menu on the Mac, the **Tools** menu on Windows).

When this checkbox is turned on and, after *TheSkyX Professional Edition* is restarted, the **Camera** window has both a **Take Photo** tab and an **Autoguide** tab. Similarly, the **Autoguider** window has both a **Take Image** tab and an **Autoguide** tab. To minimize confusion, this option is off by default. Just remember, the **Camera** and the **Autoguider** can both image and autoguide and you are free to choose which configuration option best suits your needs.

The basic steps to autoguide are:

1. Calibrate your autoguider (The *Camera Add On* determines how the mount reacts to guider corrections).
2. Choose a guide star.
3. Autoguide; that is, continually adjust the position of the mount so the guide star remains at a fixed position.

Unwanted motion of the guide star typically results from three sources:

- Poor polar alignment, which causes a slow drift of the field.
- Periodic error in the mount's mechanics, which causes star images to elongate as the mount speeds up and slows down by very small amounts during rotation of the worm gear.
- Systematic errors due to flexure, variations in gears, etc. (Paramount owners should turn on ProTrack so the autoguider has less to do).

Various complexities creep into the seemingly simple autoguiding operation (that is, slewing the telescope to a star and guiding on a star over a long period):

- The required pointing accuracy is very high, usually on the order of several arcseconds. Since one arcsecond equates to one part in 1,296,000, the magnitude of pointing accuracy isn't just high; it's extraordinarily high.
- The longer the focal length of your telescope, the greater the accuracy required for accurate, successful guiding.
- Mounts have some degree of repeating error, called periodic error. Some mounts have built in periodic error correction (PEC); some do not. Autoguiding can correct most tracking errors related to periodic error.
- If the mount is even slightly misaligned from the celestial pole, telescope drift over time is introduced and will cause tracking errors. The greater the misalignment, the greater the drift. Good polar alignment makes autoguiding easier.
- Any mechanical "looseness" in the mount can contribute to pointing error (hysteresis). There are many potential sources of hysteresis, including backlash (slop) in the gears, mirror flop, and endplay of a worm gear. Some hysteresis can create counterintuitive movements, such as a movement in declination causing a movement in right ascension. You can diagnose these types of problems by using a high-power reticle eyepiece to observe what happens during tracking and guiding.
- The tripod, mount, and the optical tube assembly are subject to different amounts of flexure as the weight of the telescope moves over time. This can contribute to guiding errors and to pointing errors as well.
- If all of the parts of the mount aren't exactly aligned with each other, pointing error is the result. For best results, you want your telescope orthogonal to the mount, especially when polar aligning. (The optional *TPoint Add On* to *TheSkyX* can be used to automatically correct these errors.)
- Turbulence in the atmosphere (seeing) can change the apparent position of the star used for reference in a random manner over time. This makes it look as if a guiding correction is

needed even when it is not, or depending on timing, it could also mask the need for guiding corrections. The worse the seeing, the harder it is to guide accurately. Longer guide exposures can compensate for poor seeing, to some degree.

In short, keeping a telescope pointing at an object over the length of time involved in an extended exposure is not a trivial task. Any given mount will have a certain level of accuracy that it can reach. Pushing a mount past this point will result in guiding and tracking errors that will at the very least reduce the quality and sharpness of your images, and at worst turn stars from round circles into ellipses or worst case lines. If you find that your mount simply cannot track or guide accurately enough for your equipment, try shortening your focal length with a focal reducer, or switch to a telescope with a shorter focal length.

## **Assessing Mount Accuracy**

A mount has two axes, and most mounts can guide by adjusting both axes. However, the right ascension and declination axes behave in fundamentally different ways.

The right ascension axis is always moving to keep up with the apparent motion of the stars. This rate of motion is called the sidereal rate, and is very nearly one revolution per day. You will often see reference to some fraction of the sidereal rate, such as 1x (exact sidereal rate), 0.5x (one-half sidereal rate), etc.

Because the right ascension axis is always moving, you have an opportunity to eliminate many (but not all) sources of error by simply making guiding corrections at speeds slower than the sidereal rate. For example, it is common to make right ascension adjustments using either 0.5x sidereal (slow the mount down to half speed to move it further east), or 1.5x sidereal rate (speed the mount up to 150% of sidereal rate to move it further west). Depending on the focal length of your telescope, you may get better results at 0.75x/1.25x (shorter focal lengths), or at 0.25x/1.75x (longer focal lengths).

The declination axis, on the other hand, is stationary until a correction needs to be made. If there is substantial looseness in the declination axis at any point (motor bearings, reduction gears, worm endplay, or worm mesh with the worm gear), the mount may literally be unable to guide adequately in declination.

The result of these differences is that special attention must be paid to the state of the declination axis components to obtain high-quality guiding results. See “Assessing Autoguiding Possibilities,” for detailed information about getting the best autoguiding results out of your mount.

## **Autoguider Calibration**

Once your mount is tuned to minimize backlash and/or correct any other problems, you can use it for autoguiding. See the section “Adjusting and Tuning Your Mount” for details on getting the most out of your mount.

Autoguiding makes small corrections to keep a guide star at a given location on a CCD. This corrects for small errors in polar alignment; for periodic error that results from slight eccentricity in the worm or worm gear; and other errors that result from a mount and system that is simply not perfect. The pixel size of your CCD, the focal length of your telescope, and the length of your guide exposures all affect the rate and amount of movement during an autoguiding correction.

The autoguide correction speed also changes with declination. At the celestial equator, correction speed is highest because the lines of equal right ascension are furthest apart. Near the poles, the effective correction speed is slower because the lines of equal right ascension are closer together. The autoguider calibration takes care of this.

Before you can autoguide, you need to perform an autoguider calibration. Calibration allows *Camera Add On* to determine your system's behavior during autoguiding corrections. The *Camera Add On* uses the calibration data to determine how long to move the mount (at whatever guide speed you are using) to make an appropriate autoguider correction. You can perform a single calibration, and *Camera Add On* will adjust the corrections for other declinations. If you choose this method, you should perform the initial calibration near the celestial equator so that the scaling will be most accurate. You can also perform a new calibration whenever you move the telescope to a new declination to achieve the highest level of autoguiding accuracy. The longer your focal length, the more you must gain from performing new calibrations when you change declination.

The basic steps in calibrating the autoguider:

1. Connect the hardware to autoguide. This is typically accomplished by connecting a guider cable from the camera to the mount. Paramount users can configure the *Camera Add On* to autoguide using DirectGuide, which eliminates the need for a guider cable.
2. Move the telescope so that a suitably bright star falls on the autoguider detector.
3. Take a reference image to verify the presence, location, and brightness of the calibration star.
4. Perform the calibration.

How often should you perform a calibration? Calibration frequency depends on your imaging session and your equipment.

If you have a GEM, and “flip” the mount to point on the other side of the meridian, the direction of correction for the x relay changes direction. When *TheSkyX Professional Edition* is controlling the telescope, the *Camera Add On* automatically detects the meridian flip and reverses relay direction.

If you are using the *Camera Add On* to autoguide, and the telescope is not controlled by *TheSkyX Professional Edition*, the **Reverse X** checkbox on the **Autoguide** tab reverses X corrections, and you can manually turn this checkbox on when the mount is on the opposite side of the meridian. But remember, (especially with longer focal lengths), you can always recalibrate the autoguider. The longer your focal length, the greater the sensitivity to changes, and the more likely you are to need to recalibrate whenever you autoguide at a new location.

To calibrate the autoguider, from the **Autoguider** tab, click the **Autoguide** tab. For an overview of all of the controls on the **Autoguide** tab, see “Autoguide Tab” on page 491.

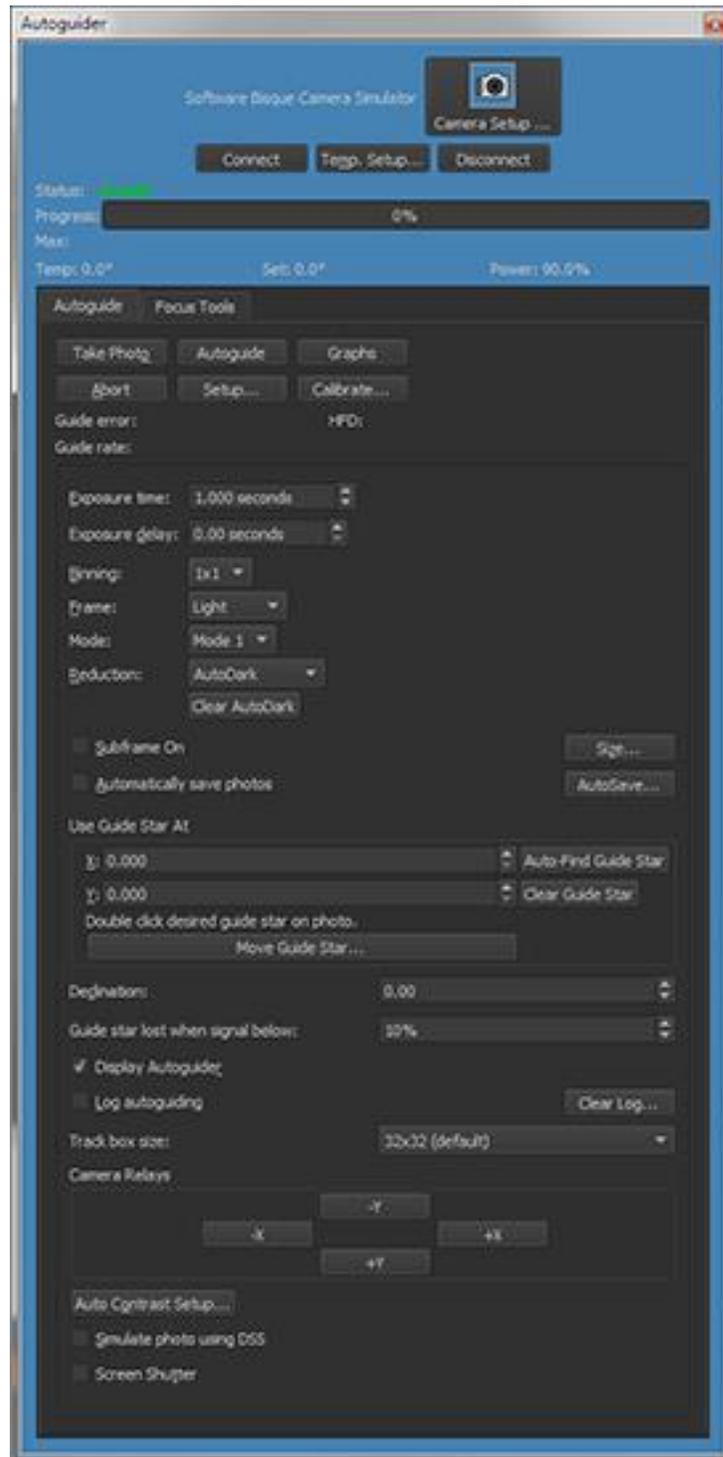


Figure 207: The Autoguider window.

**Make sure the hardware is connected**

To autoguide, you need either a camera that will be dedicated to autoguiding, such as a video camera, SBIG ST-i, or an SBIG dual CCD camera that has its own built-in autoguiding detector.

Consult the camera documentation for instructions on how to connect the autoguider cable to the camera. The other end of the autoguide cable attaches to your mount; consult your mount documentation for the location of the autoguider connection.

Not all mounts support input from an autoguider. Contact the mount manufacturer for information on how to build an interface box or cable to fit such a mount. Most cameras come with a standard autoguider cable. If the standard cable doesn't fit your mount (such as for a Takahashi mount, or a Vixen Sky Sensor-equipped mount), consult the mount documentation for information about building or buying a suitable cable. Some mounts require the use of third-party relay hardware to provide appropriate guide signals; read your camera and/or mount documentation for details.

### ***Choosing a Good Autoguider Calibration Star***

When calibrating the autoguider, selecting an appropriate calibration star is important. As you will see shortly in the list of possible errors, the brightness and location of the star used for autoguider calibration plays a major role in the success or failure of the calibration. Here are some tips in picking a good autoguider calibration star.

- Don't use a dim, hardly recognizable, calibration star.
  - The calibration star should be bright enough to show clearly against the background. Typically this is achieved if you can visually and easily identify the star on the autoguider photo using the *Camera Add On's* standard auto-contrast routines. In other words, do not try to calibrate the autoguider using a dim, hardly recognizable star. You can run the cursor over the star and the background to see how bright they are; the brightness values appear at the left of the status bar at the bottom left of the photo window. The longer the exposure, the brighter the stars and background, but star brightness will increase faster than background brightness. If you can't find a suitable calibration star for a given exposure, increase the exposure time to see if any good candidates emerge.
- Don't use a saturated calibration star.
  - The calibration stars brightness should not be close to the camera's saturation level. The calibration star brightness will indeed vary and you want make sure it does saturate because saturation can lead to an incorrect star position and thus leading to an incorrect autoguider calibration.
- Don't use a calibration star close to the edge of the CCD.
  - The calibration star should not be near any edge of the autoguider CCD. This is critical when calibrating, since the *Camera Add On* will move the mount during autoguider calibration and you don't want the calibration star to move off the detector. If the calibration star moves within 10 pixels of an edge, calibration will fail with an error stating so. You can use the camera relay buttons, the telescope's motion controls, or the mount's hand controller to move the calibration star more toward the center of the photo.
- During autoguide calibration, the *Camera Add On* finds the autoguide calibration star after each calibration relay adjustment (that moves the mount) by scanning the photo for the brightest light source. Because the *Camera Add On* can autoguide with the camera at any

orientation, the *Camera Add On* does not make any assumptions about which way the calibration star will move with respect to relay activations and instead relies on the convention that the brightest light source on the autoguider photo during autoguide calibration is the calibration star. It is critical that during autoguide calibration the calibration star is significantly brighter than all other stars on the image otherwise the *Camera Add On* might incorrectly choose a different calibration star of similar brightness on a subsequent photo.

- Sometimes an unintended bright star will enter the photo after relay activation and usually results in the calibration error "invalid motion". In this case, pick a different autoguide calibration star in a different area. No other star in the tracking detector's image should be close to the brightness level of the calibration star when calibrating. Otherwise, the *Camera Add On* can get confused about which star is the calibration star. You can use the *Camera Add On* to visually inspect the area around your selected guide star. Check for a distance equal to the 1.5 times the width of the area covered by the autoguiding CCD detector at a minimum. See the section "Select a Guide Star," in this chapter, which can help you select a guide star.
- Accurate focus is required to accurate autoguider calibration. See "Using @Focus2" on page 572 for a reliable, automated focus method.
- Make sure the camera is cooled to the desired temperature setpoint to minimize noise/hot pixels.
- Turn on **AutoDarks** so that calibration images do not have as much noise or hot pixels.
- Do not use a long calibration time. The shortest calibration time that results in a successful calibration without a "Motion too small" error is optimal. There is not a lot to gain by having an unnecessarily long calibration time and there are in fact disadvantages; the whole calibration takes longer and the chances of the calibration star moving off the photo increase.



If you find that calibration repeatedly fails because the *Camera Add On* finds a different calibration star from photo to photo, use the a subframe to capture less of the photo and aid the *Camera Add On* in finding the same bright, calibration star in photo to photo.

In other words, the subframe applies during autoguide calibration and you can use that to your advantage (and perhaps avoid a say pesky hot pixel in a certain region of the CCD). Avoid making the subframe too small or the calibration might move the guide star off the photo.

### **Choosing a Good Guide Star**

- The *Camera Add On* is able to autoguide with either a dim guide star that is only a few counts above the background, which can be challenging, or a guide star that is bright and easily recognizable to the eye, which is less challenging. Generally speaking, autoguiding will do fine if the guide star is, say, 1,000 or more counts brighter than the background (more if you are doing tricolor imaging, since color filters will reduce the star's brightness, and the brightness of the star will often vary with the filter used).
- If your image composition makes it impossible to put the guide star near the center for autoguiding, you can still get good results as long as the star is at least 10 pixels from an edge.

However, you increase the risk of losing the guide star during downloads from the Imager. The *Camera Add On* will automatically reacquire the guide star after Imager download, but cannot do this if the guide star has moved off the detector. The greater the periodic and random errors of your mount, or the poorer the polar alignment, the greater the chances of losing the guide star during Imager download.

- When autoguiding, a star of similar brightness should not be within the autoguider track box, or the *Camera Add On* may jump between the two stars during autoguiding.

### **Take a Photo as a Reference**

Typical autoguide exposures range from 1 to 10 seconds. Shorter and longer exposures can be used, but are not often necessary. Guide exposures shorter than 1-2 seconds can be affected by seeing. When the guide exposure is very short, the autoguiding often winds up measuring and correcting for fluctuations in the atmosphere rather than actual guide star movement that needs to be corrected. If the autoguide exposure time is too long, the guide star could move so much that corrections are not being made when they should be, resulting in an undesirable final image with elongated stars.

The *Camera Add On* automatically accounts for autoguiding at a declination different from where the autoguider was calibrated, provided *TheSkyX Professional Edition* is controlling the mount during autoguider calibration and during autoguiding. If no mount is connected, you must manually enter the declination that the telescope is pointing to in the box labeled **Declination**. An accuracy of one-tenth degree is sufficient if you enter this value manually.

The image you take as a reference image should be long enough to clearly acquire a star suitable for guiding. If you are unsure, start with an exposure of 1 to 10 seconds. You can always adjust the exposure length as needed.

Click **Take Photo** on the **Autoguide** tab to acquire an autoguider photo. Figure 208 shows the result for the guide detector on an SBIG ST-2000 camera. The guide detector is much smaller than the imaging detector, so download times are short. By default, a dark frame is automatically taken and subtracted from the light frame (reduction is set to **AutoDark**).

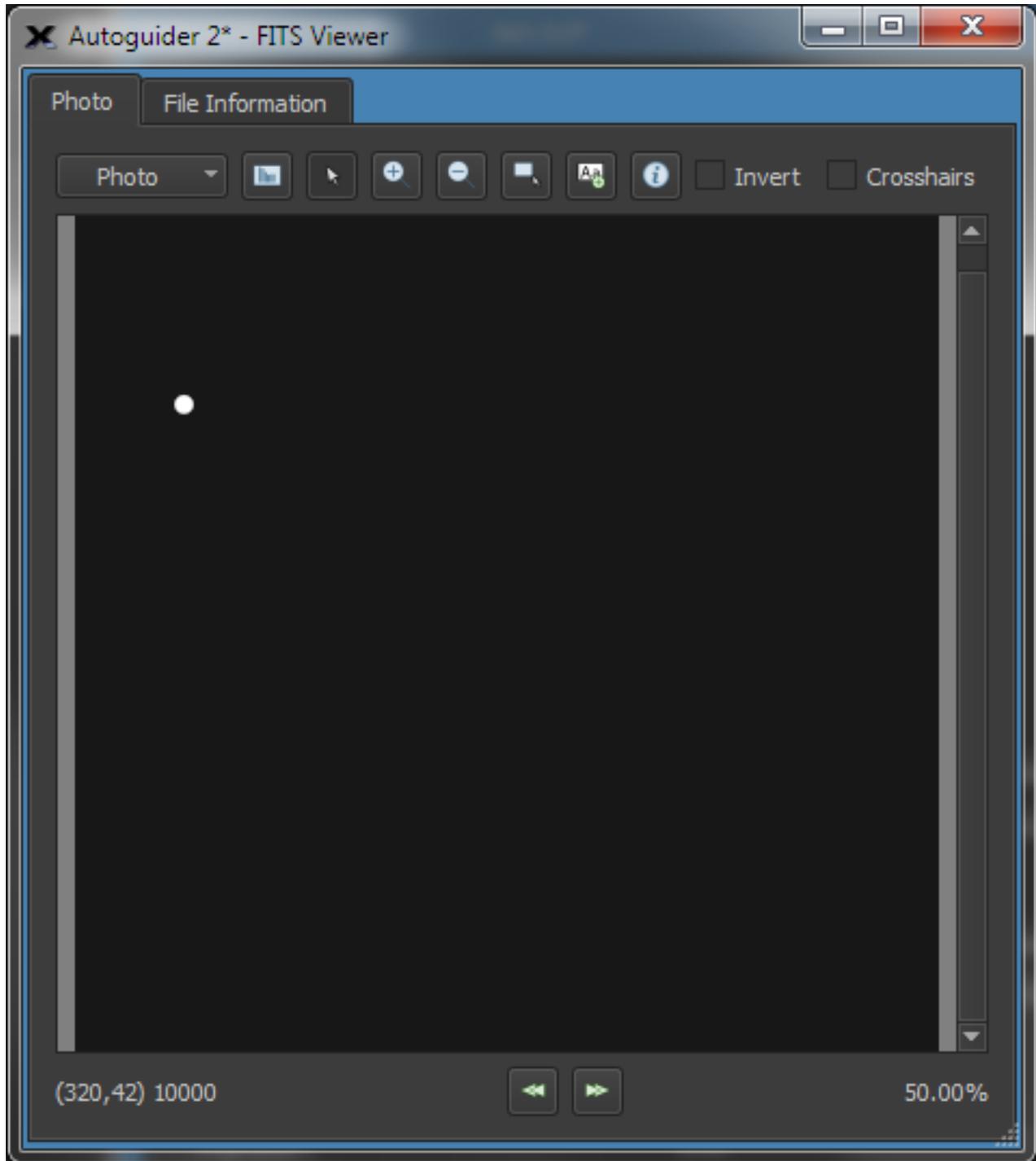


Figure 208: An autoguide image taken for reference. Note the isolated, bright star makes a good choice for a guide star.

Evaluate the image to determine if the exposure time provides a suitable brightness level for the guide star. As mentioned earlier, a good guide is at least 1,000 units over background level, and not near saturation.

### **Select a Guide Star**

You can either click **Auto Find Guide Star** on the **Autoguide** tab to have the *Camera Add On* pick the brightest star for the guide star, or you can double click any desired guide star on the photo.

A white track box flashes briefly around the star to indicate that it has been selected as the guide star. Also, the coordinates of the selected guider star appear in the **X** and **Y** boxes of the **Use Guide Star At** control.

The *Camera Add On* can display the precise coverage of your CCD detector on the sky display (ST-237 and similar cameras) or both the imaging and tracking CCD detectors (ST-7/8/9/10) on the map of the sky. Figure 209 shows the projection for an ST-8E camera. The inner rectangle is the imaging detector; the small rectangle above it is the tracking detector. The circles show the position of the tracking detector if you rotate the camera. These circles can help you find an alternate guide star just by rotating the camera, instead of moving the mount. The *Camera Add On* does not require that the camera be orthogonal (square) to the mount in order to autoguide. It will calibrate and guide successfully at any camera angle.

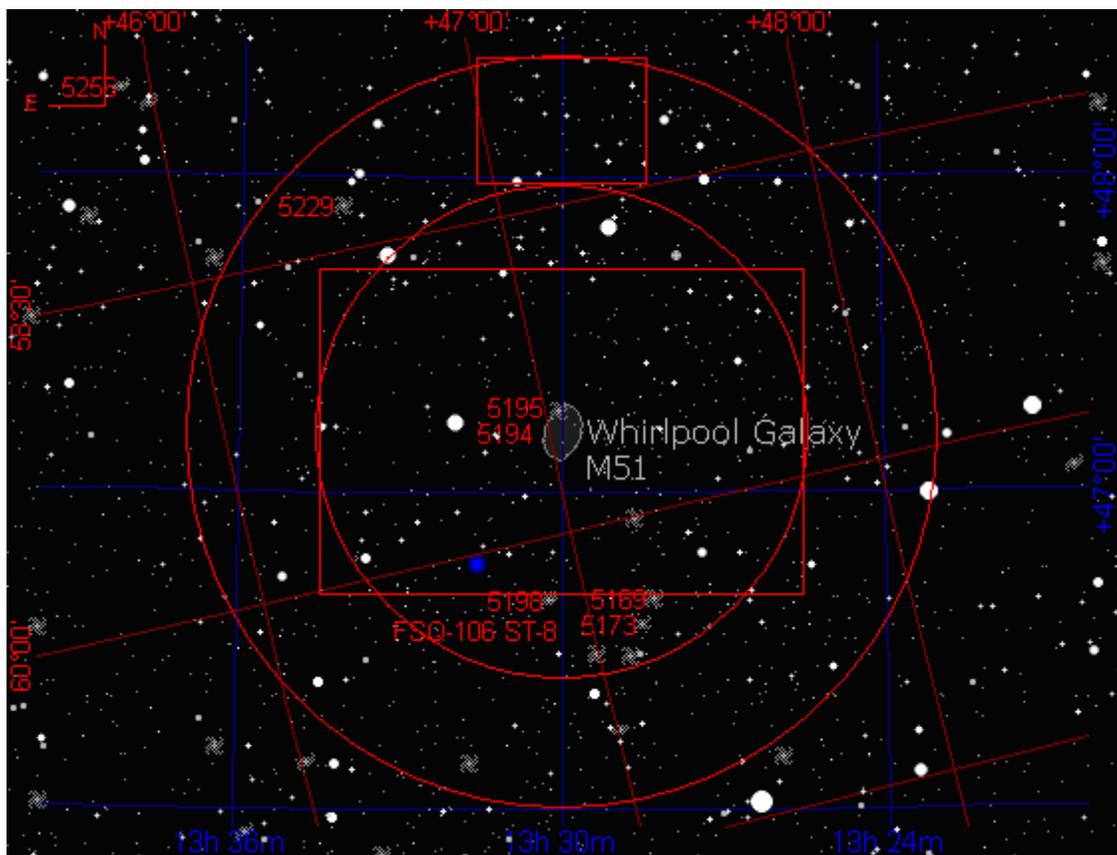


Figure 209: The imager and autoguider detectors of an ST-8E with an ST-237 guider camera.

To set up your camera's field of view indicator, follow these steps in *TheSkyX Professional Edition*:

1. Click **Display > Field of View Indicators**.
2. Choose your telescope and detector and click **Create My FOVIs**.
3. Click the **My FOVIs** tab, turn on the checkbox next to your FOVI and click **Center**.

The field of view indicator will only appear when magnifications on the start chart are large enough to see it. Zoom in if necessary to see the field of view indicator (page 119).

In Figure 210, the pair of interacting galaxies known as Messier 51 (M51) is centered on the imaging detector, and celestial north is straight up on the Sky Chart. The box at the top shows that there are a few dim stars on the tracking detector, but none is very bright, and none are near the center. The two galaxies form a nearly vertical line with each other, and several dimmer galaxies are also in the frame. You could try to guide using the star at the eight o'clock position on the tracking detector, but for calibration you should move the mount to bring a brighter star onto the tracking detector.

A brighter guide star allows you to use a shorter guide exposure time. If your mount is very stable and accurate, you can use longer guide exposure times and therefore dimmer guide stars are suitable. If your mount has poor polar alignment, larger periodic error, or suffers from random movements during tracking, brighter guide stars are more important to a nicely autoguided Imager photo.

Figure 211 shows one approach to finding a nice, bright guide star: move the mount so that a bright star falls on the guide detector, while M51 remains in the same orientation. M51 has been moved away from the center of the imaging detector. If you want M51 near the center, you can also rotate the camera to bring a guide star onto the guide detector. If your mount has goto features, you can control it from *TheSkyX Professional Edition*. Changing the camera's rotation requires a trip out to the telescope, unless the *Camera Add On* is connected to the rotator.

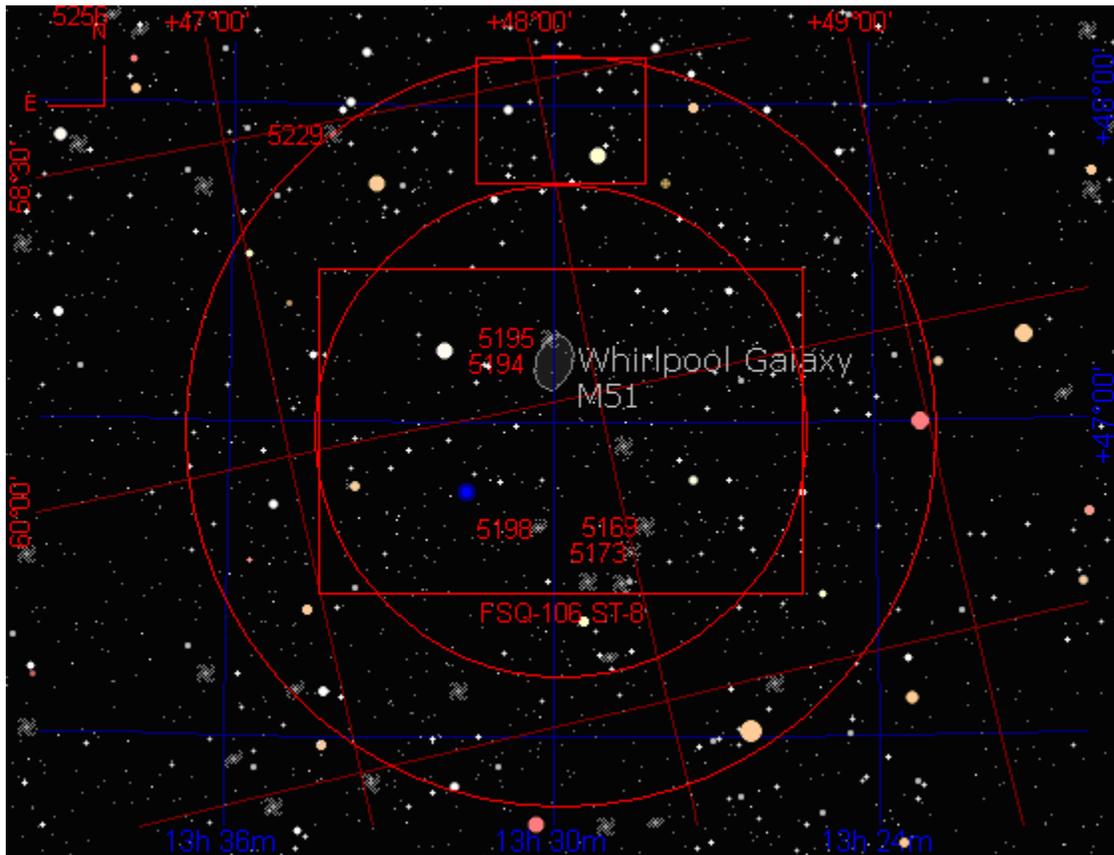


Figure 210: Placing a guide star on the autoguider.

If you were performing a calibration, the bright star in Figure 211 is clearly brighter than others in this field. It is an ideal star for calibration. For this star, use short exposure time; this also will speed up the calibration process. In general, you should expect to move your mount away from the object you intend to image to do a calibration, because putting a bright calibration star near the center of the detector is important to successful autoguider calibration. With the *Camera Add On* available to position the mount, you can move, calibrate, and return to your object very quickly.

If you want to keep M51 at or near the center for taking the actual image, rotating the camera to bring a guide star onto the tracking detector works well. Figure 211 shows that a rotation that puts north at about eight o'clock puts a reasonably bright star on the tracking CCD detector. You can experiment with *TheSkyX Professional Edition* to find the right rotation angle, and then physically adjust the camera to the new orientation. Since the *Camera Add On* can guide accurately at any orientation, even 45 degrees away from orthogonal, you have complete flexibility in framing your images. If the *Camera Add On* is connected to a camera rotator, your FOVI can be linked to the rotator (page 609) so that when you rotate the FOVI on screen, the rotator hardware follows.

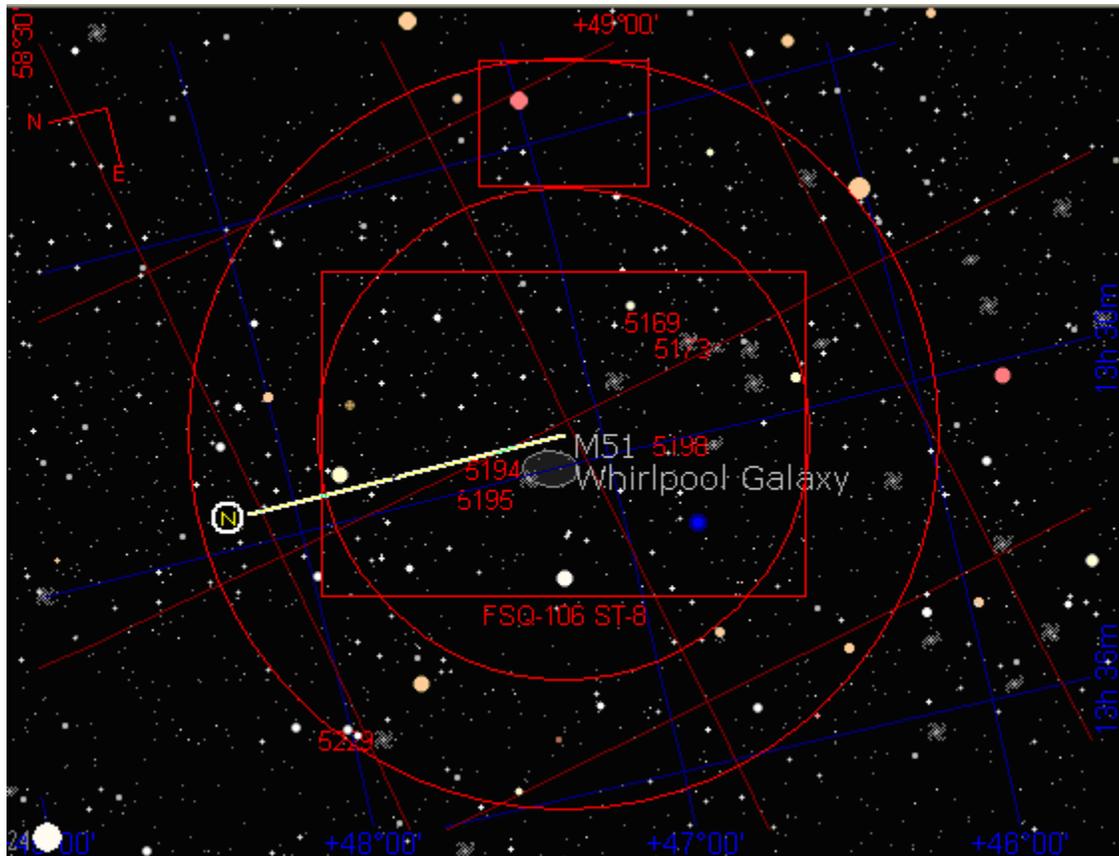


Figure 211: Rotating the view to look for a suitable guide star.

### **Adjust Calibration Settings**

During calibration, the *Camera Add On* will move the mount for a period of time, then take another image and determine the motion of the calibration star (that is, how far the mount has

moved). Each photo is displayed along with graphical arrows indicating how the calibration star moved so that you can follow along. These images and arrows (resultant calibration vectors) are a useful for diagnosing common problems that occurs during calibration.

The software measures the amount of movement of the calibration star from one photo to the next. The exact sequence is as follows:

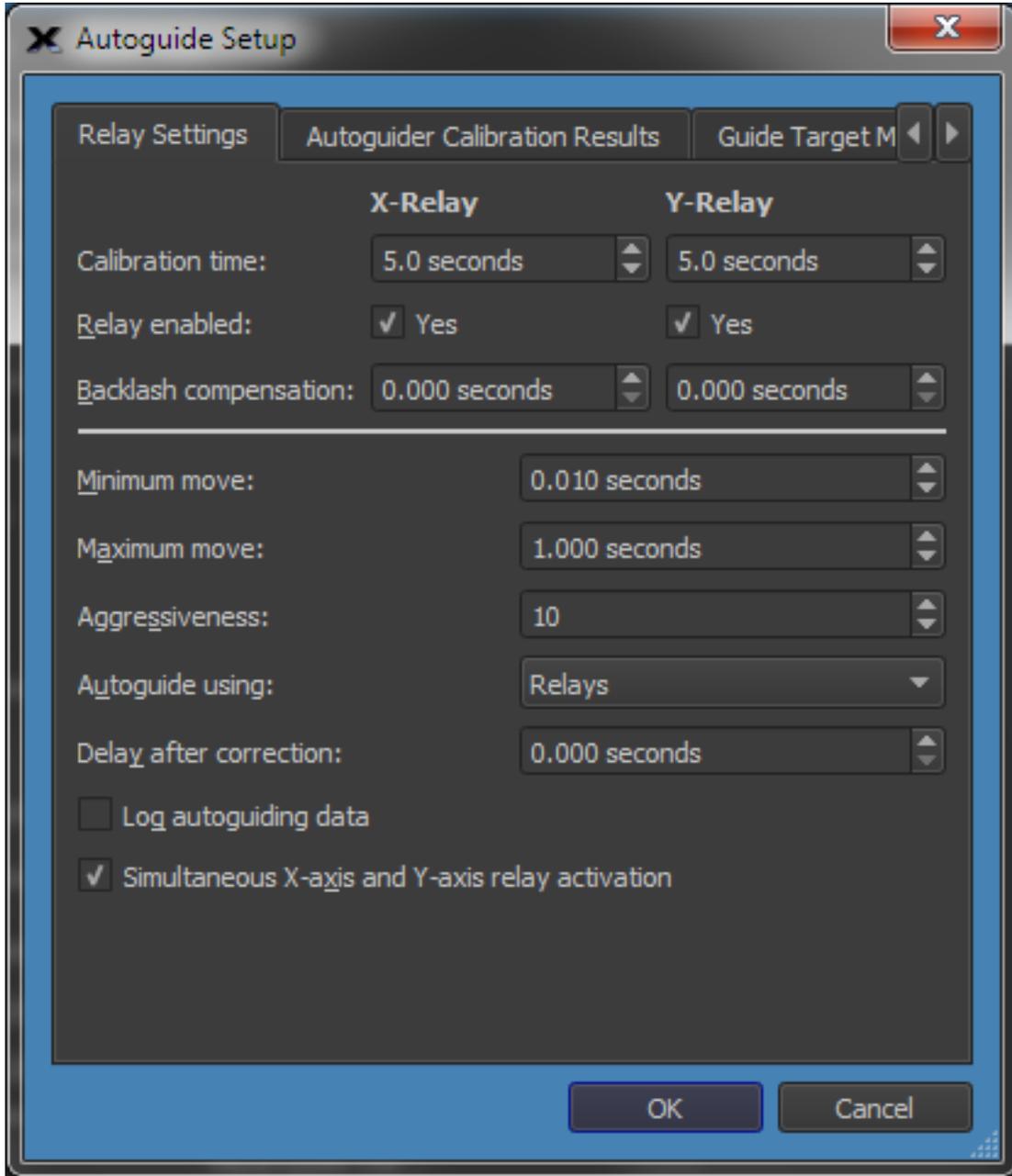
1. Take an initial reference photo.
2. Active the +X relay, take a photo, measure calibration star movement.
3. Active the -X relay, take a photo, measure calibration star movement.
4. Active the +Y relay, take a photo, measure calibration star movement.
5. Active the -Y relay, take a photo, measure calibration star movement.

An ideal mount and imaging system concludes this sequence with the guide star in the exact same position as at the start of the calibration procedure. In most cases, there will be at least a small difference in starting and ending position due to whatever errors accumulated while the mount moved in all four possible directions.

It is intuitive to relate relay activation to calibration star motion when the camera is aligned square to the mount's right ascension and declination axis. For example, when the camera is aligned square to the mount's right ascension and declination axes, X relay activation corresponds to calibration star motion changing in X pixels on the resultant photo and Y relay activation corresponds to calibration star motion changing in Y pixels on the resultant photo. In contrast, if the camera is rotated so that it is not "square" with the right ascension and declination axis, activating, say, the X relay, will produce calibration star motion in both X and Y pixels on the resultant photo. The *Camera Add On* can cope with a completely non-square camera position. This gives a great deal of flexibility in selecting a guide star.

To set the time interval for calibration, as well as other related settings, click **Setup** on the **Autoguide** tab. See Figure 212 for the default appearance of the **Autoguide Settings** window. The calibration time is the length of time in seconds that each relay is activated during the autoguide calibration process.

**Relay Settings Tab**



**Figure 212: The Relay Settings tab on the Autoguide Setup window.**

The calibration time you enter depends on, primarily, the focal length of your telescope, the pixel size of your camera and the bin mode. If the camera is reasonably well matched to the telescope (a camera with anywhere from 1 to 4 arcseconds per pixel), the values shown in the following table are useful starting values for calibration time.

| Focal length (mm)                 | Suggested calibration time (seconds) |
|-----------------------------------|--------------------------------------|
| 100-300 (typically a camera lens) | 15                                   |
| 300-500                           | 10                                   |

| Focal length (mm) | Suggested calibration time (seconds) |
|-------------------|--------------------------------------|
| 500-1000          | 5                                    |
| 1000-2000         | 5                                    |
| 2000-3000         | 3                                    |

Here are the remaining autoguide setup parameters on the **Relay Settings** tab:

### **Relay Enabled**

Determines whether autoguiding corrections are applied to the indicated axis. For example, if the mount's polar alignment is exceptional and exposure duration is under about one hour, you can turn off corrections to the declination axis to avoid spurious corrections that result from atmospheric turbulence. In addition, if you are creating a tracking log to determine your mount's periodic error, you will want to disable both axes.

### **Backlash compensation**

Backlash exists when the motors on the mount must turn for some period after a change of direction before the gears fully engage and move the mount. Backlash compensation is the time that the *Camera Add On* should turn the motors to take up backlash when the direction reverses. Since guide speeds in right ascension are typically less than sidereal rate (0.5x is commonly used), no reversal occurs, and you should not set a backlash compensation time for right ascension backlash compensation unless you are using a mount autoguide speed of 1x sidereal or faster. You should always slightly under compensate for backlash; over compensation leads to over correction and can make autoguiding impossible.

### **Minimum move**

This specifies the minimum autoguiding correction that the *Camera Add On* will make. If the autoguide correction is less than this amount, no autoguiding correction occurs. When an autoguiding correction is equal to or greater than this amount, the autoguide correction will be made.

### **Maximum move**

The longest time to move the mount during an autoguide correction. If you find that the mount is too active, no matter how you change other settings, this can force the *Camera Add On* to use shorter corrections. However, if at all possible, you should find the source of the problem and fix it instead.

### **Aggressiveness**

A number from 1 to 10, indicating the relative aggressiveness of the corrections. With a setting of 10, the *Camera Add On* makes the full, computed correction. With a setting of 5, the *Camera Add On* makes fifty percent of the computed correction. With a setting of 1, ten percent of the indicated correction occurs.

If autoguider corrects cause the mount to overshoot, you can reduce the amount of the correction with this setting to minimize guiding errors. For example, when pointed near the

zenith, your mount may be more responsive to corrections due to changes in balance. You can use a lower aggressiveness setting to compensate if your mount behaves in this manner.

### **Autoguide Using**

This setting determines how the *Camera Add On* makes autoguiding corrections.

- **Camera Relays:** If a camera relay cable is connected directly to the mount (or connected through the SBIG relay box), then use the **Camera Relays** setting.
- **RelayAPI (serial):** If you are using a special, custom arrangement via the serial port of the computer running the *Camera Add On*, then choose **RelayAPI (serial)**.
- **Direct Guide™:** Paramount Robotic Telescope Mounts, and mounts that employ the *Bisque TCS* (Software Bisque Telescope Control System) support Direct Guide, a technique that allows autoguider corrections to be applied directly to the mount's control system so that a separate autoguider relay cable is not required.
- **PulseGuide:** Autoguiding corrections can also be made directly to the mount using PulseGuide.

### **Delay After Correction**

If your mount tends to vibrate or bounce slightly after a correction is applied (needs a settling time), a delay can help ignore this oscillation. This is usually true only of lighter mounts, but it can also occur with larger mounts that are over loaded.

### **Log Autoguiding**

When this checkbox is turned on, tracking data is saved to a log file.

- The name of the log file is automatically generated so that earlier tracking log data is never overwritten.
- The name of the log file has the form *Auguider.001.log* where .001 is incremented each time the **Autoguide** button is clicked.
- The location of the log file is defined by the **AutoSave** path. This option is immediately applied *while autoguiding is in progress* so that you can control when logging starts and stops. The **Clear Log** button on the **Autoguide** tab applies immediately as well. See the section "Graphically Examining Autoguider Data" on page 504 for information about the tracking log file.

### **Simultaneous X- and Y-Axis Relay Activation**

Turn this option off if your mount is not capable of making an x and y correction at the same time (some older mounts). By default, this checkbox is on so that autoguider corrections that involve both an x-and y-relay activation are applied to the mount at the same time. Some much older model Losmandy mounts (Gemini controlled mounts excluded) cannot perform simultaneous corrections.

## Autoguider Calibration Results Tab

### Calibration Procedure

Click **OK** to save changes. Click **Calibrate** to start the calibration process. You will see information reporting the progress of the calibration in the Autoguide tab, such as **Moving Mount (Plus X)**. The calibration procedure starts with a new reference image and dark frame. It then moves plus and minus in the X and Y directions, measuring how the calibration start moves for each relay activation.

If there are any problems during the calibration, an error is reported in the calibration results windows. The following table lists common problems and explains what you can do to try to fix the problem.

| Calibration Problem   | Solution   |
|---|--|
| Error message:<br><br><i>“Star too dim. Lost during +X, -X, +Y, or -Y”</i>                                | The guide star is too dim, and could not be found on one or more of the photos acquired during calibration. Use a longer exposure, or choose a brighter star. A star is too dim not just when it is too dim to be pulled from the background, but also when the brightest star in a calibration image is less than 25% as bright as in the preceding image.  |
| Error message:<br><br><i>“Motion too small during +X, -X, +Y, or -Y move. Increase calibration time.”</i> | The calibration time was too short to move the star far enough to get a valid result. The solution is to use a longer calibration time. For a valid calibration, the star must move at least 5 pixels.   |
| Error message:<br><br><i>“Star too close to edge after +X, -X, +Y, or -Y move.”</i>                       | The calibration star is too close to the edge of the image after a move. You can reduce the calibration time to cause less movement, and you can also begin calibration with the guide star at the center of the frame. This error will occur when the guide star moves to within 10 pixels of the edge.   |
| Error message:<br><br><i>“Invalid motion in X- or Y-axis.”</i>  | This error typically occurs when:<br><br>The brightest star in a calibration image is a star other than the original guide star due to random variations in brightness. The guide star should be significantly brighter than any other star in the image.<br><br>A brighter star moves into the guide frame during calibration. The guide star should be isolated from similarly bright stars by at least 1.5 times the width or height of the guide frame in arcseconds.<br><br>The mount is very inaccurate, with motion in X resulting in motion in Y, or vice versa. Check the <b>Calibration Results</b> graph to see if it |

| Calibration Problem   | Solution  |
|---|---|
|   | provides any clues about what kind of invalid motion is contributed by the mount.   |
| Error message:<br><br><b>“Unable to calibrate, both axes are disabled. At least one axis must be enabled to calibrate.”</b> | With both axes disabled, no calibration is possible.<br><br>To enable one or both axes, from <b>Autoguide</b> tab, click <b>Settings</b> , then turn on the <b>Enabled</b> checkbox for one or both axes.   |
| Problem:<br><br>No calibration in one axis.   | If an axis is disabled, no calibration will occur for that axis.<br><br>To enable one or both axes, from <b>Autoguide</b> tab, click <b>Settings</b> , then turn on the <b>Enabled</b> checkbox for one or both axes.   |
| Problem:<br><br>Calibration star moves out of frame.  | This problem can cause several different error messages to appear, depending on what happens when the calibration star moves off of the photo. You might see “Star too dim” if another star winds up being interpreted as the calibration star, or you might see “Star too close to edge” or another message depending on where the brightest star winds up.<br><br>The <i>Camera Add On</i> displays the photos taken at each step in the calibration process; watch these images to see if the guide star is moving out of the frame. Use a shorter calibration time to keep the guide star in the frame, and start with the guide star as close as possible to the center of the frame. Severe mount errors can also move the star out of the frame at longer focal lengths. |

Once you have successfully calibrated the autoguider, you are ready to begin autoguiding. If you moved the mount to find a good calibration star, move it back to the object you want to capture.

## Autoguiding in Action

Once your system is calibrated, you can start autoguiding. The *Camera Add On* supports autoguiding independent of imaging. This means that you can start an autoguiding session and then take a series of Imager images while the autoguiding continues uninterrupted. If the autoguider is integrated into the camera, as with an SBIG dual CCD’s, autoguiding is temporarily paused during the Imager photo download since the shutter must be closed during the Imager download and the autoguider shares the same shutter (and since the shutter is close the autoguider cannot capture photos).

If you have a good polar alignment – which is always a good idea when imaging anyway – the guide star will be more likely to remain within the autoguider track box when autoguiding resumes. If the guide star moves, the *Camera Add On* will perform corrections to move it back to the center of the autoguide window. If this move tends to be large, you can add a delay to your Imager exposures. This will give the *Camera Add On* time to make corrections before the next Imager exposure begins.

The larger the corrections, the longer the delay should be to give the autoguider time to settle down. For most applications, use a delay that is a few seconds longer than two times the autoguide exposure. For example, if your guide exposure is 4 seconds, then use a delay of about 10 seconds. The extra time allows for downloading the autoguider images and processing time. If you find that your particular mount requires shorter or longer delays, adjust accordingly.

Once you have calibrated the autoguider, you can begin autoguiding. A typical autoguiding session includes the following steps:

1. Adjust the position of the mount if necessary to put a suitable guide star on the autoguider detector.
2. Click **Take Image** on the **Autoguide** tab, and verify the location of the guide star using an appropriate exposure length. If you are not sure, try 10 seconds.
3. If the brightness of the guide star is too high or too low, adjust the exposure time. Aim for a brightness level of about 1000 counts and less than saturation.
4. Enter the current declination of the telescope. If you are using *TheSkyX Professional Edition* to point your telescope, this will be filled in automatically when you click **Autoguide**.
5. Click **Autoguide** to begin guiding.

If you have *TheSkyX Professional Edition* controlling your mount, it will automatically get the current declination of the telescope and use it to scale your calibration. If you move a large distance across the sky, or if you cross the meridian, then you may want to do another calibration. If you are imaging at longer focal lengths (2500 mm and larger), you can calibrate before every image if necessary to get the best possible autoguiding out of your system.

During autoguiding, the *Camera Add On* continuously updates the autoguider photo to show the guide star. The current autoguide error appears near the top of the **Autoguide** tab, showing the number of pixels that the guide star has moved from the original position (X Error and Y Error). These numbers may be positive or negative, and are reported for both X and Y directions to the nearest hundredth of a pixel. Each photo captured for autoguiding shows a progress bar in the line for the autoguider at the **Autoguider** tab.

Autoguiding will continue until the **Abort** button is clicked. If there is an error during autoguiding, autoguiding will continue when possible, for instance if the guide star's brightness falls drastically due to clouds, autoguiding corrections are not made and autoguiding continues until the guide star brightness returns. If the guide star is lost and will not return (such as when the telescope is bumped), abort autoguiding and start over.

When using an SBIG dual CCD, the shutter will be closed when the Imager photo is being downloaded from the camera. Autoguiding is suspended while the shutter is closed, and will resume after the Imager download is complete. If the mount's polar alignment is good, the guide star will still be visible, and autoguiding will resume. You can enter an exposure delay in your Imager exposure(s) to allow for guiding corrections to settle right after the guide star is reacquired.

**Recalibration**

When should you recalibrate? The simplest way to tell is to start an autoguiding session and observe what happens. Start autoguiding after the telescope moves to a new position. Observe what happens to the X error and Y error numbers. If the both stay within +/- 1.0 pixel, you will likely have good results. If both stay within +/- 0.5 pixel, then the seeing is very good, and you should get excellent results. If one or both shows values greater than +/- 1.0, either the seeing is poor, or you may need to recalibrate for the new position. The need to recalibrate varies greatly from mount to mount, your image scale, and only experience will show you what works best for your particular mount.

Sometimes, autoguiding will not work as expected. Common problems, and possible solutions, include:

| <b>Autoguiding Problem</b>  | <b>Suggested Solution</b>   |
|---|---|
| No corrections occur, and the X and/or Y Error numbers continue to increase                     | Most likely, autoguiding corrections are not getting to the mount, check the cable between the camera and the mount. Make sure that corrections are enabled for the appropriate axes. Verify that the guide speed is set to an appropriate value (usually 0.5x sidereal) for the mount. You can test connections by pressing the relay buttons on the Autoguider tab and verifying if the stars in the photo move accordingly or worst case see if the mounts coordinates change (warning you will have to press a relay button a long time before seeing a change in mount the position reported by the mount.   |
| Corrections tend to oscillate between positive and negative values (for example, +1.3 and -0.9) | If the load on your mount is too carefully balanced, the mount will be unusually sensitive to guide corrections, and may overshoot. You want a slight but definite excess of weight on the east side. This keeps the gears meshed, and reduces the tendency of the mount to over-react to corrections. Oscillations can also occur when working near the zenith. You can also simply reduce the aggressiveness setting to see if that will eliminate the oscillation. Sometimes the mount will simply have a resonant period similar to the exposure duration and certain correction speeds; try a shorter or longer guide exposure length to see if it will eliminate the oscillation. |
| The mount suddenly makes  | A "large movement" is any sudden movement of two pixels or more. This usually results from irregularities in the mount's bearings or gears, and   |

| <b>Autoguiding Problem</b>  | <b>Suggested Solution</b>  |
|---|--|
| <p>large movements, and then comes back to zero.</p>                  | <p>may limit the success you will be able to achieve with autoguiding. Shorter exposures can help by allowing you to complete an image before you hit one of the large movements. Contact your manufacturer to see if you might need to replace a worn or damaged part. Dirt or grit in the gears can also cause this problem. Another possibility: wind gusts. If it's very windy, you may not be able to guide or track successfully, as the mount will bounce around. The larger and/or longer your telescope, the more likely it is to catch wind and cause deflections that will show up as guiding errors. In some cases, if the movements are not extreme, you may be able to guide successfully by shortening the guide exposure so that the <i>Camera Add On</i> can detect these movements sooner and correct for them more often. Guide exposures of 1-3 seconds can give you better results on less-expensive mounts, but not all objects will have a sufficiently bright guide star for you to try this option.</p> |
| <p>The guide star suddenly disappears</p>                             | <p>The most common cause for this is simply clouds. Guide exposures are short enough that many stars will simply disappear if even a thin cloud moves through that part of the sky. If your mount is well aligned to the pole, and tracks accurately, you can sometimes simply wait out the cloud and guiding will resume when it passes. Any exposure you were taking during the time the cloud was in the way may or may not be salvageable. The guide star can also disappear if the mount is disturbed, in which case you probably have also lost your polar alignment. You might have touched your mount accidentally, but even a stray cat rubbing against a tripod leg has been known to cause trouble!</p>   |
| <p>Corrections occur, but the X and Y errors are large and random</p> | <p>This could be a sign of over correction. Try recalibrating and see if that happens smoothly. Another option is to lower aggressiveness setting. Try lowering the aggressiveness one unit at a time and see if you get any improvement. Stop lowering the aggressiveness when you get into the range of +/- 1.0 pixels (average seeing) to +/- 0.5 pixel (good seeing). Problems with your mount's bearings or gears are another potential source of trouble; consider tuning your mount if you get wild changes in the X and Y errors. For any given mount, there is a limit to how accurately it will track and autoguide; if tuning and/or service won't improve your results, you may need to upgrade your mount to work at a given focal length.</p>  |
| <p>The guide star keeps trying to move in a specific direction.</p>   | <p>If the move is always in declination, this is most likely the result of a polar misalignment that is fairly large (more than 0.5 degree). If the autoguider is able to handle the movement in declination and keep it within a trouble-free range, the only concern is field rotation for long (one hour or more) photos or series of photos. If the autoguider fails to make the</p>   |

| Autoguiding Problem                           | Suggested Solution   |
|---|--|
|   | corrections and keep the error in a reasonable range, you can usually solve this problem by refining your polar alignment. See “Camera-Assisted Drift Alignment,” later in this chapter.   |
| The guide star wanders slowly back and forth. | Typically, this happens in right ascension, and you are seeing the periodic error of your mount. If your camera is oriented with north up, this will be a side-to-side (x pixels) motion in the autoguider photo. If the camera is turned 90 degrees (east or west up), then the motion will be up and down (y pixels). Periodic error usually results in slow, steady changes that go back and forth, so it is relatively easy for the autoguider to compensate. If your mount has the ability to record periodic error and then compensate for it (usually called PEC, for periodic error correction), you can use it or not, as you wish. It will not harm the performance of the autoguider if PEC and the autoguider are operating at the same time. However, the autoguiding is usually able to compensate for periodic error on its own, and you do not need to engage your PEC feature to get accurate guiding. You can also use the autoguider to log guide star motion which is sufficient to create PEC for capable mounts. |

### Autoguide Tab

The table below lists the controls in the **Autoguide** tab.

| Control               | Description  |
|-----------------------|--|
| <b>Take Photo</b>     | Click this button to take a photo using the current <b>Exposure Time</b> , <b>Exposure Delay</b> and other settings. |
| <b>Autoguide</b>      | Click this button to initiate autoguiding.   |
| <b>Graphs</b>         | Click this button to display the <i>Autoguiding Graphs</i> window.   |
| <b>Abort</b>          | Click this button to abort the camera operation in progress.   |
| <b>Setup</b>          | Displays the Autoguide Setup window.   |
| <b>Calibrate</b>      | Start the autoguider calibration process.  |
| <b>Exposure Time</b>  | Enter the exposure time, in seconds, for the autoguider photo.   |
| <b>Exposure Delay</b> | Enter a pre-exposure delay in seconds.   |
| <b>Binning</b>        | Enter the camera binning.  |

| Control                          | Description   |
|----------------------------------|---|
| <b>Frame</b>                     | The type of photo to be acquired:<br><b>Light</b><br><b>Dark</b><br><b>Bias</b><br><b>Flat</b>  |
| <b>Reduction</b>                 | Choose the type of reduction that is applied to each image acquired.<br><b>None</b><br><b>AutoDark</b><br><b>Full Calibration</b>   |
| <b>Clear AutoDark</b>            | Clears the AutoDark frame causing the <i>Camera Add On</i> to acquire a new dark frame on the next photo (when <i>Reduction</i> is set to <i>AutoDark</i> ).  |
| <b>Sub-frame On</b>              | When checked, only a portion of the CCD is acquired when a photo is taken.<br><br>The sub-frame size is set by either dragging a sub-frame on the photo or by typing in the size after clicking the <i>Size</i> button.   |
| <b>Size...</b>                   | Type in the size of the desired sub-frame.  |
| <b>Automatically Save Photos</b> | When checked, every photo is automatically saved to the hard drive.   |
| <b>AutoSave...</b>               | Click to display the AutoSave setup window.   |
| <b>Use Guide Star At X, Y</b>    | The x and y pixel coordinate of the guide star.   |
| <b>Auto-Find Guide Star</b>      | Scans the photo for the brightest guide star and sets Guide Star XY accordingly.  |
| <b>Clear Guide Star</b>          | Removes any selected guide and sets guide star's X,Y position to 0,0.   |
| <b>Declination</b>               | The telescope's declination.  |
| <b>Reverse X</b>                 | Allows reusing of autoguide calibration results after flipping a GEM even though initial calibration happened on the other side.<br><br>Note that the Camera Add On, when used with a TheSkyX Professional Edition-controlled mounts, automatically reverses the X direction. |

| Control                         | Description   |
|---------------------------------|---|
| <b>Display Autoguider</b>       | This checkbox is on by default, and forces every autoguider photo acquired to be displayed. On slower computers, turn this checkbox off so that autoguider photos are not displayed and increase the photo throughput.  |
| <b>Log Autoguiding</b>          | Generate a tracking log for periodic error correction.  |
| <b>Clear Log...</b>             | Delete the existing autoguider log file.  |
| <b>Track Box Size</b>           | Choose the size of the track box, in pixels.  |
| <b>Camera Relays</b>            | Click or click and hold one of the +X, +Y, -X, -Y buttons to activate the camera relays in that direction.  |
| <b>Auto Contrast Setup...</b>   | Click this button to show the <i>Auto Contrast</i> window and choose the desired method to adjust the contrast method to apply to subsequent photos.<br><br>Auto Contrast options:<br><br>SBIG: Use Santa Barbara Instrument Group's autocontrast algorithm to compute the photo's black and white points.<br>Bjorn: Use the proprietary algorithm, along with the selected <i>Background</i> and <i>Highlight</i> options to compute the photo's white and black points. |
| <b>Simulate Photo Using DSS</b> | Turn on the <i>Simulate Photo Using DSS</i> checkbox to take photos of Digitized Sky Survey objects, instead of collecting "actual" photons with the camera's detector and a telescope.   |
| <b>Screen Shutter</b>           | Turn this checkbox on to show a completely black computer during exposures. This can minimize "light leak" from your monitor.   |

## Assessing Autoguiding Possibilities

Once you have mastered enough CCD imaging skills to take focused photos, the next step is to lengthen your exposures so you can take deeper, more detailed, and cleaner photos of your favorite celestial objects. The accuracy of your mount determines how deep you can go. The more accurate your mount, the easier it will be to take long exposures.

Some mount manufacturers specify the accuracy of their mounts. This accuracy is expressed in arcseconds. An exceptional mount can guide with accuracy of 2-3 arcseconds or less. A very good mount can guide to about 5-6 arcseconds. The average low-cost mount guides to within 15-20 arcseconds. Mounts with even less accuracy are less suitable for CCD imaging unless the focal length of the telescope or lens is exceptionally short.

Whatever the accuracy of your mount, the key to success is matching the focal length of your telescope or camera lens to the abilities of the mount. For example, consider a CCD detector with pixels that are 9 microns square, such as the ST-7E. The angle on the sky covered by each pixel varies with the focal length of your telescope:

| <b>ST-7E (9-micron pixels)</b>            |                                  |
|---|----------------------------------|
| <b>Focal Length of the Telescope (mm)</b> | <b>Angle of Sky (arcseconds)</b> |
| 300                                       | 6.2                              |
| 500                                       | 3.7                              |
| 700                                       | 2.6                              |
| 900                                       | 2.1                              |
| 1100                                      | 1.7                              |

For example, imaging with a 300mm camera lens, at least 6 arcseconds of error are tolerable because a single pixel covers just over 6 arcseconds. Imaging with a refractor that has 1100mm focal length, a single pixel covers only 1.7 arcseconds, and the need for tracking accuracy is almost four times higher.

In practice, star images cover more than one pixel due to atmospheric scattering, the same process that causes stars to twinkle, so you would have more leeway than shown here. The important concept is that the shorter your focal length, the less the need for tracking accuracy in your mount.

A short focal length alone won't necessarily solve the problem, however. Smaller or larger pixels on your CCD detector alter the numbers. As shown in the following table, large pixels cover more sky for a given focal length, and smaller pixels cover less sky:

| <b>ST-9E (20-micron pixels)</b>       |                                   |  | <b>ST-237 (6.8-micron pixels)</b>     |                                   |  |
|---------------------------------------|-----------------------------------|--|---------------------------------------|-----------------------------------|--|
| <b>Focal Length of Telescope (mm)</b> | <b>Angle of Sky, (arcseconds)</b> |  | <b>Focal Length of Telescope (mm)</b> | <b>Angle of Sky, (arcseconds)</b> |  |
| 800                                   | 5.1                               |  | 300                                   | 4.7                               |  |
| 1000                                  | 4.1                               |  | 500                                   | 2.8                               |  |
| 1200                                  | 3.4                               |  | 700                                   | 2.0                               |  |
| 1500                                  | 2.7                               |  | 900                                   | 1.5                               |  |
| 2000                                  | 2.0                               |  | 1100                                  | 1.3                               |  |

For best results, match the focal length of your telescope to both your CCD camera and your mount. Most CCD imagers aim for a camera/telescope combination that yields from 1.5 to 4 arcseconds per pixel. Your choice of mount should match the capabilities of whatever combination you select. You can calculate the arcseconds per pixel of your camera/telescope combination using the following formula:

$$(\text{pixel size in microns} / \text{focal length in mm}) * 206$$

Experience shows that, to get good results, your mount error should be no more than +/- 2 pixels. For high-quality images, one and a half times the arcseconds per pixel value is a safer limit. Very high precision results demand a value of a single pixel. For very long focal lengths (2500mm and up), local seeing and other conditions becomes more important and the calculations are not so straightforward; experience of local conditions is needed to assess the requirements for the mount.

In general, then, for high-quality images, a mount should be able to guide to within 2.25 and 6 arcseconds, depending on the pixel size of the CCD camera in relation to the focal length of the telescope.



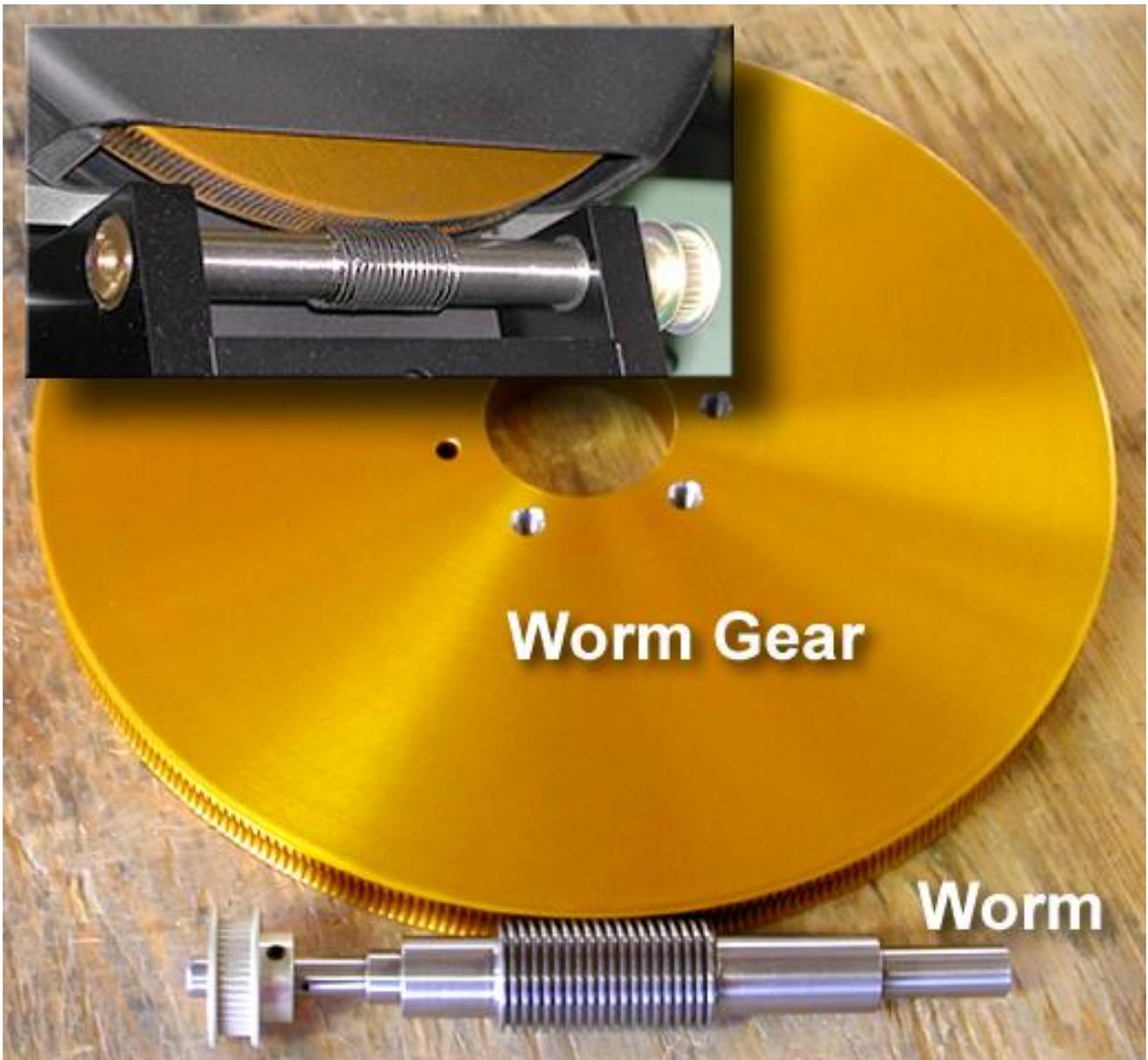
If your mount isn't providing the pointing accuracy needed by your telescope, you can either use a focal reducer to shorten the focal length of your telescope, or take steps to increase the pointing accuracy of your mount, or both.

If you already own a mount, and want to assess its approximate pointing accuracy, you can follow this procedure.

## **Adjusting and Tuning Your Mount**

Mounts come in a variety of designs. Most mounts intended for use CCD cameras involve a worm and worm gear, as shown in Figure 213. There is normally one pair for right ascension, and another pair for declination, but some mounts are only driven in right ascension.

A motor drives the worm gear, and there will usually be gears between the motor and the worm to reduce the speed of rotation at the worm. The worm in turn drives the worm gear, which is attached to the shaft. The right ascension shaft turns at sidereal rate, which is the rate stars appear to move across the sky (approximately one revolution per day). The motor speed and gear ratios are set to track accurately at the sidereal rate. Some mounts provide a way to adjust the tracking rate for the highest possible accuracy, but most do not.



**Figure 213: A Byers precision worm and worm gear.**

To track and autoguide accurately, a worm-driven mount must often be adjusted or tuned in several ways. Before using a mount for autoguiding, we suggest the following; please consult your mount's documentation or the manufacturer for specific procedures on making these adjustments:

- Verify that the worm and worm gear are properly seated. If the end bearings of the worm are too tight, the worm will bind and could be damaged. If the worm is too loose between its end bearings (end play), reversals of direction will be erratic. Endplay in the worm gear is the usual cause if you observe that the mount initially and briefly moves in the wrong direction when reversing directions.
- Verify that the mesh between worm and worm gear is appropriate. Some mounts are made from harder materials and to closer tolerances, and these will typically require a very tight

mesh between the worm and worm gear. Other mounts are made of softer metals, or to looser tolerances, and will require a looser mesh. If the mesh is too tight for the design, the gears will bind and could overheat or be damaged. If the mesh is too loose, there will be excessive backlash. Some mounts have built-in backlash compensation that allows you to keep the gears appropriately loose; the *Camera Add On* provides software backlash compensation that serves the same purpose. During backlash compensation, the motor is run at a higher speed to take up slack in the gears. Too much compensation will result in a jerky movement; too little compensation will result in a delay before a guiding correction is effective. It is always better to have too little rather than too much backlash compensation. If in doubt about how tight to mesh the gears, err on the side of being too loose. See the section “Assessing Mount Accuracy” on how to measure backlash.

- A slow-turning motor usually has less torque (that is, less force available to move the mount). This means that a slowly turning motor is more likely to stall than one that is turning quickly. If the worm and worm gear are too tightly meshed, the slowdown to 0.5x sidereal that occurs during autoguiding could cause the mount to stall, or move at the wrong speed.
- Cold conditions can cause some lubricants to become stiff, and this can alter the behavior of your mount. If you need to operate your mount in very cold conditions, or if you observe increased stiffness in cold weather, check with the manufacturer to find out whether you will need to use different lubrication for cold conditions.
- Some mounts, after tuning and adjustment, will have a large enough residual error that it will limit the focal length telescope you can use successfully. The larger the error (from periodic and non-periodic sources), the shorter the focal length of the telescope you can use for imaging. The actual limit depends on the weight of your telescope and its overall physical length as well as its focal length. Long, heavy telescopes require more careful balancing and tuning for successful guiding. Focal reducers are available to help with this situation. Otherwise, you will need to use a telescope with a shorter focal length.
- Test the balance of your mount in various positions. Off-center equipment, such as a finder offset from the centerline of your telescope, or a camera attached piggyback fashion onto your telescope, can dynamically alter the balance of your mount as you point at different areas of the sky. A mount should always be loaded so that there is slightly more weight on the east side of the mount. This keeps the right ascension axis loaded at all times, eliminating backlash as a factor in right ascension autoguiding (as long as the correction speed is less than sidereal rate). If off-center equipment does cause the balance to change at different pointing angles, you can either rearrange equipment and/or counterweights after pointing to a new area of the sky, or you can incorporate sliding weights or some other weight-shifting system into the design of your setup. An out of balance mount can oscillate or wander unpredictably, or require a new calibration when pointing to different parts of the sky even if the declination remains similar.
- You can calibrate your setup at a higher correction speed than you use when autoguiding. This tends to mask some errors, but it isn't a cure-all. It slows down the correction process, and if your mount tends to be over-responsive, it can eliminate unnecessary corrections and provide smoother autoguiding.

More than any other single factor, the ability of your mount to track accurately and to respond quickly and smoothly to guiding corrections determines the success of your imaging. It is well

worth measuring the accuracy of your mount, and tuning and adjusting it to improve that accuracy to the greatest degree possible.

### **Polar Alignment**

In order to track accurately, your mount needs to be aligned close to the celestial pole. Many mounts include a polar telescope (also called a bore telescope or bore sight) to help you polar align. There are many different kinds of polar telescopes, but most contain some kind of reticle that allows you to point the mount at specific stars to achieve alignment. Most mounts also contain provisions for aligning in either the northern or southern hemispheres.

Although you do not need perfect polar alignment for autoguiding, there are some issues to be aware of with respect to polar alignment. If you are taking single images of less than five minutes, even a rough polar alignment will be satisfactory if you are autoguiding. The lack of a perfect alignment will cause the field of view to drift during the exposure, but the autoguider will detect the drift and correct for it. The field will rotate a small amount during the exposure, but if the exposure is short enough, the amount of rotation is generally negligible. If you are concerned about the effects of field rotation in your photos and use TPoint, type **FROT** in the **Command** text box on the **Command Line** tab of the **TPoint Add On** window to show the amount for field rotation, in radians per hour, over a range of declinations.

Autoguiding can correct for small misalignments to the celestial pole. If the misalignment is too large, however, the autoguider will have to make large, frequent corrections making the autoguider work very hard and only high quality mounts will respond accordingly. The larger the misalignment, the shorter your guide exposures must be in order to make corrections before they become too significant and pollute the Imager photo (stars not round).

If your exposures are longer than fifteen minutes or so, rotation of the field over time may become an issue. If you are combining short-duration images for better signal-to-noise ratio or for color, the routine must also rotate the photos before combining.

Very short focal lengths are more sensitive to field rotation because the image covers a larger area of the sky. You can minimize field rotation by taking the time to polar align your mount very carefully. Use the polar telescope for rough alignment, and then use drift alignment to refine alignment. You can do drift alignment manually, or you can use the CCD camera to assist. You can also use the TPoint Add On, a Software Bisque software tool that increases telescope-pointing accuracy, to achieve extremely accurate polar alignment.

### **Manual Drift Alignment**

1. Level the base of the mount if possible. A level mount is not required, but it makes adjust easier by reducing interplay between altitude and azimuth adjustments.
2. Locate a bright star near the celestial equator and near the meridian (the midpoint between east and west). Center the star in the crosshairs of an illuminated reticle eyepiece.
3. Observe the star until it drifts north or south; ignore drift to the east or west. If the star drifts north, adjust azimuth so the mount points more to the east. If the star drifts south,

adjust azimuth so the mount points more to the west. Repeat until north/south drift becomes negligible over a 5-minute observing period.

4. Locate a bright star near the celestial equator and near either the east or west horizon. Center it in the crosshairs of an illuminated reticle eyepiece.
5. Observe the star until it drifts north or south; ignore drift to the east or west.

If you are looking **east**:

- If the star drifts north, adjust altitude downward.
- If the star drifts south, adjust altitude upward.

If you are looking **west**:

- If the star drifts north, adjust altitude upward.
- If the star drifts south, adjust altitude downward.

Repeat until north/south drift becomes negligible over a 5-minute observing period.

|   |  |
|---|--|
|  | <p>To determine which way is north in the eyepiece, move the telescope toward the south and note the direction the stars move; they are moving toward the north in the field of view.</p> <p>In general,</p> <ul style="list-style-type: none"><li>• If you move the telescope to a slightly more positive declination the stars will move south in the field of view.</li><li>• If you move the telescope to a slightly bigger right ascension the stars will move west in the field of view.</li></ul> |
|---|--|

### **Camera-Assisted Drift Alignment**

Calibrate your autoguider as described earlier in this chapter.

1. See if the camera is currently orthogonal (square) to the mount. If you have performed a calibration, you can use the *Camera Add On* to tell you how close the camera is to orthogonal. On the **Autoguide** tab for the **Autoguider**, click **Setup**. This opens the **Autoguide Setup** window. Click the **Relay Calibration Results** tab. This displays a graph showing how the camera is oriented with respect to the right ascension and declination axes of the mount. Ideally, the X- and Y- relay vectors will line up closely with the X- and Y-axis of the photo/CCD (Figure 214). Ideally, but not necessarily, the angle of the +X vector should be close to zero, and the +Y axis vector should be nearly perpendicular to the +X vector. If your camera is rotated with respect to the mount axes (Figure 215), you will not get accurate readings for camera-assisted drift alignment.

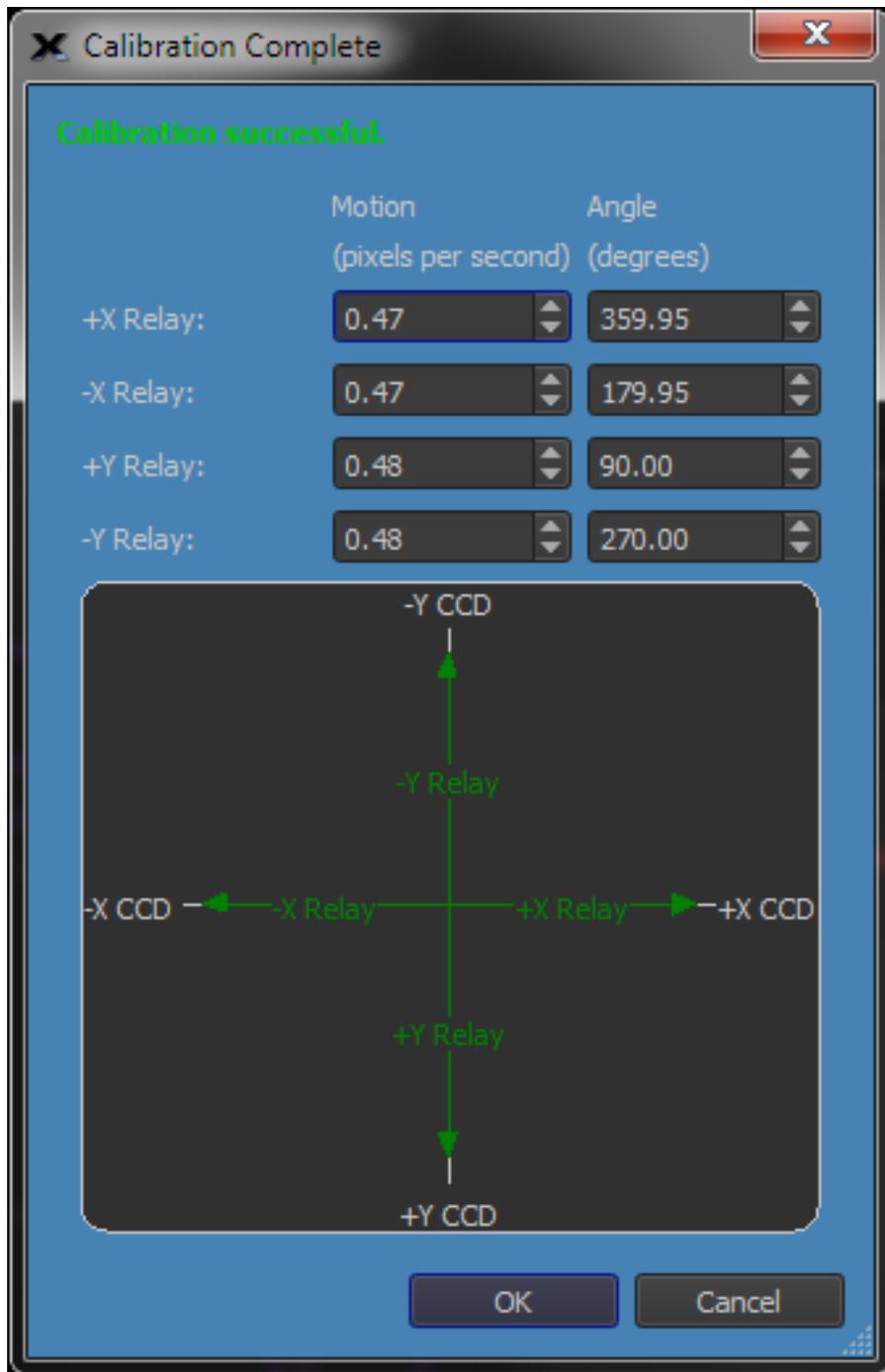


Figure 214: Relay calibration results that show the camera is ready to assist with drift alignment.

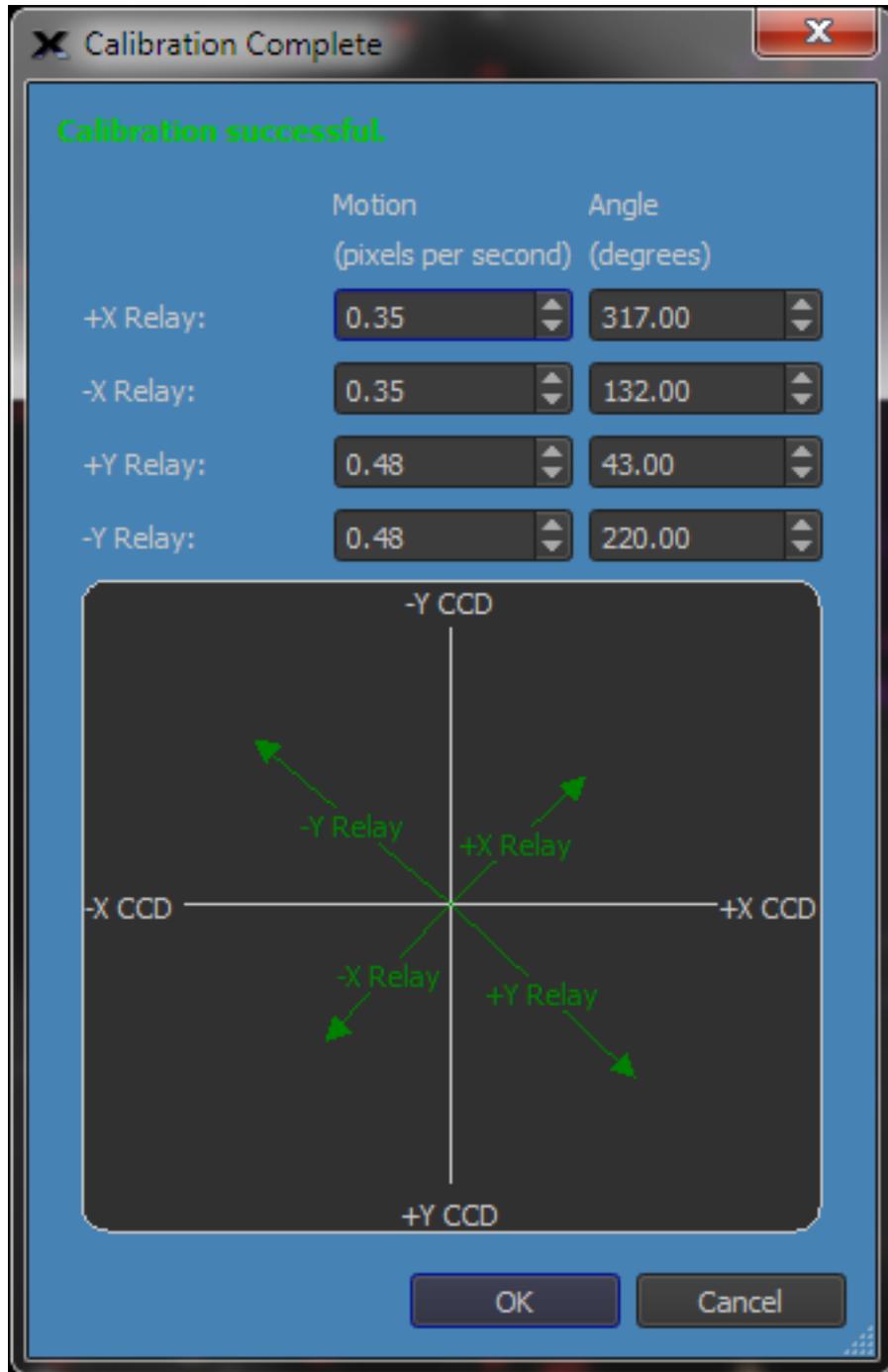


Figure 215: The camera axes are not square to the mount axes. The camera rotation is not well situated for assisting with drift alignment.

2. If the camera isn't square with the mount, adjust the camera so that the top of the CCD detector points toward north. For the greatest accuracy, repeat calibration to verify alignment of the camera. Repeat until you've got everything lined up to your satisfaction.
3. Using the **Autoguide** tab, set an appropriate exposure time (for example, 5-10 seconds), and then click **Take Photo**. Check your results, and adjust the exposure time as needed. Double click on a suitable guide star.

4. Click **Log Autoguiding**. This allows you to examine your data later if you have any questions about the progress you are making toward polar alignment. The log file is named `autoguider.XXX.log`, and can be found under the camera's autosave folder. See the next section, "Autoguider and Tracking Log," for a list of the fields contained in the log file.
5. To measure drift, you need to turn off corrections. From the **Relay Settings** tab, uncheck the **Relay Enabled** checkboxes for X-and Y-relay. Note: Remember to re-enable corrections when you are done.
6. Click **OK** to close the Autoguide setup window.
7. Click the **Autoguide** button on the **Autoguide** tab. You can now observe the Y (declination) error to measure drift very accurately and very quickly. You can examine the log file at any time to determine the total amount of drift versus elapsed time. Positive Y error values are northward drift; negative Y error values indicate a drift to the south.
8. Once you have a measurement of the current amount of drift north (+Y) or south (-Y), adjust the mount as for manual drift alignment and repeat the autoguiding process.
9. For optimal results, continue drift aligning until you can autoguide for several minutes with a Y error no larger than +/- 1.0. For critical applications, continue until you can autoguide for five minutes with a Y error no larger than +/- 0.5.

## Autoguider and Tracking Logs

You can turn on logging of autoguider operation using the either the **Log Autoguiding Data** checkbox on the **Autoguide** tab or the same checkbox under the **Setup** button on the **Autoguider** tab. Turn the checkbox on to collect autoguiding data. New autoguiding data is always automatically saved to a new file per autoguiding session. To clear the log file, click the **Clear Log** button.

A sample `autoguider.log` file is shown below. The lines are wrapped because the data content is too long to fit on a single line here. In the file itself, each line of data is a single line.

```
TheSkyX Camera Add On Autoguiding Log
Camera = Imager's built-in autoguider
X Axis = Enabled
Y Axis = Enabled
ExposureTime = 0.10
Aggressiveness Factor = 10
Calibration Time X = 4.00
Calibration Time Y = 4.00
Calibration declination = 0.00
Declination now = 0.00
Minimum Move = 0.01
Maximum Move = 1.00
Backlash X = 0.00
Backlash Y = 0.00
Delay After Move = 0.00
Autoguide using Relays

Calibration Determined Velocity Vectors (pixels/sec)
XPlus Speed= 5.00106 (XPlus X= 5.00076, XPlus Y= 0.05490) Angle= 0.00000
XMinus Speed= 5.00016 (XMinus X= -4.99985, XMinus Y= -0.05594) Angle= 0.00000
YPlus Speed= 4.99963 (YPlus X= -0.00182, YPlus Y= -4.99963) Angle= 0.00000
YMinus Speed= 4.81357 (YMinus X= 0.05687, YMinus Y= 4.81323) Angle= 0.00000

|Elapsed Secs|RefCentroidX|RefCentroidY|CurCentroidX|CurCentroidY|GuideErrX |GuideErrY |TotGuideErr
|XPlusRelay |XMinusRelay |YPlusRelay |YMinusRelay |PECIndex RA |PECIndex Dec|
| 0.0000| 49.8300| 49.0000| 49.7707| 48.9768| -0.0593| -0.0232| 0.0637|
1| 0| 0| 0| 0| 0|
```

|        |        |         |         |         |         |         |         |        |
|--------|--------|---------|---------|---------|---------|---------|---------|--------|
|        | 2.4020 | 49.8300 | 49.0000 | 49.8054 | 48.9818 | -0.0246 | -0.0182 | 0.0306 |
| 0      | 0      | 0       | 0       | 0       | 0       | 0       | 0       | 0      |
|        | 3.3230 | 49.8300 | 49.0000 | 49.8077 | 48.9778 | -0.0223 | -0.0222 | 0.0314 |
| 0      | 0      | 0       | 0       | 0       | 0       | 0       | 0       | 0      |
|        | 4.2590 | 49.8300 | 49.0000 | 49.8038 | 48.9827 | -0.0262 | -0.0173 | 0.0314 |
| 1      | 0      | 0       | 0       | 0       | 0       | 0       | 0       | 0      |
|        | 5.1950 | 49.8300 | 49.0000 | 49.9322 | 48.3956 | 0.1022  | -0.6044 | 0.6130 |
| 0      | 2      | 0       | 13      | 0       | 0       | 0       | 0       | 0      |
|        | 6.1310 | 49.8300 | 49.0000 | 49.8545 | 48.8989 | 0.0245  | -0.1011 | 0.1040 |
| 0      | 0      | 0       | 2       | 0       | 0       | 0       | 0       | 0      |
|        | 7.0670 | 49.8300 | 49.0000 | 49.8569 | 48.9807 | 0.0269  | -0.0193 | 0.0331 |
| 0      | 1      | 0       | 0       | 0       | 0       | 0       | 0       | 0      |
|        | 7.9870 | 49.8300 | 49.0000 | 49.8139 | 48.9820 | -0.0161 | -0.0180 | 0.0241 |
| 0      | 0      | 0       | 0       | 0       | 0       | 0       | 0       | 0      |
|        | 8.9080 | 49.8300 | 49.0000 | 49.8128 | 48.9798 | -0.0172 | -0.0202 | 0.0265 |
| 0      | 0      | 0       | 0       | 0       | 0       | 0       | 0       | 0      |
| 0.0000 |        | 0       | 0       | 0       | 0       | 0       | 0       | 0      |

The top portion of the file record the camera used, as well as which axes are enabled. The exposure time and the aggressiveness setting are also recorded.

The next section lists the calibration details. This is a text version of the information you see in the **Relay Calibration Results** window (Figure 214).

The bottom section contains a record of all guiding corrections. The example above shows only a few lines. You could have hundreds of correction entries for a long exposure. The following data is included for each correction; for X/Y coordinates, the origin is the upper left corner of the detector:

| Heading             | Description   |
|---------------------|---|
| <b>Elapsed Secs</b> | Total number of seconds that have elapsed since the start of the current autoguiding session.                                       |
| <b>RefCentroidX</b> | The X coordinate of the starting position of the guide star centroid.   |
| <b>RefCentroidY</b> | The Y coordinate of the starting position of the guide star centroid.   |
| <b>CurCentroidX</b> | The current X coordinate of the guide star, in pixels.  |
| <b>CurCentroidY</b> | The current Y coordinate of the guide star, in pixels.  |
| <b>GuideErrX</b>    | The number of pixels the guide star has moved from the starting position along the X-axis. Equal to $(CurCentroidX - RefCentroidX)$ |
| <b>GuideErrY</b>    | The number of pixels the guide star has moved from the starting position along the Y-axis. Equal to $(CurCentroidY - RefCentroidY)$ |
| <b>TotGuideErr</b>  | The total current guide error in pixels, measured in a straight line from the origin. Equal to $\sqrt{(GuideErrX^2 + GuideErrY^2)}$ |
| <b>XplusRelay</b>   | Time in one-hundredths seconds that the X-plus relay was on to make the correction.   |
| <b>XminusRelay</b>  | Time in one-hundredths seconds that the X-minus relay was on to make the correction.  |
| <b>YplusRelay</b>   | Time in one-hundredths seconds that the Y-plus relay was on to make the correction.   |
| <b>YminusRelay</b>  | Time in one-hundredths seconds that the Y-minus relay was on to make the correction.  |

Heads up, the deciphering the autoguiding log is not intuitive when the camera is rotated with respect to right ascension and declination since an x pixel error may manifest itself to both an X and Y relay adjustment. Another potential point of confusion: resultant autoguiding corrections account for autoguiding at a declination different from the declination at calibration time so they may be bigger or smaller than what you might expect at first glance.

## Graphically Examining Autoguider Data

If you logged autoguiding information, you can open the log file from the **Autoguiding Graphs** window to see the data graphically. Press the **Graphs** button on the Autoguiding sub tab and from the Autoguiding Graphs window, right click the "X Pix Error" graph (or the "Y Pix Error" or "XY Err Pix" graph) and choose **Open Autoguiding Log**.



If you turn off corrections during autoguiding, in addition to errors caused by atmospheric seeing, the log file will contain a record of the periodic error of your mount. Let autoguiding proceed for one full revolution of the right ascension worm. This is usually in the range of four to seven minutes. Consult your mount documentation if you aren't sure, or contact the mount manufacturer. To turn off corrections, click **Setup** on the **Autoguide** tab. Turn off the **Relay Enabled** checkboxes to disable the X- and Y relays.

## Autoguider Graphs Window

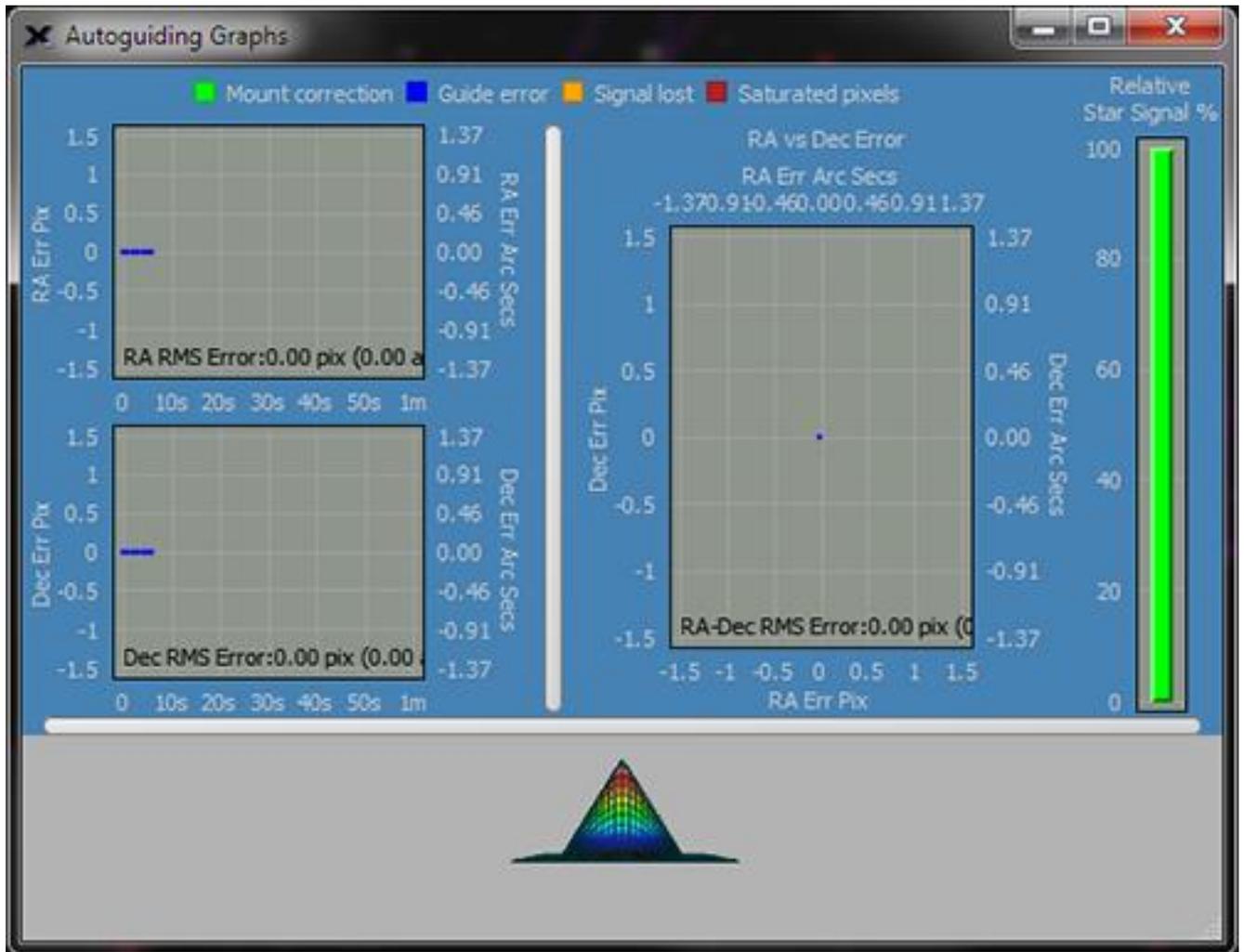


Figure 216: Sample autoguider graphs.

While autoguiding, press the **Graphs** button to display the **Autoguiding Graphs** window. These graphs give great visual feedback and provide insight into autoguiding performance at a glance.

The graphs show the X error in pixels and arcseconds (see note below), the Y error in pixels and arcseconds (see note below), the XY error as a scatter graph, the guide star's relative signal as well as a three-dimensional graph of the guide star.



The autoguider's image scale is computed from the Telescope Parameters on Imaging System Setup window (page 447). Make sure to highlight *Autoguider's Camera* (not the Imager's Camera) to view them.

If these values are not set, the autoguider graphs show errors in pixels, not arcseconds.

The XY error graphs show the error for the last 100 autoguiding cycles. You can zoom in/out on the XY error graphs by holding your mouse over the graph and using the mouse wheel. Click and drag the graphs to scroll left or right. The graphs window is also sizable allowing it to be viewed “full screen” on a second monitor, for example.

Each point on the autoguiding graphs is color coded, as described in the table below.

| Color of Point on Graph   | Description   |
|---|---|
|    | Blue points show the <b>Guide Error</b> , that is, distance the centroid of guide star moved in the photo. Guide errors can be caused by a host of factors, including poor mount tracking, polar drift, seeing errors and more.   |
|    | Green points show the <b>Mount Correction</b> which is the angular distance the mount’s position was changed or corrected. The correction distance is computed based on on the star’s centroid ( <b>Guide Error</b> ), as well as the <b>Aggressiveness, Minimum</b> and <b>Maximum Move</b> parameters.  |
|   | Orange points indicates <b>Signal Lost</b> which means the guide star’s signal (ADU) fell below a minimum threshold during a particular guiding sequence. Passing clouds are common cause.  |
|  | Red points show that the guide star contains <b>Saturated Pixels</b> , meaning that the signal from the star for the given exposure time exceeds the maximum signal the camera can record.<br><br>Saturated pixels in a guide star make centroid determination, and therefore guiding, less accurate. Try using a fainter guide star, or a shorter exposure to mitigate pixel saturation. |

Guide errors (the relative motion of the star computed from its centroid in each exposure)

You can change the viewing angle of the three-dimensional guide star by clicking and dragging within this window. Right click and choose properties to change the appearance of the three-dimensional star (these settings are not saved and the three-dimensional star will return to its default settings on exit and restart).

## Autoguide Using Adaptive Optics



There are three types of autoguiding available in the *Camera Add On*:

- Self-guiding with an autoguiding CCD built into an SBIG dual camera.
- Autoguiding with a separate autoguiding camera (in a guide scope or using an off-axis splitter).
- Autoguiding with adaptive optics (using the SBIG AO).

The first two methods work similarly: the guide corrections are calculated and TheSkyX Camera Add On makes corrections by activating a camera relay which in turn moves the mount. This section assumes you are familiar with conventional, relay-based, autoguiding, and that you understand the concepts covered in the section “*Autoguiding*” above.

With the SBIG AO, an internal mirror tilts rapidly to make the autoguide corrections. When using the SBIG AO, you must calibrate using relays so the TheSkyX Camera Add On knows how to move the guide star by moving the mount *and* calibrate using AO tip/tilt so that the *Camera Add On* knows how to move the guide star by tip/tilting the AO mirror.



Guide corrections to the mount (via camera relays or Direct Guide) may still occur when using the SBIG AO. The mirror tilt of the AO has a limited range of motion. By default, if the mirror reaches 50% of maximum tilt in any direction, the mount’s position is moved slightly, or “bumped”, to bring mirror tilt back within range. Polar misalignment and refraction are two primary reasons why the guide star drifts over time.

To optimize non-guided tracking, Paramount mount users are strongly encouraged to employ TPoint’s telescope model-assisted tracking technology called ProTrack. It continuously updates the mount’s position to correct tracking errors from polar misalignment, refraction, tube flexure, and other non-sidereal tracking errors.



Since guiding with the AO still involves use of the camera relays or Direct Guide to bump the mount when necessary, you should always confirm that you can successfully autoguide using the camera relays stand alone. Verify that the mount

moves via the camera relays, and that guiding is accurate and satisfactory. Otherwise, when the SBIG AO “bumps” the mount, you may lose your guide star and not get the result you want.

## Quick Start

If you are familiar with the *Camera Add On* and the SBIG AO, follow these steps to start autoguiding with the SBIG AO. This section assumes that you are familiar with conventional autoguiding (see “*Autoguiding*”) For details, please read “*Autoguiding with the SBIG AO*” below.



The AO quick start instructions above perform both calibrations using the autoguider, you could also perform both calibrations using the Imager. The Camera Add On will automatically calibrate the Imager upon successful autoguider calibration and vice versa. Since the Imager CCD is always bigger than the built-in autoguider, it is easier to place stars on the Camera. You must turn on the **Advanced Camera User Interface** checkbox (page 225) to enable the **Autoguide** tab on the **Camera** window.

The SBIG AO must be connected to the camera and all cabling in place between the computer, camera, and SBIG AO before you start.

1. Choose **SBIG with AO...** for the camera and **Imager’s Built-In Autoguider** as the autoguider.
  - a. Go to Telescope, Telescope Setup and from the Imaging System window, Open Imaging System and highlight Camera. Click **Camera Setup**, Select **SBIG with AO...** from the **Camera** list.
  - b. Click Imaging System, Autoguider and highlight Camera.
  - c. On the Camera Setup pop-up menu, click Choose and select Imager’s Built-In Autoguider.
2. Place an appropriate calibration star on the autoguider photo.
  - a. Click **Take Photo** to take an autoguider photo. Adjust telescope pointing and exposure time until you have a suitable star for calibration. A good calibration star must be the brightest star in the field of view, and there must not be similar bright stars nearby that will move into the field of view during calibration. Use the *Camera Add On* to help locate suitable calibration stars.
3. Calibrate the autoguider using relays.
  - a. From the Autoguider tab, Autoguide sub tab, perform an autoguider calibration using relays as you normally would when autoguiding without the AO. You do not have to uncheck **AO Enabled**. To use relay calibration, click **Calibrate** on, then click the **Calibrate Using Relays** option.
4. Set the AO settings to their default values.
  - a. Click the **AO Settings** tab. Click the **AO Default Settings** button to set the default values for the parameters. For fine-tuning the device, see the section “*SBIG AO Settings*” on page 512. Click **OK**.
5. Calibrate the autoguider using the AO.

- a. Click **Calibrate...** and then click **Calibrate using AO**. Verify that the **AO deflection...** setting is 100%. Click **Calibrate**. The SBIG AO will move its mirror, take exposures of the calibration star, and measure the movement in each direction.
6. Start autoguiding.
  - a. Click **Take Photo** to download an image using the guide chip. Adjust telescope pointing and exposure time until you have a suitable guide star. See “Autoguiding” on page 469 for information about what makes a star suitable for guiding.
  - b. Double click the desired guide star in the photo to select it as the guide star, or click the **Auto Find Guide Star** button to have the *Camera Add On* select the guide star for you.
  - c. Click **Autoguide** to start autoguiding. You can monitor progress using the information on the **Autoguide** tab, including X/Y tilt, wander, etc. See following sections for details.

## **Autoguiding with the SBIG AO**

Once the SBIG AO is installed and connected according to the instructions from SBIG, you must do the following before you can start using the AO device:

- Make the correct camera choices for the **Camera** and **Autoguider**.
- Verify that the SBIG AO is enabled on the **Autoguide** window.
- Calibrate using the SBIG AO *and* calibrate using relays.

You must choose the **SBIG with AO...** as the camera and the **Imager's Built-In Autoguider** as the autoguider before autoguiding with the AO is possible. Figure 1 shows the correct camera choices for using the SBIG AO: If you choose any of the other individual cameras instead, the SBIG AO will not be active or available.

If you have been using another autoguider, take a moment to verify that the Autoguider selection is correct. From the Imaging System Setup window, open Autoguider and highlight Camera. Choose **Camera Setup**, Choose and select **Imager's built-in autoguider** as the selected Autoguider camera (see Figure 218).

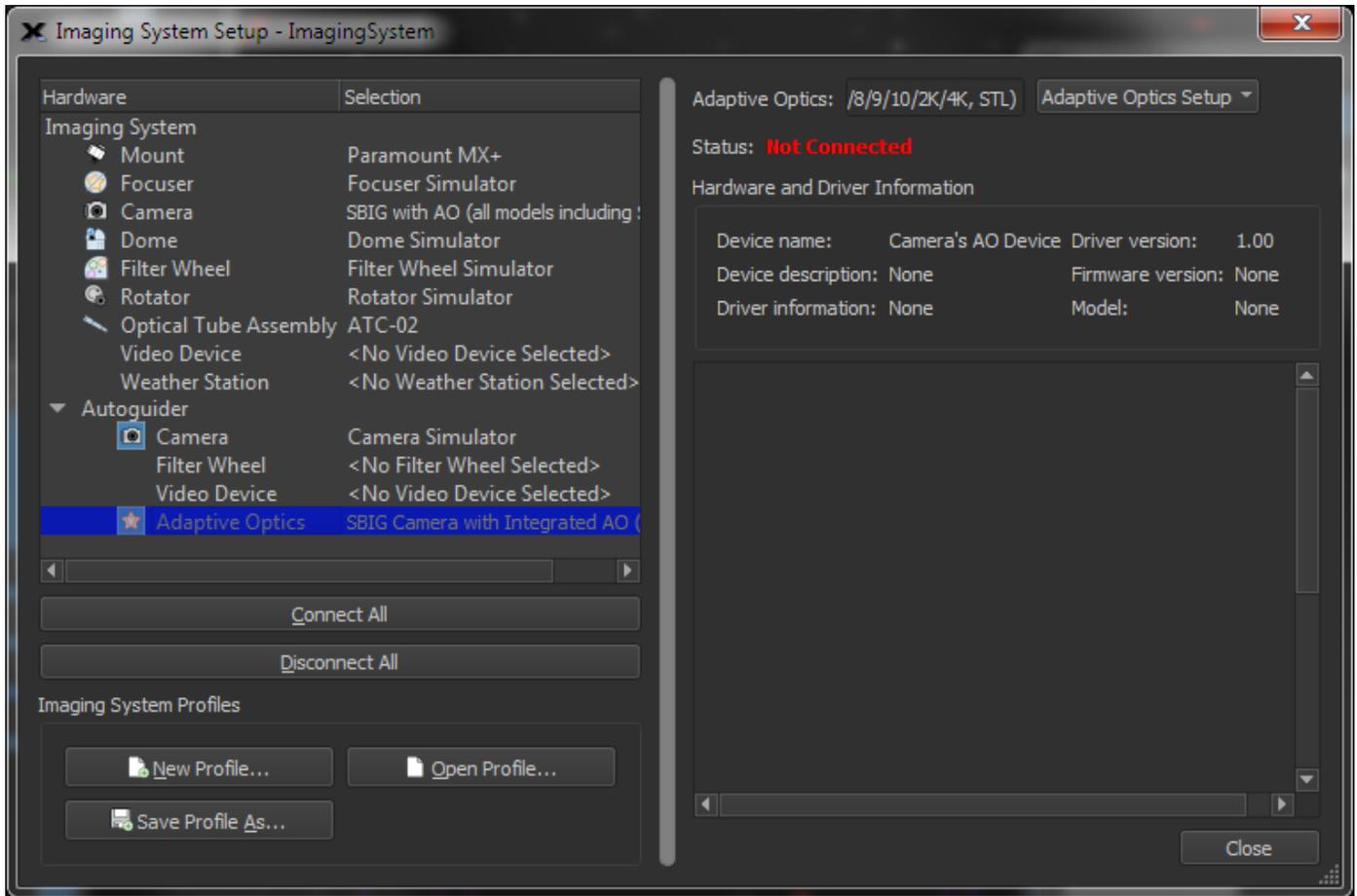


Figure 217: Make sure the Camera is *SBIG with AO (all models...)* and the Autoguider camera is *SBIG Camera with Integrated AO...*



If you are having trouble seeing the guide star, try to adjust the photo's contrast settings (click the **Show Histogram** button on the **FITS Viewer** window). When using the SBIG AO, dim guide stars and/or short exposures are common and can be difficult for auto contrast algorithms to get right. By trying different contrast algorithms, you should be able to “see” the guide star. The underlining autoguide algorithm doesn't care about the contrast setting—it will pick out the guide star if it is bright enough, only a few counts above the background, even if you can't see it. A good measure of how well the SBIG AO is autoguiding is to monitor the **Wander** (see section “SBIG AO Settings” for details).

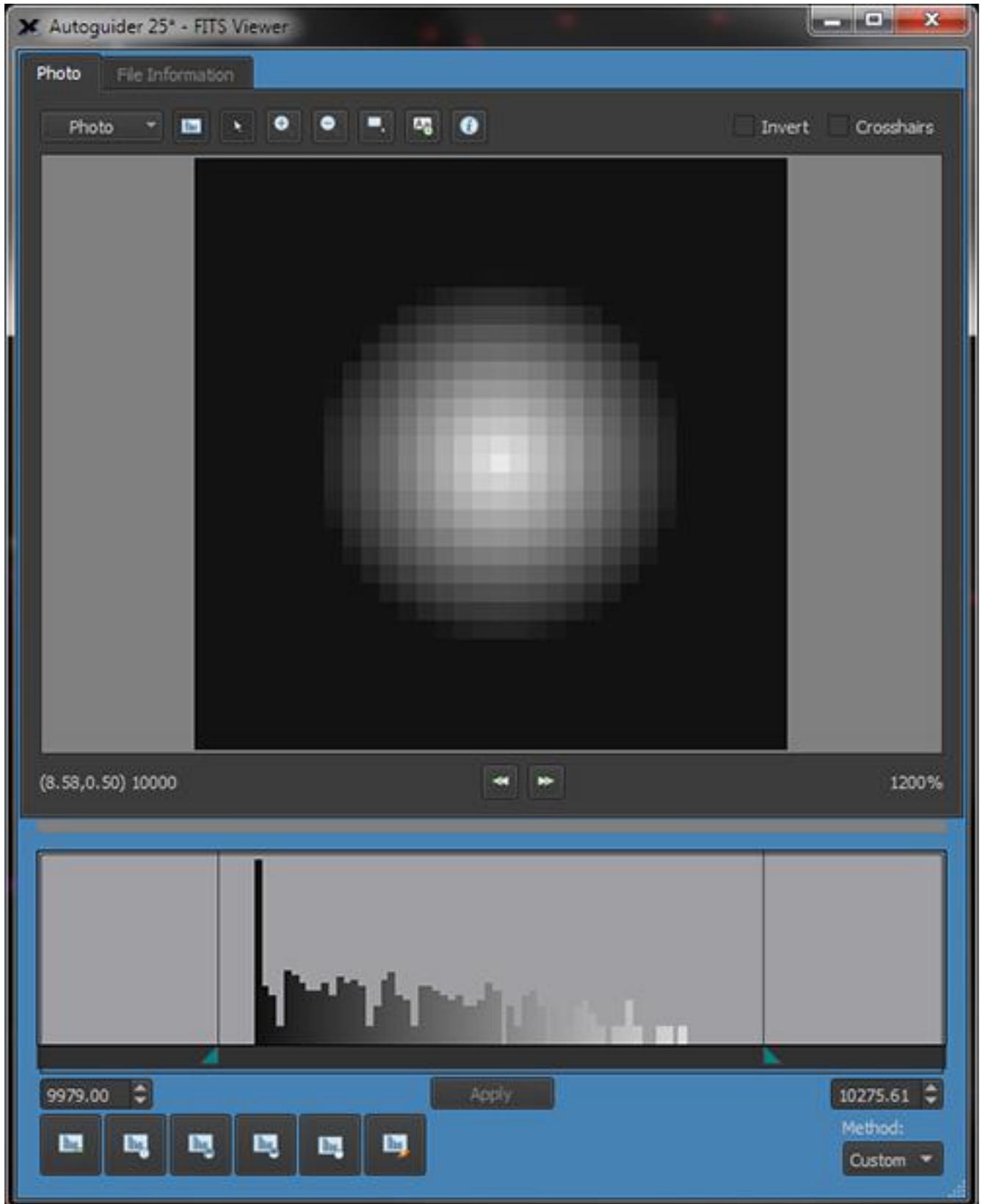


Figure 218: You may need to adjust the contrast to see fainter guide stars while autoguiding.

## SBIG AO Settings

To access the *Camera Add On's* SBIG AO controls, see the **Autoguide** tab on the **Autoguider** window (Figure 219).

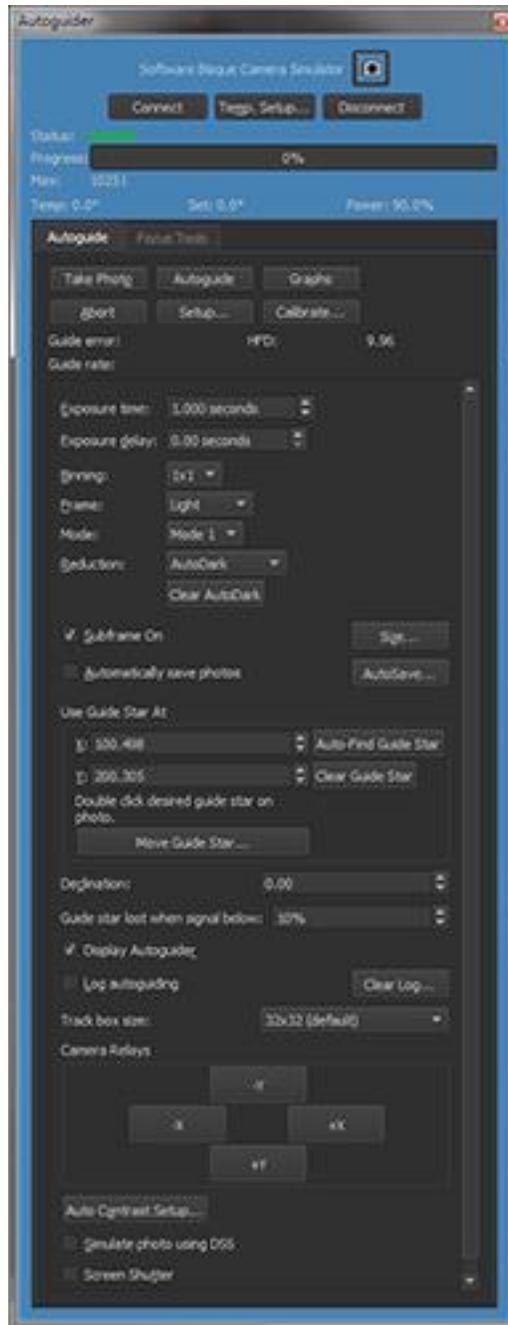


Figure 219: The Autoguide window showing AO-related controls.

The most frequently used AO settings are found at the bottom of the scrolling controls on the **Autoguide** tab. Check **AO Enabled** to turn on the SBIG AO for autoguiding. Unlike most other controls of the *Camera Add On*, **AO Enabled** (and **Fan On**, **Aggressiveness** and **Slew Rate**) are real-time controls in that they apply immediately when you change them. This allows you to turn

on AO guiding, camera fan, aggressiveness and slew rate while autoguiding is in progress. The following list explains all of the AO features found in this window.



If you have the **AO Enabled** checkbox turned on and checked the AO will “do its thing” and tip/tilt the AO mirror to guide *and* if necessary the relays will bump the mount to bring the AO mirror near center. If you do not have **AO enabled** checked, the AO will not perform any corrections *and* no relay bumps will occur. In other words, when **AO enabled** is not checked, no guiding of any kind occurs. If you want to do normal guiding, disconnect and switch to your regular camera setting (for example, a specific SBIG camera by name).

| Control               | Description  |
|-----------------------|--|
| <b>AO enabled</b>     | When this checkbox is turned on, the SBIG AO will operate during autoguiding. This checkbox can be toggled during autoguiding. Unlike most other <i>Camera Add On</i> controls, this control remains active in real time during autoguiding. When turned off, no guiding occurs (no SBIG AO mirror tilt and no “bumping” of the mount with the camera relays occurs).  |
| <b>Fan on</b>         | <p>This checkbox turns the camera fan on and off and can be toggled during autoguiding. Note that the fan may introduce a small vibration that can affect the quality of the photo; turning it off may improve your image sharpness at long focal lengths and high magnifications. Unlike most other <i>Camera Add On</i> controls, this control remains active in real time during autoguiding.</p> <div style="margin-top: 10px;">  <p>Your camera cooler may have to work harder to maintain its temperature if you shut off the fan. Keep an eye on the <b>Power</b> text at the top of the <b>Autoguide</b> tab and monitor the percentage of cooling capacity in use. It should stay below 90% for effective cooling.</p> </div> |
| <b>Center button</b>  | Click this button to center the SBIG AO’s mirror. The center position is at the middle of the range of motion for both X- and Y- axes. A warning message is displayed when this button is clicked since centering will change the field of view, so you should re-take any reference image before proceeding after centering the mirror. Otherwise, a guide star currently in the field of view could move out of the field of view, or be at a slightly different position.   |
| <b>Aggressiveness</b> | This functions like the aggressiveness setting when guiding with camera relays. A value of 10 means that 100% of a correction (mirror tilt) will be made. A value of 5 means that 50% of the indicated correction will be made, and so on.   |
| <b>Slew rate</b>      | Controls how the AO reacts to large error corrections. The units are arcseconds/second. If a correction would exceed this value, it is limited to this value. In order for this option to work correctly, you must enter your telescope focal length by clicking <b>Telescope &gt; Telescope Setup</b> , then highlight <b>Camera</b> and  |

| Control            | Description  |
|--------------------|--|
|                    | click <b>New Photo Defaults</b> . For example, a slew rate of 250 arcseconds per second at 5 Hz would result in a maximum 50 arcsecond correction.   |
| <b>X tilt</b>      | The current tilt of the mirror in the X-axis (left to right with respect to the camera, if the SBIG AO is mounted to the camera according to the instructions from SBIG). The mirror tilts in the X-axis from 0% to 100%, with 50% being the middle position.  |
| <b>Y tilt</b>      | The current tilt of the mirror in the Y-axis (top to bottom with respect to the camera, if the SBIG AO is mounted to the camera according to the instructions from SBIG). The mirror tilts in the Y-axis from 0% to 100%, with 50% being the middle position.  |
| <b>Wander</b>      | The amount of guide star position error left <b>after</b> the AO makes a correction. In other words, this is the amount of error that the AO cannot correct. It will be higher if the seeing is bad, the guide rate is too low, or when the AO is oscillating from over-correction. It may be helpful to compare the <b>Wander</b> value with and without the SBIG AO enabled: the <b>Wander</b> value without the SBIG AO is controlled by the seeing; the <b>Wander</b> value with the SBIG AO shows the improvement obtained using the SBIG AO. You can tune the <b>Slew Rate</b> and <b>Aggressiveness</b> settings to minimize <b>Wander</b> with the AO enabled. |
| <b>First count</b> | The flux (total brightness above the background) of the guide star. All the pixel values in the star above the background are summed to find the star's flux.  |
| <b>Count</b>       | The current flux (total brightness) of the guide star. Compare this to the <b>First Count</b> value during guiding. If this value changes by a large amount following a download, the current guide star might not be the same as the original. If the value drops slowly over time, focus may be shifting. If this value jumps erratically, seeing may be poor, or clouds may be passing through.   |
| <b>Guide rate</b>  | The rate at which the SBIG AO is guiding. This will sometimes be slower than the actual exposure time suggests. For example, if you are using an exposure time of 0.25 seconds, you might expect a guide rate of 4 Hz (4 times per second). However, the download time, display time, and computer processing time slow this down. A very fast computer could hit a maximum guide rate as high as 60Hz with a sufficiently bright guide star and a small track box. Dimmer stars and slower computers will achieve lower rates. As a point of comparison, a 300 MHz laptop can achieve a guide rate of 8 Hz.   |

## Autoguide Calibration Using Relays

When autoguiding with the SBIG AO, there are two *types* of autoguiding taking place. The SBIG AO tips and tilts its mirror to make rapid, precise guide corrections. Over time, the guide star may drift, and the AO accommodates this drift as it continues to guide. If the star's drift is large enough, the mirror has a larger base tilt. When the base tilt reaches a certain value, the mount is moved in the opposite direction (“bumped”) using the camera relays or Direct Guide. This puts the AO mirror back closer to the center of its range of motion.

These two types of guiding (mirror tip/tilt and camera relays/Direct Guide) are the reason that you must have both the autoguider calibrated using camera relays/Direct Guide *and* the autoguider calibrated using the SBIG AO before you can successfully autoguide using the SBIG AO.



- If you have a Paramount mount and ProTrack™ is enabled, the *Camera Add On* usually does not need to bump the relays to keep the AO within its range of motion as ProTrack adjusts for nearly all the stellar drift.
- The aggressiveness setting for the mount applies when using the SBIG AO. A lower aggressiveness setting on the **Relay Settings** tab results in smaller (but more frequent) mount movements. A higher aggressiveness setting results in larger (and less frequent) mount movements. Too frequent mount movements can reduce the effectiveness of the SBIG AO. Too large mount movements can result in elongated stars. You will need to determine a happy medium for the aggressiveness setting that balances these two extremes.

For details on relay calibration for autoguiding, please see “Autoguider Calibration” on page 469.

## Additional AO Settings

Figure 219 shows the basic AO settings available on the **Autoguide** tab. In most cases, you will not need to adjust any other settings to get good results with the SBIG AO. However, additional AO parameters are available on the **Autoguide Settings** window's **AO Settings** tab (Figure 220). You can use these settings to refine the accuracy and performance of the SBIG AO. To access this window, click **Setup** on the **Autoguide** tab of the **Autoguider** window (refer to Figure 219).

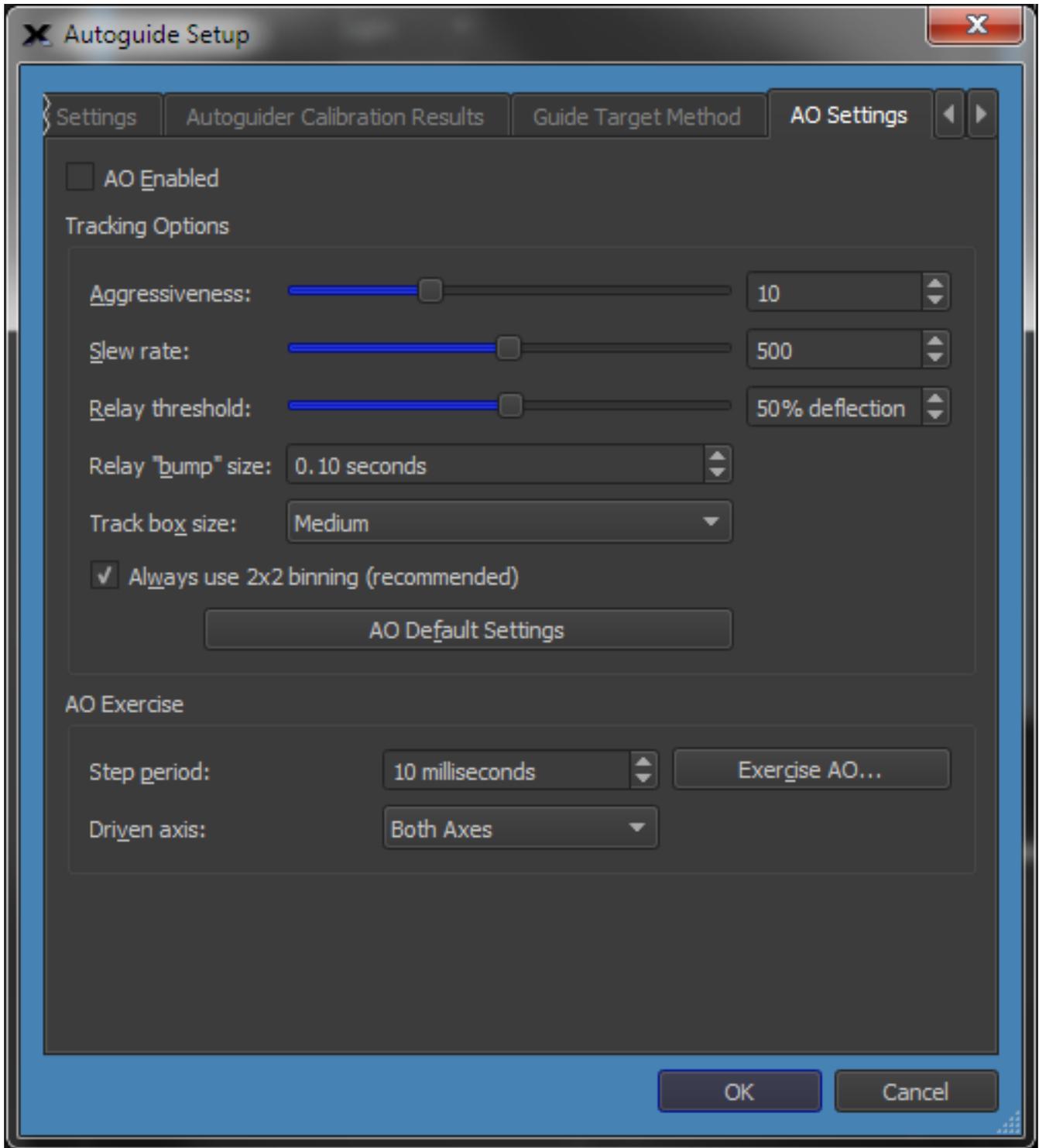


Figure 220: The AO Settings tab on the Autoguide Setup window.

The **Tracking Options** section of the **AO Settings** tab contains the following settings:

| Control               | Description   |
|-----------------------|---|
| <b>Aggressiveness</b> | This is the same as the aggressiveness setting for the SBIG AO on the <b>Autoguide</b> tab. |

| Control                  | Description  |
|--------------------------|--|
| <b>Slew Rate</b>         | This is the same as the slew rate setting for the SBIG AO on the <b>Autoguide</b> tab.   |
| <b>Relay Threshold</b>   | The amount of mirror tilt that must occur before the mount is “bumped” with the camera relays. The default value is 50%, and this will work for most situations. If the seeing is very steady, and you would like to see less frequent mount movement, set this to a higher number. Never set the number so high as to cause the mirror to reach the end of its travel; the mirror cannot make corrections beyond 100% movement. Always leave a margin of safety. If seeing is poor, you can increase the safety margin by lowering this value.  |
| <b>Relay “bump” size</b> | <p>The relay bump size defines how much the telescope is moved when the SBIG AO mirror runs out of tilt. The bump size unit of measurement depends on the type of guiding:</p> <ul style="list-style-type: none"> <li>• For camera relays, the unit is seconds of time that the relay is closed.</li> <li>• For Direct Guide, the unit is more closely related to, but not exactly, arcseconds of movement.</li> </ul>   |
| <b>Track Box</b>         | The size of the subframe used for autoguiding with the AO. Available values are small (4x4 pixels), medium (8x8) and large (16x16). A smaller track box allows for faster downloads and thus faster guiding. However, if the track box is too small, seeing-induced movement may cause the star to be lost, resulting in poor guiding. On any given night, the seeing will limit the size of the track box you can use.  |
| <b>Always Use 2x2</b>    | <p>Binning the guide chip 2x2 increases its sensitivity. For a given star, the guide rate will be slower with 1x1 binning than with 2x2 binning. Since AO corrections are limited by exposure length, the shorter exposures possible with 2x2 binning allow you to use faster guide rates. A faster guide rate means the AO can work more effectively.</p> <div style="display: flex; align-items: center; margin-top: 10px;">  <p>The increased sensitivity for 2x2 binning comes from an increase in signal to noise ratio. Signal increases 4 times (<math>2^2</math>), and noise only increases <math>\sim 1.4</math> times (square root of 2). Therefore, the best possible signal to noise increase is from <math>x</math> to <math>(4x/1.4)</math> or <math>2.85x</math>.</p> </div> |
| <b>Use AO Defaults</b>   | Click this button to restore the default settings.   |

The **Exercise AO** group of controls allows you to test the movement of the AO mirror. You should remove the AO from the telescope when testing and observe whether the motion occurs. The AO device will make a light vibrating sound while it is being exercised.

The **Exercise AO** section contains the following settings:

| Setting            | Description   |
|--------------------|---|
| <b>Step period</b> | Defines how long to move the SBIG AO for each step. The default value is 10 milliseconds.   |
| <b>Driven axes</b> | You can test the X- or Y-axis alone or both axes together.  |
| <b>Exercise</b>    | Click this button to begin exercising the SBIG AO. A window appears during exercising to show the current X and Y position of the mirror. Click <b>Cancel</b> to stop the exercise process. |

When you are finished making changes to the **AO Settings** tab, click **OK** save them, or **Cancel**.

## AO Calibration



Even if you are using the SBIG AO for guiding, you must still calibrate the autoguider using relays as well. See the section, “Autoguide Calibration,” for information. The relay calibration must be done prior to guiding with the SBIG AO. If mount calibration fails, the SBIG AO may be unable to guide accurately, because movement of the mount via camera relays during guiding will be incorrect and the guide star will be lost.

During drive calibration, the *Camera Add On* takes a photo, moves the mount in a given direction, and then takes another photo. The difference in the calibration star’s position between the two photos tells the Camera Add On how fast the mount moves in each of the four directions. Once calibrated, the *Camera Add On* can issue guide corrections that are as accurate as the mount will allow. Various factors, such as backlash and rough gear surfaces, can reduce the accuracy of mount-based guiding.

With the SBIG AO, corrections are made by tipping and tilting a small, lightweight mirror. There are no gears to worry about, and the mass of the mirror is tiny compared to the mass of a mount. In addition to its adaptive optics capabilities, the SBIG AO provides very accurate guiding and can compensate, up to a point, for an inaccurate mount. The mount must be accurate enough to move reliably with the camera relays. You can use a larger track box (see preceding section) to compensate for some of the mount’s inaccuracies—a larger track box makes it less likely that a mount error will push the star out of the track box.

As with any calibration, the key to success is finding a suitable star for calibration. A good calibration star must be the brightest star in the field of view, and there must not be similar bright stars nearby that will move into the field of view during calibration. You can use stars the simulated stars on the Sky Chart to help locate suitable calibration stars. For more information about selecting stars for calibration, please see the section “*Choosing a Good Autoguider Calibration Star*” on page 475.

Adjust the telescope position to put the calibration star roughly in the center of the photo. This will prevent it from moving out of the field of view during calibration. Next, click **Calibrate** on the **Autoguider** tab of the **Autoguider** window to show the **Calibration Autoguider** window (Figure 219).

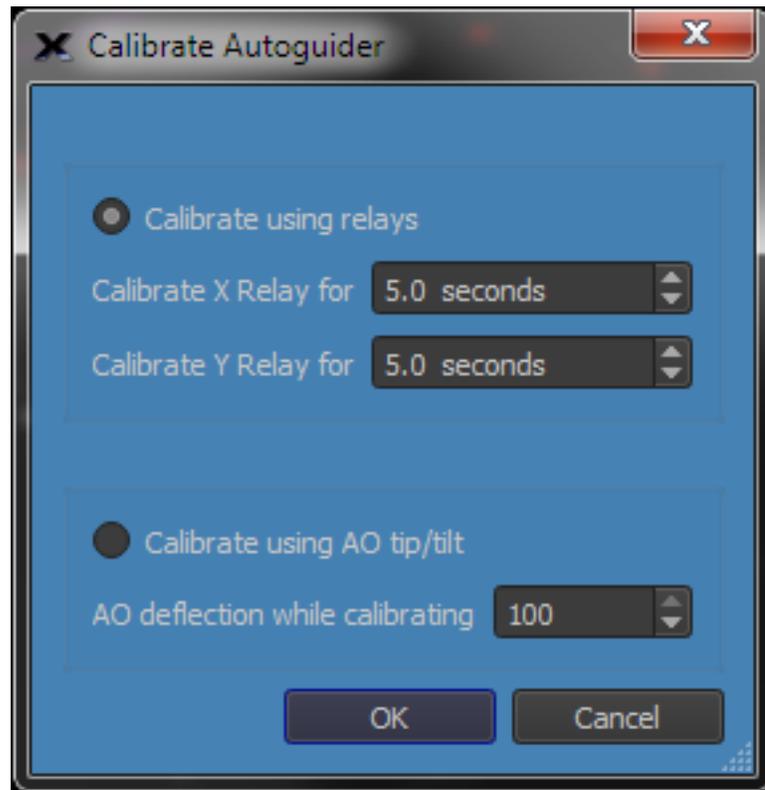


Figure 221: Calibrating the SBIG AO.

Click the **Calibrate Using AO Tip/Tilt** radio button to use this calibration method. For most applications, use 100% as the **AO Deflection While Calibrating**. You can reduce this number to see if it improves the perpendicularity of calibration. Use the **AO Calibration Results** tab of the **Autoguide Settings** window to evaluate AO calibration (Figure 222).

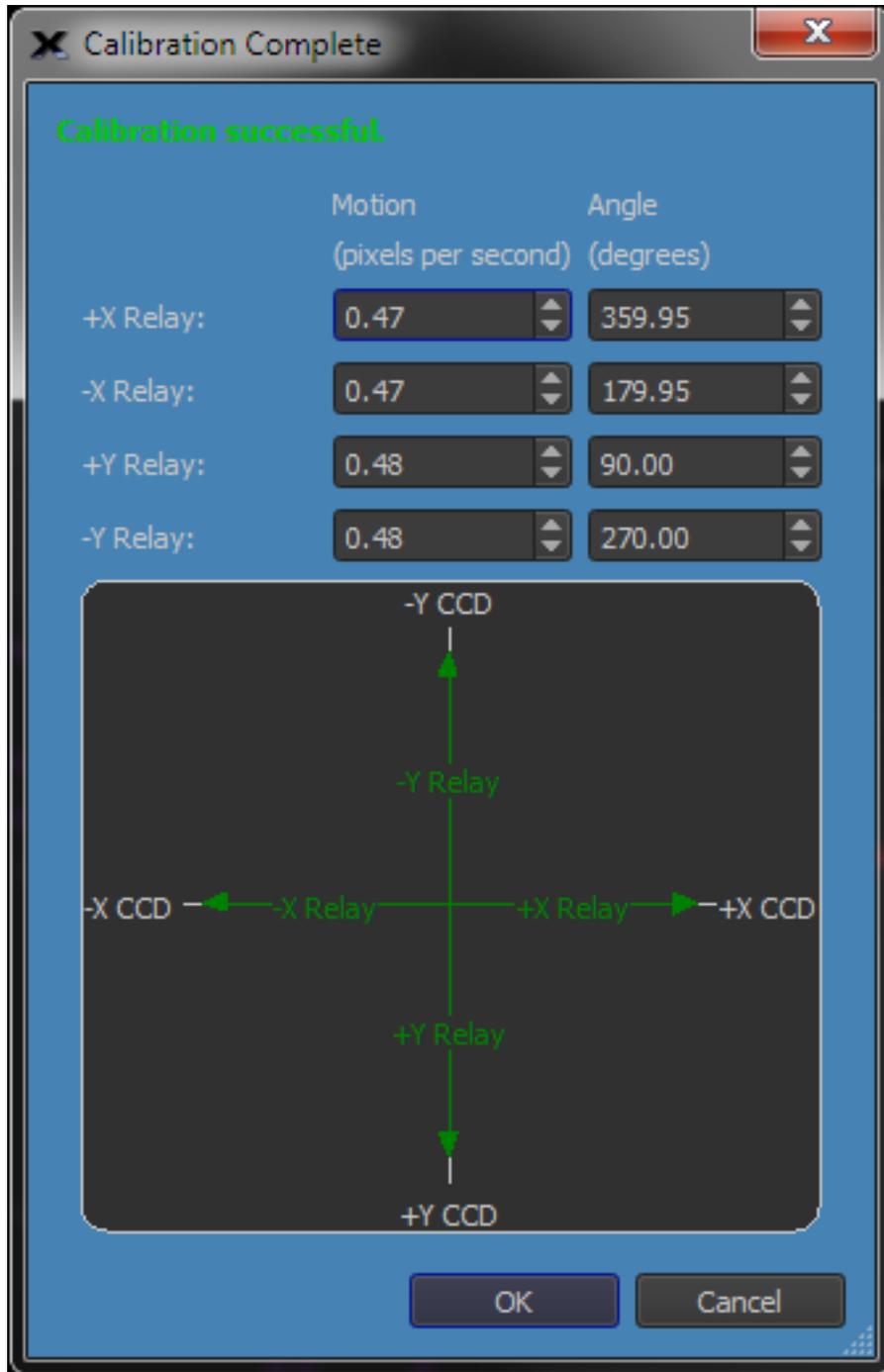


Figure 222: AO calibration results.

Note that the X/Y axes of the calibration results (green arrows) are not necessarily perpendicular to the reference X/Y axes. This is normal. Even if the camera and SBIG AO are installed exactly orthogonal to the mount's axes, the vector showing AO movement may be slightly non-orthogonal because of how the mirror moves. The *Camera Add On* takes this into account and will guide accurately with the SBIG AO.

## AO-Assisted Autoguiding

Once you have calibrated the autoguider using both relays and the SBIG AO, you can use the SBIG AO for guiding. Start by clicking **Take Photo** from the **Autoguide** tab of the **Autoguide** window.

As with calibration, the key to successful autoguiding is finding a suitable guide star. The guide star should be away from the edges of the chip, and if you are using color filters it should be bright enough to remain visible through all filters. The brighter the guide star, the faster the guide rate you can use. Since the SBIG AO works best with the brightest available guide star, it's usually worthwhile to find the brightest one you can.

You can use *TheSkyX* to help locate suitable guide stars, adjust the framing of your photo, or rotate the camera to find the best available guide star. For more information about selecting stars for guiding, please see the section "Select a Guide Star" on page 478.

Adjust the telescope position to put the guide star at least 10 pixels away from the edges of the guide window. This will make it less likely that the guide star will move off of the guide chip during guiding. You can adjust the guide star's position using the mount's hand paddle; *TheSkyX* mount controls; or using the **NSEW** buttons on the **Autoguide** tab. The **NSEW** buttons move the telescope at the current guide rate using the camera relays, and you can use them to make very small adjustments to position.

Before you start autoguiding, you can make final adjustments to guide parameters. Settings for **Aggressiveness** and **Slew Rate** can be made right on the **Autoguide** tab. You may also need to adjust the **Track Box Size** to adjust for seeing conditions. The better the seeing conditions, the smaller the track box you can use. Figure 223 shows the appearance of the three track box sizes. Note that different zoom levels are used for the track boxes, so the track box stays the same size, but the relative size of the star changes. From left to right, they are Small, Medium, and Large. The Small track box requires very good seeing (steady skies), or the star will move out of the track box. The Medium setting is good for more typical seeing conditions, and the Large track box allows you to use the SBIG AO on nights when the seeing is below average.



Figure 223: Different sizes of the AO track box. From left: Small, Medium, and Large.

Once the guide star is properly positioned, click **Autoguide** to begin guiding. The *Camera Add On* takes multiple dark frames and averages them to reduce noise in the dark frame. This master dark is subtracted from all light frames to provide as clean an image as possible during guiding. If your exposure time is relatively long (for example, 5 seconds), it will take longer to capture the multiple dark frames before the start of guiding. A 5-second exposure will not give you any

benefits of the adaptive optics, but could be used instead of conventional guiding if your mount does not handle guide corrections effectively.

During guiding, you can monitor the effectiveness of guiding by watching the values in the **AO Enabled** section of the **Autoguide** tab. The **X** and **Y Tilt** values show the current tilt of the SBIG AO mirror. These values should change over time as the mirror tilts to accommodate drift. When tilt reaches the maximum value allowed (default is less than 25% or greater than 50%), The **Camera Add On** will bump the mount and the tilt should return closer to 50% for both axis. The amount it will go down depends on the aggressiveness setting of the mount. With low aggressiveness settings on the mount, smaller bumps will occur, and the bumps will therefore be more frequent.

The **Wander** metric indicates how accurately the SBIG AO is guiding. If the SBIG AO aggressiveness is too low, wander will be high because the SBIG AO will under correct. If the SBIG AO aggressiveness is too high, over-correction may occur and this will also increase the **Wander** value. Adjust **Aggressiveness** and the **Slew Rate** to obtain the optimal **Wander** value.



- The **Wander** metric is computed based on the physical characteristics of the telescope. Enter these parameters on the **Imaging System Setup** window (**Telescope > Telescope Setup**, highlight **Camera**, and enter the telescope's **Telescope Focal Length**).
- Local seeing conditions also affect **Wander**. Compare the **Wander** value with and without SBIG AO guiding so that you know the contribution to **Wander** from seeing.

A good measure of the optimal tuning of the aggressiveness, guide rate, etc. is the RMS wander. This wants to be as small as possible and ideally will not degrade when the AO is turned off momentarily.

Ideally an AO guided image will have 30% lower stellar half-width and 50% to 100% better peak brightness.

You can also use **First Count** and **Count** to monitor guiding. If the **Count** value drops, you may have clouds moving in or a focus shift. Focus can shift from changes in temperature, or from a physical slippage of the focuser.

The **Guide Rate** may be lower than you expect, depending on the processing speed of your computer's processor. For example, if you are using an exposure of 0.02 seconds, you might expect a guide rate of 50 Hz (exposures per second). However, it takes time to download and display images, and it takes additional time to perform calculations on your computer. This time is added to each exposure, resulting in the actual guide rate. In this example, the guide rate might be anywhere from 6 to 40 Hz depending on your equipment.

Autoguiding will automatically suspend during downloads from the main imaging chip. Autoguiding will resume when the download is complete. If you are using a Small or Medium

track box, the guide star may have drifted out of the field of view during the download. Cameras with USB download are much faster, and it is more likely that you will retain your guide star using a USB-equipped camera. An extremely accurate polar alignment will also help you retain your guide star following a download.

If the guide star is lost, or if a different guide star is found, you can **Abort** the guiding and restart it with the desired star. Re-center the mirror if tilt is large. Click **Take Photo** to get a new image using the guide star, click to select the guide star, and then click **Autoguide** to begin again. If you are taking a sequence of images, you may need to monitor the downloaded images and the guide star window to determine if the guide star is still available.



## Taking Series of Photos

The *Camera Add On* gives you the ability to acquire multiple photos, in sequence, using the **Take Series** tab on the **Camera** window.

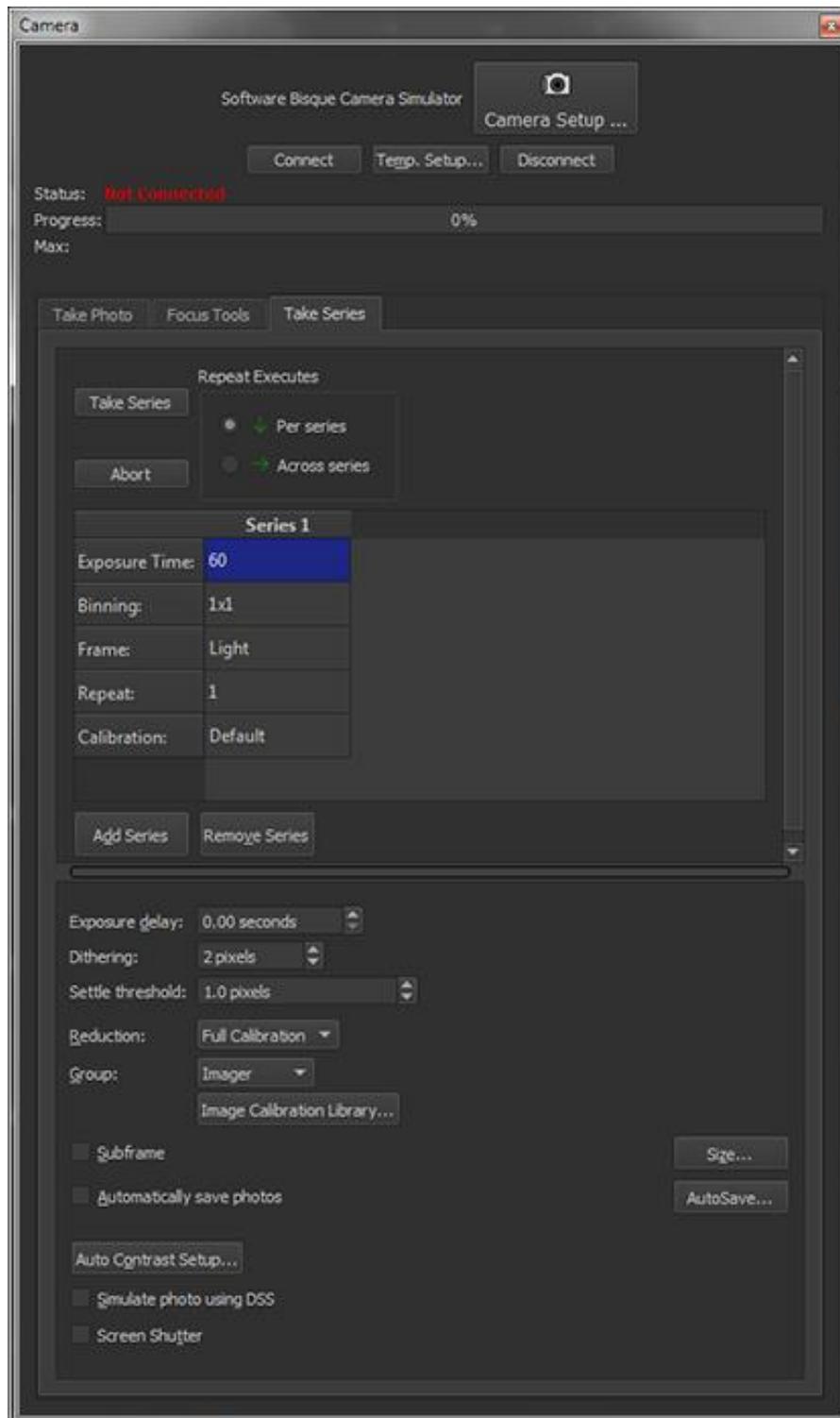


Figure 224: The *Take Series* tab on the *Camera* window.

### **Take Series Button**

Click this button to begin the process of taking photos based on the settings in the **Series** table.

### **Repeat Executes Options**

These two options permit a flexible means to control how individual series are executed.

#### **Per Series**

When this option is selected, **Series 1** is repeated based on the **Series 1 Repeat** value, followed by **Series 2**, which is repeated based on the **Series 2 Repeat** value, and so on until the series is completed.

For the series defined in Figure 224, **Series 1** is repeated 10 times, followed by **Series 2**, which is repeated five times, followed by **Series 3**, eight times, followed by **Series 4**, three times.

#### **Across Series**

When this option is selected, **Series 1** is executed first, and once, regardless of the **Repeat** value, then **Series 2** is executed once, regardless of the **Repeat** value, and so on until the end of the series. The series execution continues for each series that has a **Repeat** value greater than one.

For the series defined in Figure 224, **Series 1-4** are each executed three times, then series 1-3 are executed two more times (since the **Repeat** count of **Series 2** is 5, and that makes five repeats), then Series 1 and 3 are each executed three more times, and Series 1 repeats to more times for a total of ten repeats.

#### **Abort**

Click this button to stop taking a series of photos.

### **Series Table**

The top row of the **Series Table** lists each series, starting with **Series 1**.

The left-most column of the **Series Table** lists the camera settings (and filter settings, if a filter wheel has been selected) that will be applied to each series. To edit any one of the series parameters, double-click the appropriate table entry. For example, double-clicking on the number *10* next to **Exposure Time** shows the spin box that lets you enter a different value.

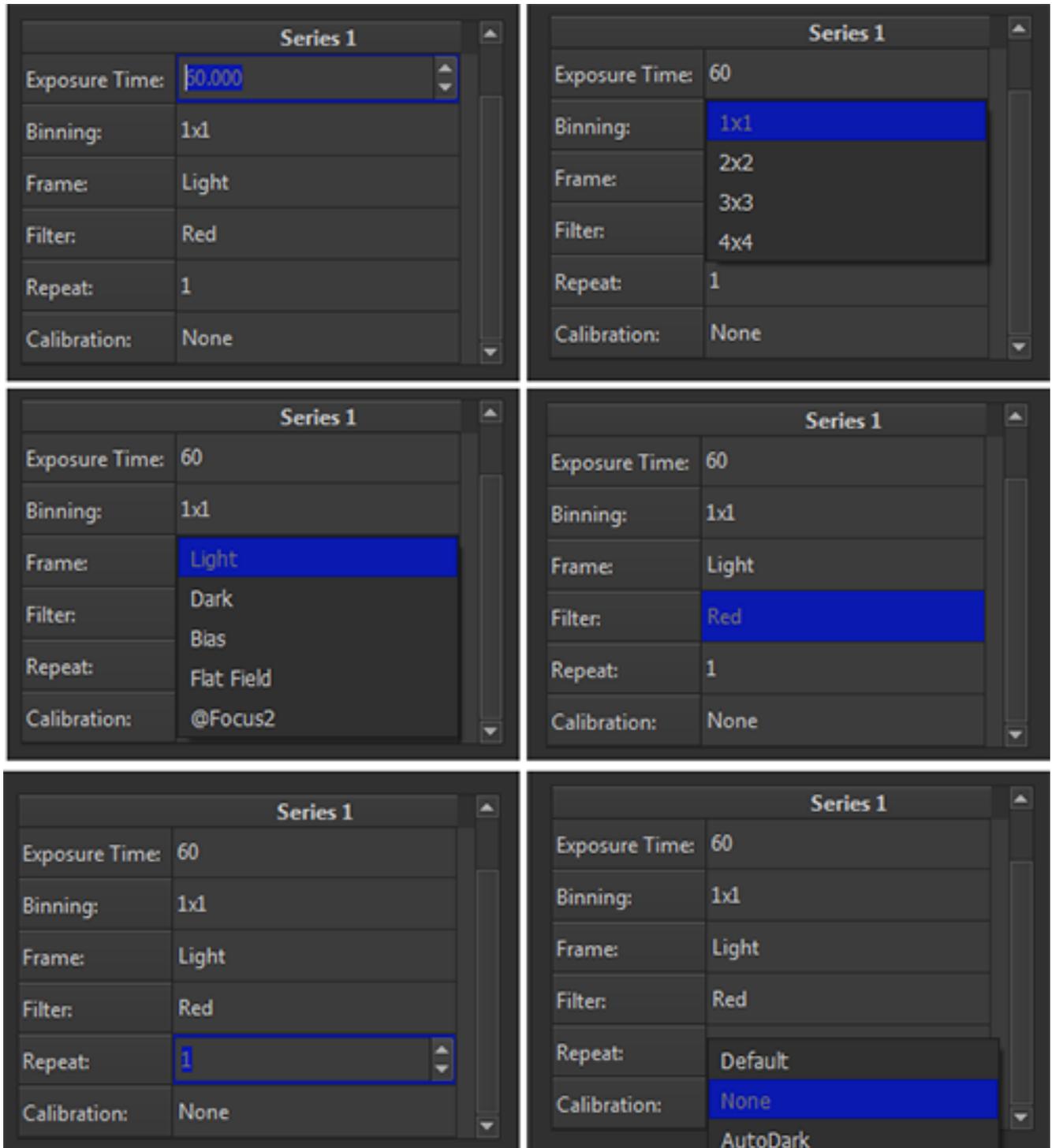


Figure 225: To change a camera or filter setting for a series, double-click the appropriate table to reveal the text input control or pop-up menu.

### ***Exposure Time***

Enter the length of the exposure, in seconds, for this series. See “Select Exposure Length (Exposure Time)” on page 456 for details about this camera setting.

### **Binning**

Choose the binning for this series. See “Select Bin Mode (Binning pop-up)” on page 458 for details about this setting.

### **Frame**

Choose the type of frame (**Light, Bias, Dark, Flat Field**) to capture for this series. See “Set Frame Type to Light” on page 460 for details about this camera setting.

### **Filter**

Select the desired filter for this series. Note that the **Filter** option is displayed only if an appropriate filter wheel is selected on the Imaging System Setup window.

### **Repeat**

Enter the number of times to repeat this series.

### **Calibration**

Each series can have its own image calibration setting.

- **Default:** Apply the selected **Reduction** option (**None, AutoDark, or Full Calibration**) described under **Reduction (Default Calibration)** below.
- **None:** Do not calibrate the images acquired in this series.
- **AutoDark:** Apply a dark frame to photos.
- **Full: Imager:** Apply a calibrated photo to the photos acquired with the imaging camera.
- **Full: Autoguider:** Apply a calibrated photo to the photos acquired with the guiding camera.

These options allow, among other possibilities, creating master flat images for multiple filters and to have the reduction process proceed automatically during image acquisition without user intervention.

### **Add Series**

Click this button to add a new series to the **Series Table**.

### **Remove Series**

Click this button to remove the selected series from the **Series Table**.

The options that appear on the lower portion of the **Take Series** tab are applied to each series. For example, an **Exposure Delay** of 10 seconds, is applied to every series automatically.

### **Exposure Delay**

Enter the delay between each exposure in each series to allow for telescope settling.

### **Dithering**

Enter the number of pixels to move the guide star (specifically, the telescope) between successive photos in the series.

### **Settle Threshold**

Enter the maximum deviation, in pixels, of the guide star after the telescope's position has been adjusted during dithering process.

The threshold value only applies when dithering is taking place. While dithering, the guide star is "moved" and the next photo from the autoguider is interpreted as a large guider error. Over subsequent guider photos, the error is corrected until the guider settles into its new position. This value represents the largest acceptable guider error that should be detected before resumes.

### **Reduction (Default Calibration)**

This reduction setting is used when the **Default** option is selected from the **Calibration** pop-up menu in the series.

- **None**: Do not apply any reduction to the photo.
- **AutoDark**: Apply a dark frame to the photo.
- **Full Calibration**: Apply a calibrated photo to the photo.

The following options are only displayed when the **Full Calibration Reduction** option is selected.

### **Group Pop-up Menu**

Choose either **Imager** to apply a calibrated photo from **Image Calibration Library** for the imager, or **Autoguider** to apply a photo for the autoguider.

### **Image Calibration Library Button**

Click this button to show the **Image Calibration Library** window. See "Taking Calibration Frames" on page 534 for more information about image reduction and calibration.

### **Subframe On**

Turn this option on to show and use a portion or subframe of the photo instead of the full frame.

### **Size Button**

Click this button to define the size of the subframe.

### **Automatically Save Photos**

Turn this checkbox on to automatically save photo acquired during the series.

### **AutoSave Button**

Click this button to show the **AutoSave Setup** window to configure the AutoSave settings (page 462).



## ***Image Reduction***

Image reduction allows you to clean up images to better reveal the data in them. You can in effect take pictures of some of the noise in your imaging equipment, and then use those pictures to remove much of the noise.

Noise is the error in the brightness levels in an image. Noise can occur from a variety of sources. Some noise is random and unpredictable. Such noise can be limited, but never removed. This type of noise is defined as the level of uncertainty in brightness levels. For example, if you took four images of an object, you might see brightness levels of 98, 97, 103, and 102. That variation in brightness reflects the error level.

Other types of noise are inherent to the imaging equipment, and this type of noise is called system noise. System noise can be subtracted from your images to clean them up. It builds up while you are taking your image, and while reading the image off of the CCD detector. By taking steps to limit noise in the camera (mainly by cooling the detector), and by removing the repeatable noise that is left, you can achieve very high-quality images. Image reduction, however, can only clean up an image so far. The quality of the image itself determines that limit. Longer exposures, or combined exposures, when reduced properly, will give you the highest level of quality possible.

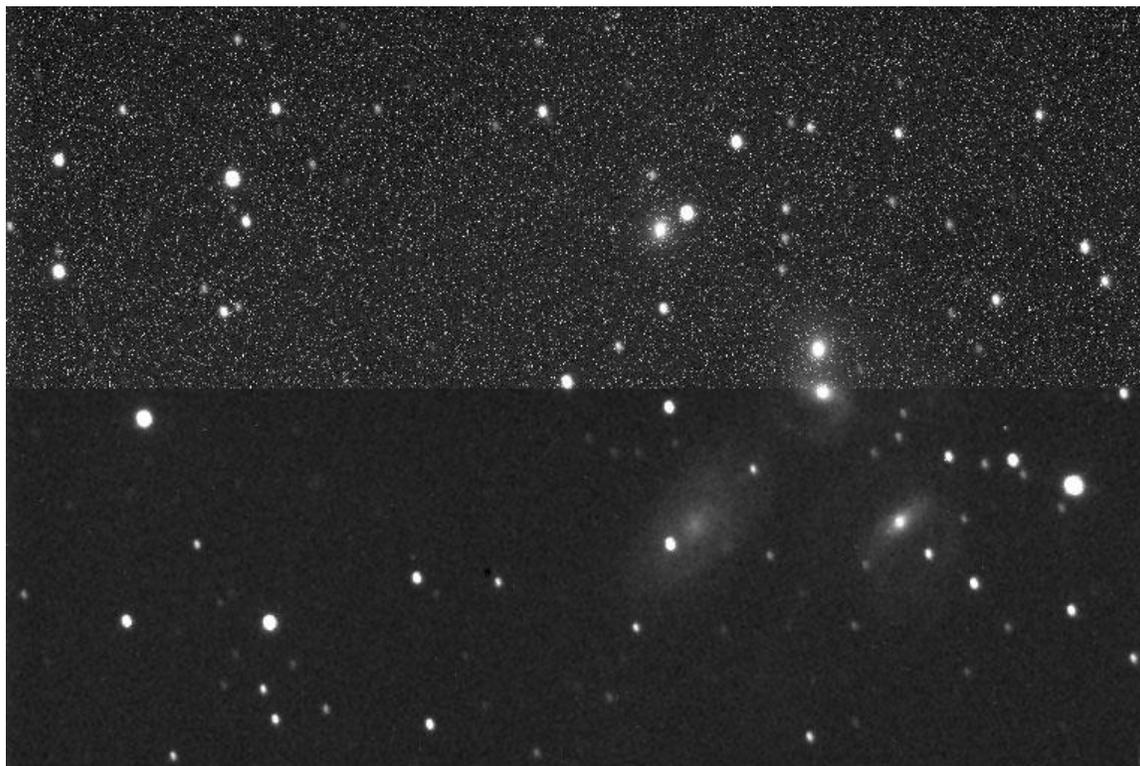
All noise by nature creates uncertainty in the brightness levels of the pixels in your image. If a picture has a lot of noise in it, you can see this visually. There will be variations in brightness in areas that you expect to have a more uniform brightness. Words commonly used to describe this effect are “grainy” and “gritty.”

Some common sources of system noise in CCD imaging include:

- **Readout noise** results from collecting, amplifying, and converting pixel data to electrons inside the camera.
- **Dark current** results from electrons accumulating in pixels even in the absence of light.
- **Optical dust** is debris and bits of dust in the optical path that cast shadows on the CCD detector.
- **Background noise** results from sky glow.
- **Reflections** are the effects of light that reflects off various surfaces in the telescope, focuser, or CCD camera, and falls on the CCD detector.
- **Image processing noise** results from processing the image using various techniques.

Removing the system noise from your images is a form of **data reduction**. The term “calibration” is sometimes used to refer to this process, but data reduction is a more accurate description of the procedures involved. Calibration involves comparing values to a known accurate reference, such as calibrating the brightness of a star in an image using its known magnitude, or determining how far your mount moves in 10 seconds (autoguider calibration).

Even when you take steps to remove noise, you also add some noise back into the image at the same time. For example, when you subtract a dark frame (page 538), you add the dark frame's noise to the image. You are usually removing much more noise than you add, providing a net gain from this and most other noise reduction processes. Thus, there is no way to remove all the noise from an image. You can remove a lot of noise with careful technique, however. Figure 1 shows two halves of an image. The top half shows the original image; the bottom half shows the same image after data reduction.



**Figure 226: The benefits of data reduction on an image of Stephan's Quintet.**

This chapter describes how to use TheSkyX Camera Add On to remove noise from your images, leaving them cleaner and ready for further processing. In this chapter, you will learn how to:

- Acquire bias frames.
- Acquire and apply dark frames.
- Acquire and apply flat-field frames.
- Create and manage groups of bias, dark, and flat-field frames.
- Manually and automatically apply data reduction to images.

### **Quick Start for Experienced Users**

For this section, an experienced user is someone who has experience creating and applying bias frames, dark frames, and flat field frames to CCD images.

The most powerful way to apply reduction is to create **reduction groups**, consisting of any number of bias, dark, and flat-field frames. You can apply reduction groups to individual images, to a folder of images, or automatically to each image as you acquire it.

1. Create a reduction group, and add images to it. To begin, you must have appropriate bias, dark, and flat-field images to add to the group. Follow accepted guidelines for optimal creation of these files:
  - Bias and dark frames should be taken at the same temperature as the light frames.
  - Bias frames should be taken using the shortest possible exposure time.
  - Dark frames should be taken with same exposure as the light frames.
  - If matching exposure temperature and duration is not practical, the *Camera Add On* can be set to compensate for these differences.
  - Flat fields can be taken at different times and temperatures than light and dark frames. If appropriate, you can use separate dark frames for flat fields.
2. Click **Input > Photo Calibration Library** to open the **Photo Calibration Library** window. Click **Add Group** to create a new group. Try using a name that includes the date, detector temperature, and/or other items that can help you with later re-use of the group.
3. The new group will have placeholders for bias frames, dark frames, dark frames for flats only, and flat frames. Click on the placeholder, and then click **Add Frames**. Navigate to the folder with the files you want to add. Highlight the frames you want to add (use Ctrl and Shift keys to select more than one), and then click **Open**.
4. Continue until you have added all the images you desire to any or all of the four placeholders.

You now have several options for using the newly created reduction group:

- If you have one or more images open that you want to reduce, click **Calibrate**, select the photos to calibrate, and click **OK**.
- If you have a folder of photos to reduce, click **Calibrate Folder** and navigate to that folder. Then select the output folder and click the **Calibrate** button. This is a powerful feature that can save you hours of effort. For example, in just a few minutes you could apply bias, dark, and flat frames to hundreds of photos. Note: *every file* in the folder must be an appropriate photo in FITS format for the calibration group. For best results, copy images with the same calibration characteristics into a folder.
- If you are taking new photos, and want to apply the calibration group to each photo as it is acquired, start by making sure to save your photos by turning on the **Automatically Save Photos** checkbox on the **Camera** window. Next, select **Full Calibration** as the **Reduction** option. Then select the desired group from the **Group** option just below the **Reduction** option. Note: The **Group** pop-up menu is hidden unless you choose the appropriate **Reduction** option. The group you select will automatically be applied to each photo. The original photo and the reduced photo are both saved to the **AutoSave** folder. The reduced photo will have the keyword "REDUCED" added to the filename.

## Principles of Image Reduction

There are many sources of noise in the data collection process. There are three things you can do that will remove most of the noise from most images, and they all involve taking a picture that captures the noise you want to remove. These are bias, flat-field, and dark frames. Figure 2 shows an example of each type of frame.

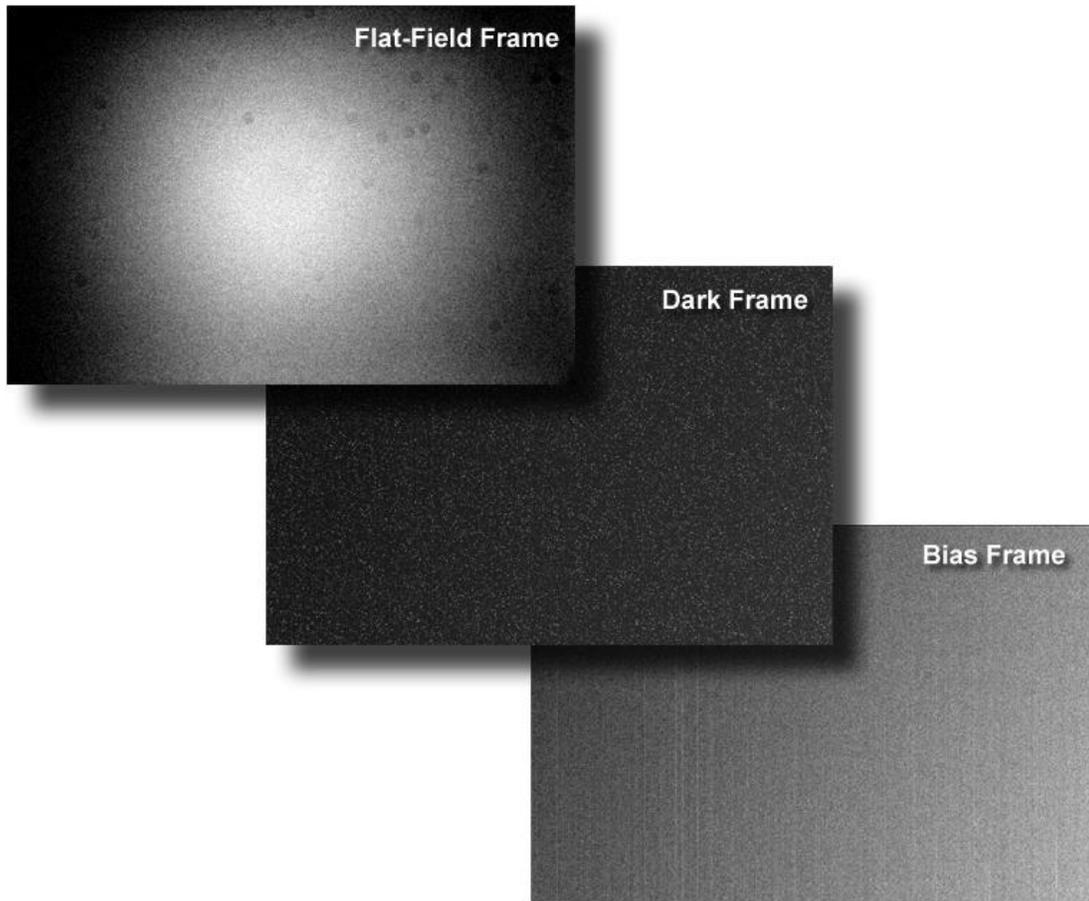


Figure 227: Samples of bias, flat-field, and dark frames.

**Bias Frames:** Bias represents pixel values that occur on your CCD detector even if the exposure time is zero (or as close to zero as possible). In other words, even a zero-length exposure still delivers non-zero brightness values. This means that pixels do not necessarily start with a zero value at the beginning of an exposure. Note: SBIG cameras include a 100-unit pedestal (that is, 100 units are added to the value of every pixel). This is true not just of bias frames, but of all frames (bias, dark, flat-field, and light). TheSkyX Camera Add On appropriately subtracts the pedestal during data reduction. You will find instructions for taking bias (and other types of data reduction frames) in later sections of this chapter.

**Dark Frames:** Even if no light strikes the CCD detector, the individual pixels change value over time, building up an electrical charge consisting of electrons that accumulate in the pixels. Most of this energy comes from heat, and it is called thermal noise or dark current. Most CCD detectors

are cooled to reduce this type of noise, but there will always be some level of dark current. The greater the cooling, the lower the dark current will be. Each pixel responds to dark current differently. Some are more sensitive, and will be brighter as a result of dark current. Others are less sensitive, and may change very little. The top half of figure 1 shows many hot pixels from dark current. Dark current varies slightly from image to image, but it is highly consistent. Thus, as with a bias frame, you can take an image with the shutter closed (or your hat over the front of the telescope if your camera has no shutter) to create a dark frame. TheSkyX Camera Add On subtracts dark frames from light frames to remove most of the effects of dark current.

**Flat Field Frames:** As light comes through the telescope and CCD camera, several things can happen. Under the best of circumstances, the light will come through unobstructed and perfectly distributed. This ideal situation is seldom the case, however. For example, the center of the focal plane is often brighter than the edges. Also, dust can get on the optical surfaces, casting shadows that affect the amount of light reaching each pixel. In addition, internal reflections can cause unwanted light to fall on the CCD detector. A flat-field frame records these variations in brightness. To create a flat-field frame, take an image of an evenly illuminated surface. Various parts of the optical path add or subtract light from the evenly illuminated surface, and the flat field records the variations.

## **Taking Calibration Frames**

Bias frames are easy to take, and require no special technique. You simply take the shortest possible exposure that your camera provides. Dark frames are also relatively simple, though you should match the temperature and exposure length of the light frame(s) reasonably well. Flat-field frames are the trickiest to master. It's not as easy as it sounds to create an evenly illuminated surface. You'll learn some useful techniques for creating good flat fields later in this chapter. The

## Bias Frames

Figure 3 shows the Take Series tab set up to take a series of three, one-minute light exposures. **Binning** is **1x1**, and no image reduction will occur because the **Reduction** option is set to **None**. See the section “Automatic Reduction” later in this chapter for information about automatic image reduction.

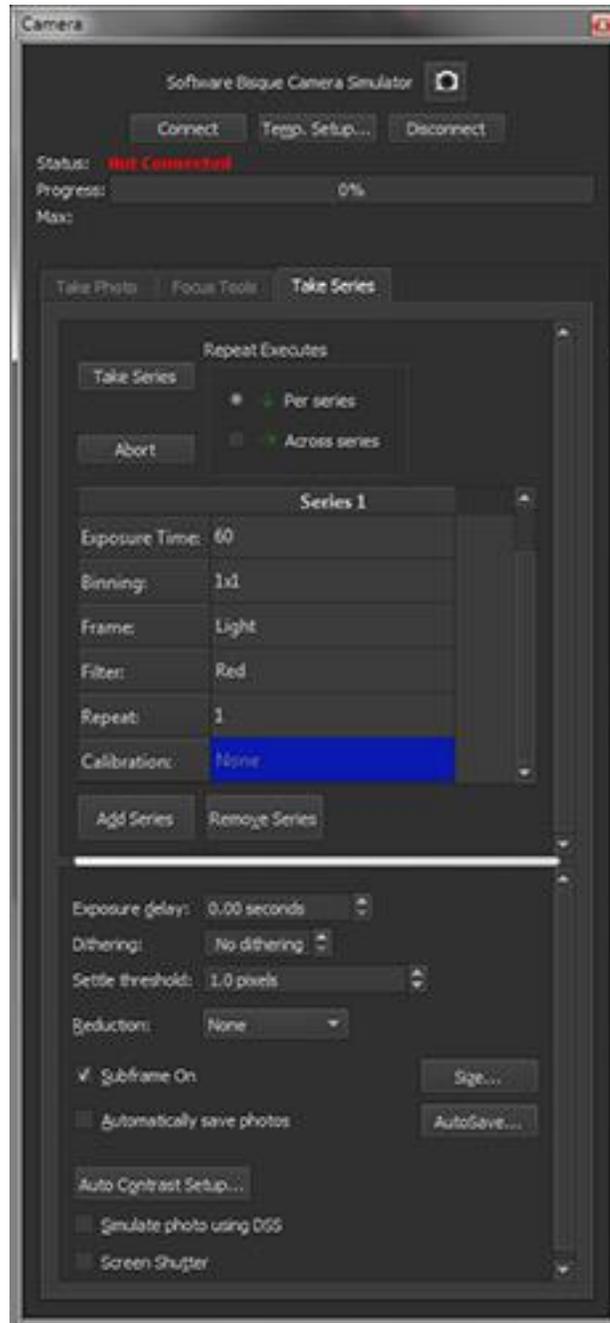


Figure 228: The light frame to which the sample bias, dark, and flat-field frames will be later applied. Note that the *Filter* row is only shown when connected to a filter wheel.

To take a bias frame for this photo, simply double click Light and instead choose Bias. Since the bias frame is the shortest possible exposure, the Exposure Time settings is ignored. TheSkyX Camera Add On will automatically use the shortest possible exposure for your camera when it exposes a bias frame.

Note that the **Repeat** setting is set to 3. We recommend taking at least three bias frames. These can be averaged to reduce noise. The images you take for image reduction have their own levels of random noise. Combining images is one of the most effective ways of reducing the random noise in your reduction frames and your images. This occurs automatically when you use reduction groups with multiple frames. See the section “Using Groups for Reduction” later in this chapter for details.

When you are ready to take your bias frames, click **Take Series**. If you have set **AutoSave** on, the filename will contain the word BIAS in it so you can readily distinguish your bias frames. For most situations, we recommend leaving **AutoSave** on to make sure that no images or reduction frames are accidentally lost. As with any image, you can cancel the bias frame or its download by clicking **Abort**.

Bias frames can only be applied as part of a group; there is no command for applying only a bias frame to an image.

The Take Series tab allows for taking multiple series of a single target. For the example at hand, we could have taken three lights, three bias and three darks like this by simply clicking Add Series. When you press Take Series photos would have been acquired in just that order, three lights, three darks, and three bias frames.

If instead you wanted to take one light, one bias, one dark, three times, simply set Repeat to one, then copy all three columns and paste to the end twice. There is really no limit to the number of series and the ability to copy and paste a series makes it fairly easy to get most any combination of frames.

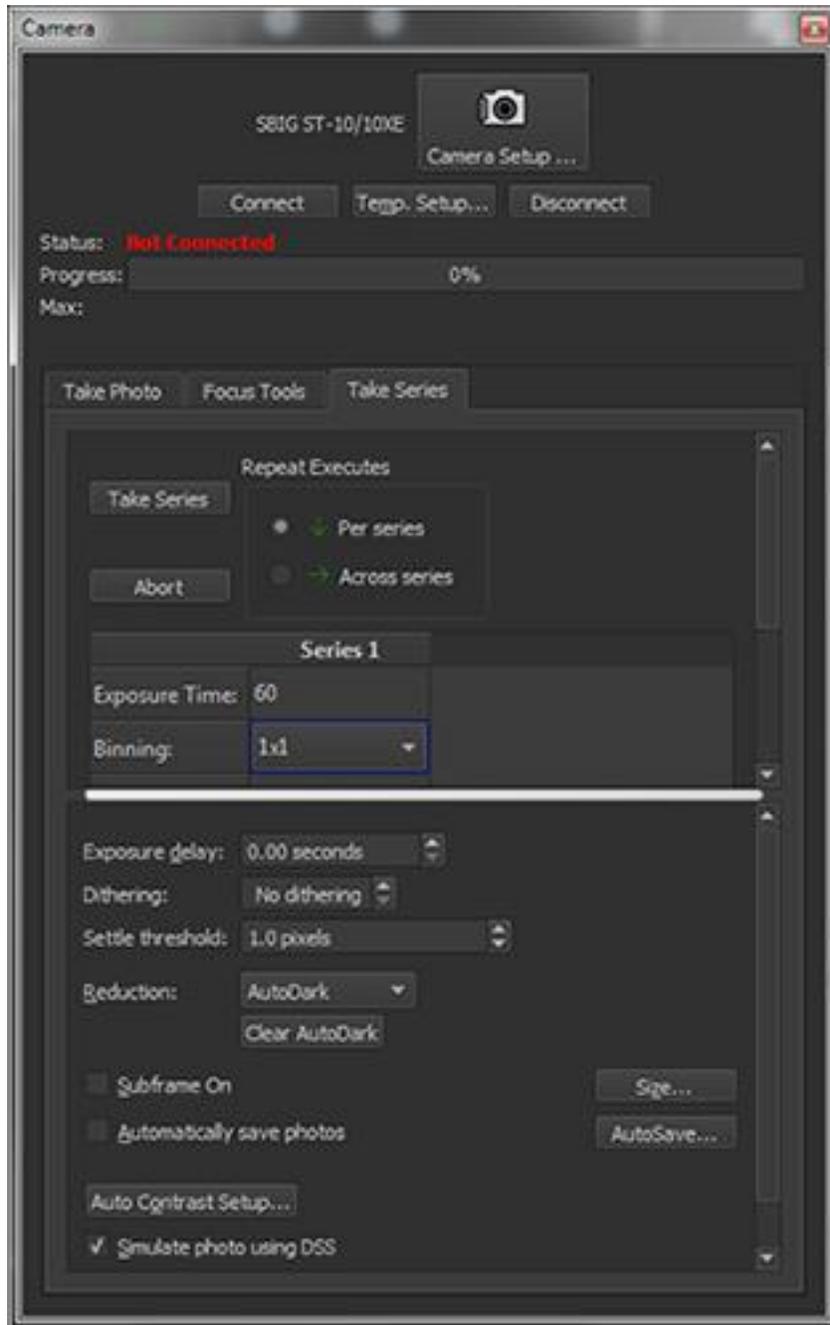


Figure 229: Take Series tab on the Camera window.

### **Dark Frames**

Dark frames are an important tool for image reduction. Dark current varies with the temperature of the CCD detector. Most CCD cameras cool the detector, some by as much as 35 degrees Celsius or more. The warmer the CCD detector, the greater the dark current and the greater the need for dark frames. For optimal noise reduction, take at least three dark frames and use them in a reduction group.

Each CCD detector has a pattern of hot and cold pixels that varies minimally from image to image. The intensity of the hot pixels varies with exposure length and temperature, however. For this

reason, you should, whenever possible, take dark frames that have the same temperature and exposure length as your light frames. If you are unable to do so, TheSkyX Camera Add On will scale dark frames to fit the exposure of a light frame. The results will not be quite as good as when you match temperature and exposure length precisely. The greater the difference in exposure time, the less likely this compensation will be effective. For example, if you have a light frame with a two-minute exposure, a dark frame of 90 seconds or three minutes will be reasonably effective. A ten-minute dark frame, however, will probably add substantial noise to the image. The colder the CCD, the less of a problem this will be, since the total noise in the image will be less.

To take a series of three dark frames matching the light frame from figure 3, simply change **Frame** to **Dark**. Note that the exposure time matches that of the light frame, and that the temperature is the same. There will often be small fluctuations in CCD detector temperature (less than a quarter degree, typically), and these can be safely ignored. The Frame has been set to **Dark**. Note that the Reduction drop-down list is disabled, since there can be no reduction of a dark frame.

When you are ready to take your dark frame(s), click **Take Series**. If you have turned **AutoSave** on, the filename will contain the word DARK so you can readily distinguish your dark frames. For most situations, we recommend leaving **AutoSave** on to make sure that no images or reduction frames are lost accidentally. As with any image, you can cancel the image or the download by clicking **Abort**, which is only active when imaging or downloading.

You may notice on some cameras that one side of the dark frame is a little brighter than the other. This is normal. It may take as much as a minute or more to download the data from cameras with very large pixel arrays, and during this time dark current continues to build up on the CCD detector. Since this gradient occurs in both the light frame and the dark frame, it is automatically removed during image reduction. Cameras that transfer the image instantly via frame buffers will not show this effect.

You can apply a single dark frame to an image, or you can apply multiple dark frames as part of a group. Since the thermal noise (dark current) in dark frames is also present in the light frame, the idea is to simply subtract the dark frame from the light frame, leaving a clean record of the light that struck the CCD detector. TheSkyX Camera Add On automatically handles the 100-count pedestal that is added to images acquired with SBIG cameras (see bias frame section above for details).

### ***Flat-Field Frames***

Like dark frames, flat fields can make a big difference in the appearance of your images. Flat, in this case, means “evenly illuminated.” Unlike dark frames, which simply require you to take an image to record the dark current, taking a good flat field requires much more operator involvement. You should expect to spend some time perfecting your technique in making high-quality flat-field frames. It’s not as easy as it might seem to evenly illuminate a surface. Stray light and reflections outside the optical tube are a challenge to control.

The flat-field frame is a record of the optical path's characteristics (see figure 14 for an example of a flat field). Anything that casts a shadow or causes a reflection leaves its imprint on the flat-field image. This includes dust on any of the optical surfaces; lint hanging from the inside of the tube into the optical path; light reflecting off of any surfaces within the tube, focuser, filter wheel, and/or camera, etc.

If you rotate your camera, change filters, use a different dew shield, or make any other changes to your system, you'll probably need a new flat field. You'll also want to take new flat fields periodically to account for any new dust that settles on the optical surfaces, or that moves or falls out of the system.

### ***Quality Issues for Flat Fields***

The best way to judge the quality of a flat field is to apply it to a test image. The ideal test image is of a sparse star field unaffected by light pollution, without any large galaxies or nebulas in the field of view. This allows you to examine the effects of the flat field on the entire background of the image. If applying the flat field removes shadows from dust particles, and provides a flat, even background in your images, then it is an effective flat field. If you do not have an area of sky unaffected by light pollution, you may have to use your best judgment on the quality of your flat field.

Several things can get in the way of this simple test of a flat field, however:

- If there is a moon or other bright light source, the sky background may not be flat. It will be brighter on the side toward the light source, and darker away from the light source. This gradient may be very small, but after you apply a flat field the gradient will be much more visible. A bright full moon, a nearby streetlight, or lights from an urban area near the horizon can all create severe problems that are a major challenge to solve. It's difficult to test a flat field when such a gradient is present, and the flat field won't solve this type of gradient problem because the source is outside the optical system. In some cases, such as when the light is very bright or the dynamic range of your CCD detector is small, the gradient will overwhelm the image completely.
- Off-axis light sources can pollute a flat field. For example, suppose you are using a dew shield and that there is a neighbor's security light to the left of the telescope's optical axis. If that light reflects off of the dew shield, it could make it down the optical tube and hit the CCD detector. As a result, one side of the flat field image will be brighter than the other. The off-axis light source prevents you from getting even illumination. Similarly, if you are using a translucent panel to create the even illumination, an off-axis light source could reflect preferentially at some angles and create bright spots in the flat field.

All of these obstacles can be overcome. You need to invest some time to discover the ways in which undesired light is interfering with even illumination. Once you eliminate the extraneous light sources, you wind up with a very high quality flat field that will give you much better looking images.

Flat fields have value for scientific research. A properly executed flat field will remove distortions in brightness levels from an image, and allow you to make accurate measurements of the relative brightness of objects in the image. Without a good flat field, your calculations will contain a larger amount of error.

But flat fields are also important for taking “pretty pictures,” too. It is difficult – sometimes impossible – to process an image that has variable levels in the background. Dim areas of an image get lost in the brighter portions of the background. A properly executed flat field can completely solve such problems. Getting to a flat, even background is very important no matter what kind of images you take.

A good flat field will correct for any shadows and reflections in your optical system. Any gradient in the background that remains after a good flat field is either caused by brightness in the sky itself, as from the moon or a bright planet; light pollution; or by off-axis light sources that cause additional internal reflections. Creating a counter gradient and subtracting it can remove gradients, but you will almost always lose some image quality in the process.

### ***Flat Fields***

Figure 230 shows the settings to use for taking a flat field. The exposure time need not (and mostly will not) match the exposure time of the original image. Likewise, the temperature need not be the same. You will need to take a separate dark frame (or set of dark frames) that match the temperature and exposure time of your flat field frames. If you apply a flat field individually to an image, apply the flat’s dark frame first. If you use reduction groups, the dark frames for the flat field frames are part of the group, and will be applied to the flat frame automatically. In Figure 230, the **Frame** type has been set to **Flat Field**, and the **Reduction** is set to **None**.

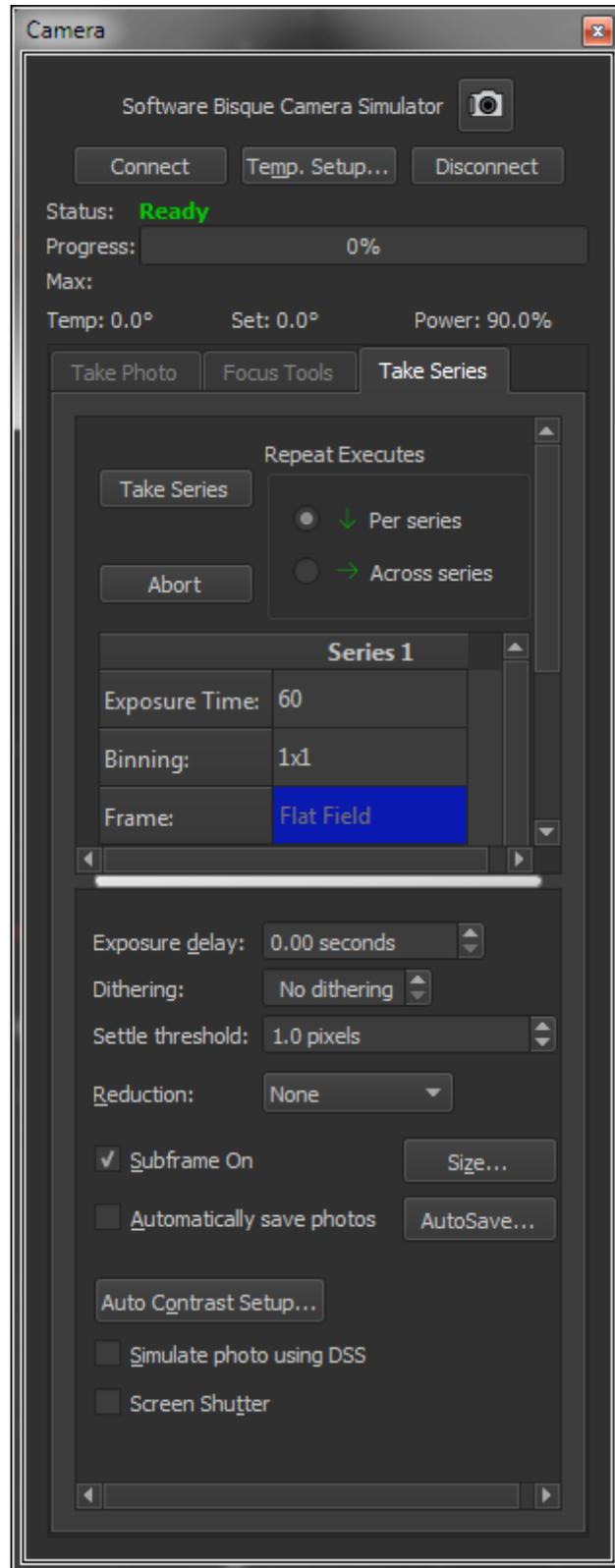


Figure 230: Settings for taking a series of flat-fields.

The obvious question about a flat field is how long to expose. The goal is to have a flat-field image with an average value that is about 33-50% of the CCD detector's saturation level. The

table below summarizes the ideal range for flat-field images for various SBIG cameras binned 1x1. For other camera brands, or for binned images, you will need to calculate the saturation level yourself, using the following formula:

$$\frac{\text{full well capacity}}{\text{electrons per ADU}}$$

The full-well capacity is the largest number of electrons that a pixel can hold, and is normally available in the technical specifications for the CCD detector. “Electrons per ADU” is called the gain of the camera. “ADU” stands for Analog to Digital Unit, and is a single brightness level.

Each camera also has a certain number of bits that are used to perform the analog to digital conversion. The ST-7E, for example, uses 16 bits, which provide a maximum value of about 65,500 units. The ST-237 uses 12 bits, with a maximum value of 4096. If the saturation level is greater than the maximum value based on the number of bits, use the number based on the number of bits.

**Table: Saturation values for flat-field frames**

Average value of the brightest area should fall between 33% and 50% of saturation.

| Camera/<br>Guider     | Full Well<br>Capacity | Gain * | Calculated<br>Saturation | Effective<br>Saturation | 33% ***<br>Saturation | 50% ***<br>Saturation |
|-----------------------|-----------------------|--------|--------------------------|-------------------------|-----------------------|-----------------------|
| ST-4<br>8 bits        | 80,000                | 150    | 533                      | 533                     | 175                   | 250                   |
| STV<br>10 bits **     | 20,000                | 4.0    | 5,000                    | 1024                    | 350                   | 500                   |
| ST-5C<br>16 bits      | 50,000                | 2.0    | 25,000                   | 25,000                  | 8,500                 | 12,500                |
| ST-237<br>12 bits     | 20,000                | 4.0    | 5,000                    | 4.096                   | 1350                  | 2000                  |
| ST-6B<br>16 bits      | 400,000               | 6.7    | 59,700                   | 59,700                  | 20,000                | 30,000                |
| ST-7E ABG<br>16 bits  | 50,000                | 2.3    | 21,740                   | 21,740                  | 7,250                 | 11,000                |
| ST-7E NABG<br>16 bits | 100,000               | 2.3    | 43,500                   | 43,500                  | 14,500                | 21,750                |
| ST-8E ABG<br>16 bits  | 50,000                | 2.3    | 21,740                   | 21,740                  | 7,250                 | 11,000                |
| ST-8E NABG<br>16 bits | 100,000               | 2.3    | 43,500                   | 43,500                  | 14,500                | 21,750                |
| ST-9E<br>16 bits      | 200,000               | 2.8    | 71,400                   | 65,000                  | 21,600                | 32,500                |
| ST-10E<br>16 bits     | 77,000                | 1.5    | 51,000                   | 51,000                  | 17,000                | 25,500                |

\* Electrons per ADU

\*\* Varies with binning mode; see SBIG documentation.

\*\*\* Rounded values for easy memorization

**Note:** CCD detectors and CCD cameras have natural variations in their full-well capacity and gain settings. The numbers shown in the table for saturation are only approximate.

**Note:** When measuring brightness of a flat-field image, be sure to average a small group of pixels so that a single bright pixel won't throw off the reading. To find the value of a pixel in TheSkyX Camera Add On, pass the mouse cursor over the image. The coordinates and brightness value appear on the status bar at the bottom of the TheSkyX Camera Add On window.

The best way to take a flat field depends on your telescope and overall optical configuration. Here are some suggestions for different ways to take a flat field; you can try them to see which provides the best results for you.

### ***Taking a Flat Field Image***

The idea behind a flat field is simple: Using the same focus position you use for taking light images, take an image of an evenly illuminated surface so that you achieve approximately one-third to one-half the saturation level of the CCD chip. Here are some things to keep in mind when taking a flat field:

**Same Focus Position:** The flat field is a snapshot of your optical system in a specific arrangement. If you change the focus position, the relative positions of the optical elements change, and any dirt or dust will cast different shadows, and reflections will change as well. To get a useful flat field, the optical system must be in the same position as when used for astronomical imaging.

**Take An Image:** The flat field is an image of something. That means that it must be treated like any other image: it will need a dark frame, for example.

**Evenly Illuminated Surface:** Whatever it is that you are taking a picture of when you take a flat-field image, the surface needs to be evenly illuminated. Otherwise, the flat field isn't flat. The flat field represents the variations from flat illumination caused by your optical system. If the surface you are imaging is not evenly illuminated, then the flat field is only an approximation, not a true flat field. You can get away with some unevenness at times, but the more even your illumination, the better your flat field will work.

If you normally use a dew shield when imaging, make sure you also use it when you take the flat. Otherwise, off-axis illumination can cause internal reflections that vary from those that occur when you image.

Here are some things you can try for making flat field images.

- The ***Two-Surface Flat*** (Figure 231) involves shining a light on a flat object so that it reflects off of another flat object and into the front of the telescope. The main disadvantage to this method is that it frequently takes two people to get enough distance between the two diffusing surfaces.

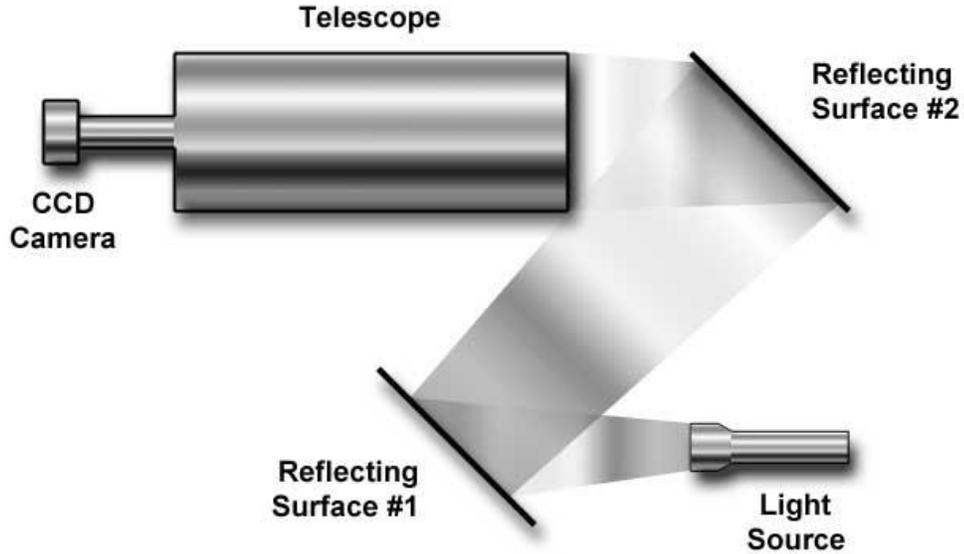
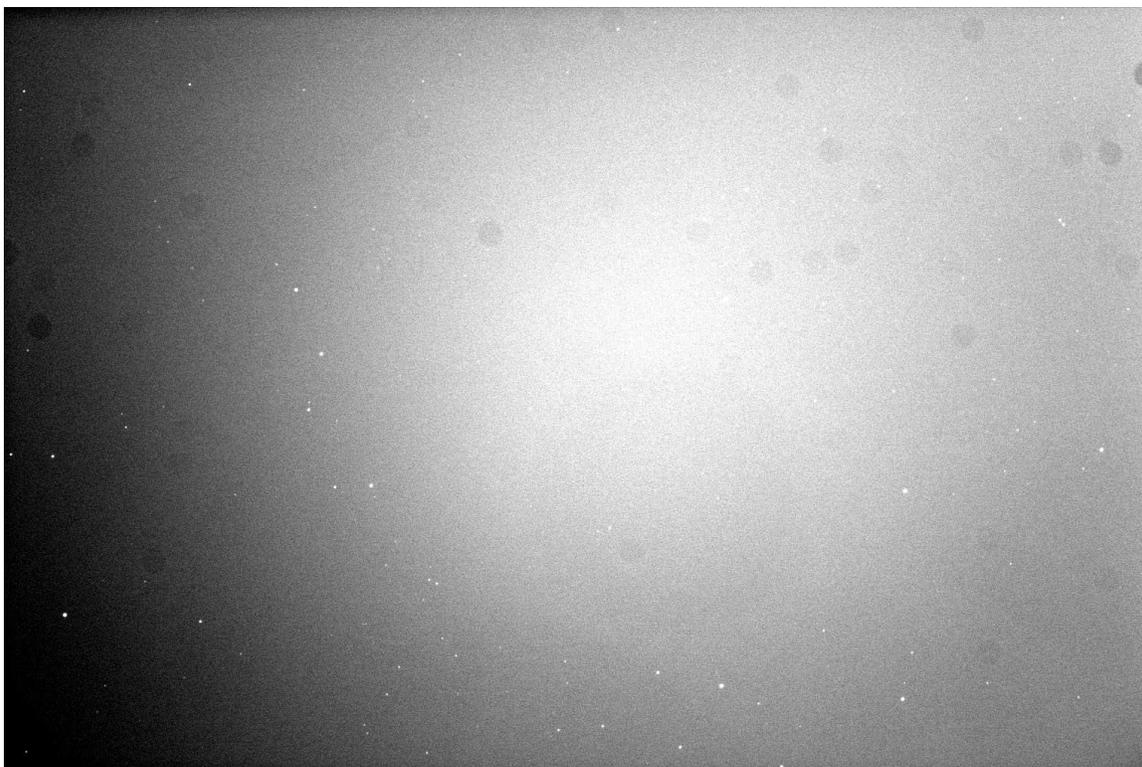
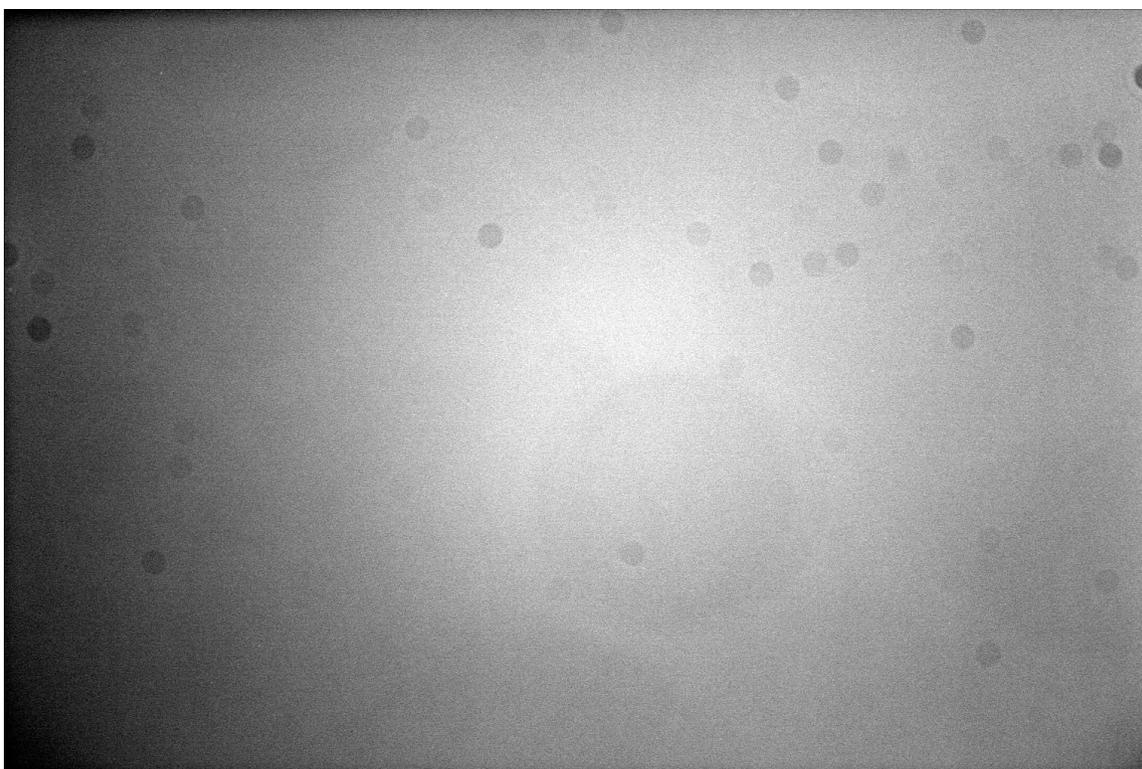


Figure 231: Taking a flat using two surfaces to diffuse light to create even illumination.

- The **Dome Flat** involves imaging the inside of an observatory or the wall of a nearby house, shed, or fence. You can use any evenly lit surface to take this kind of flat, but getting even illumination can be tricky. Try moving the scope slightly between images, and average multiple images to improve evenness.
- The **Sky Flat** involves taking many images of the sky at twilight, and averaging them to create a flat field. You may get some dim stars, but taking 8 or 12 or even 16 images, and moving the mount between images, will allow you to combine the images by averaging to remove the stars. Figure 232 shows a typical twilight flat; Figure 233 shows how averaging a dozen such images can remove any trace of stars.



**Figure 232: A single sky flat taken at twilight.**



**Figure 233: An average of twenty twilight flats.**

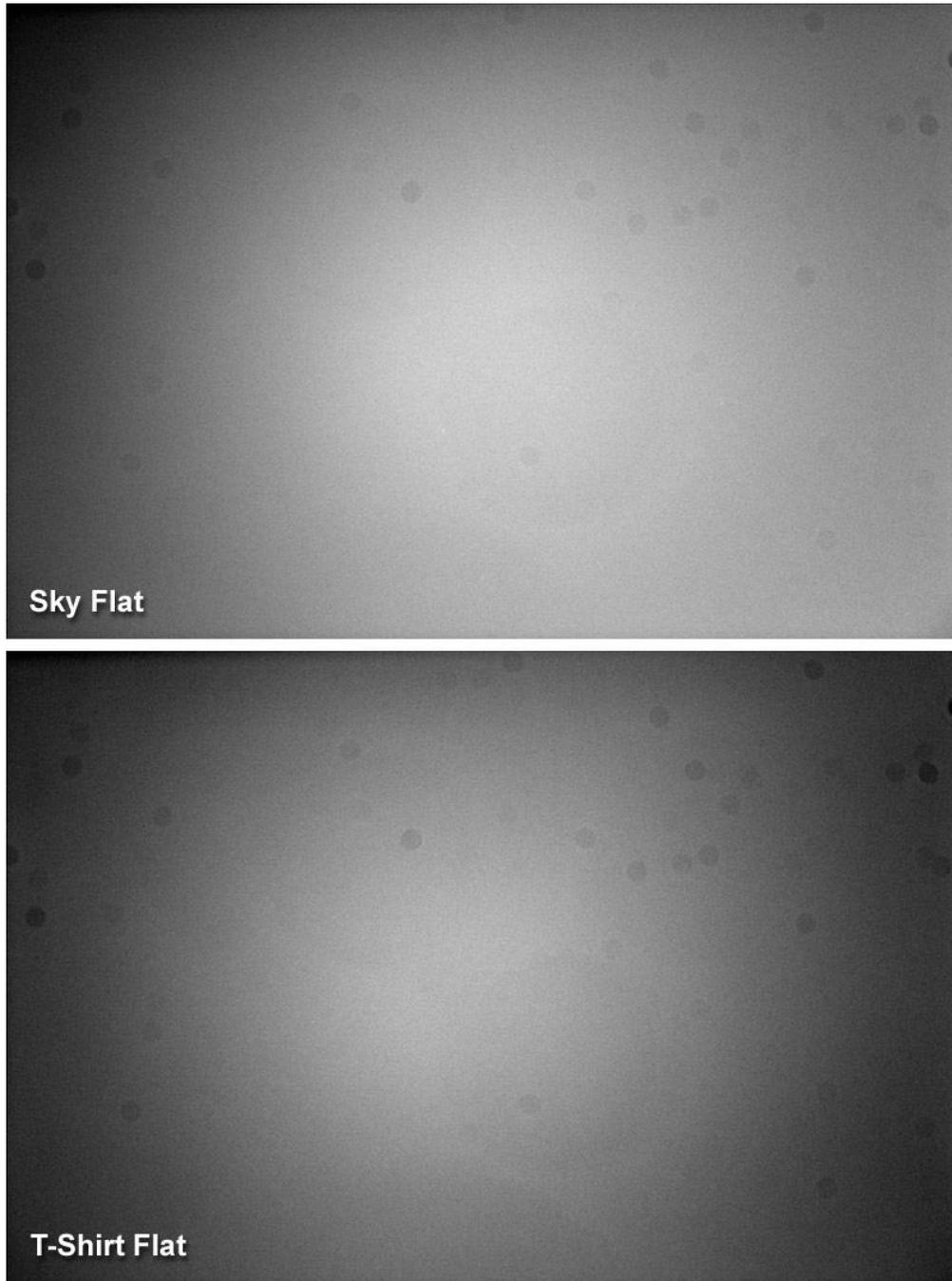
- The **Light Box Flat** involves a box with a light source and a diffuser, which is placed on the end of the telescope. These are available commercially, or you can build your own. Numerous plans for light boxes can be found on the web.
- The **T-Shirt Flat** uses a T-shirt or other white cloth over the front of the telescope. Figure 234 shows this in operation. It may not be pretty, but if you are very careful about off-axis light sources, this method can generate very high-quality flat field frames. Make sure the cloth is stretched as flat as possible across the aperture. Point the telescope away from bright lights (toward the ground in daylight) to get the most even illumination possible. The goal is to get a perfectly even, indirect light falling on the cloth. If you use a dew shield, attach the cloth, and then put the dew shield on before you take your flat field.



**Figure 234: Using a T-shirt to take a flat in daylight. Be sure to point the scope away from bright sources of light.**

Figure 235 shows a comparison between a good flat and a great flat. The important point is that the difference is actually very small. The sky flat in Figure 235 has a brighter right edge. The T-shirt flat has a distinctly darker right edge. How do you determine which is the “better” flat field

image? You apply each to a test image as described earlier in this chapter. The sky flat created a gradient in the test image, while the T-shirt flat left an even background. It is important to make sure that your flat-field setup doesn't allow any off-axis light into the telescope. Off-axis light can reflect off of the flat surface and/or interior surfaces of the optical system and make a mess of a flat field. A dew shield can help prevent off-axis light from being a problem. If you use a dew shield for imaging, be sure to also use it for creating your flat fields.



**Figure 235: Comparing the results from two types of flat fields.**

Figure 236 shows some examples of evaluating the quality of flat fields. Take an image that is near the zenith on a night with good transparency and minimal sky glow. Now apply your dark

frame(s) to the light image. Measure the variations in the background levels. If the levels vary by only a small amount, then you have a good test image for your flat field. If you are having trouble evaluating the quality of the background numerically, you can also adjust the background and range to give you useful visual feedback. Set a low background and a very small range. This will reveal variations in the background clearly. Adjust the black and white point settings (click the **Histogram** button on the **FITS Viewer** window, page 109) to provide a fairly bright background, and then reduce the range until it is grainy and any brightness variations present show up clearly.

Figure 236 shows the differences between the results obtained with the two flat fields. The upper left image is the raw image. The upper right image had the sky flat applied to it. Note that the right side of the upper right image is darker, which indicates that the bright right edge of the sky flat was probably the result of some off-axis illumination. To get a good sky flat, the off-axis source would have to be identified and removed. If it was a streetlight, for example, putting a stepladder with a tarp over it between the telescope and the streetlight should solve the problem.

The lower left image shows the results of using the T-shirt flat. The background is almost completely even, so the T-shirt flat does a better job, and was the more accurate flat field of the two. The “optimized” version of the T-shirt flat at lower right has had the background and range adjusted for best results. The T-shirt flat in this case is the better flat because it does a better job. But with appropriate adjustments during exposure, a sky flat or any other type of flat could do just as well.

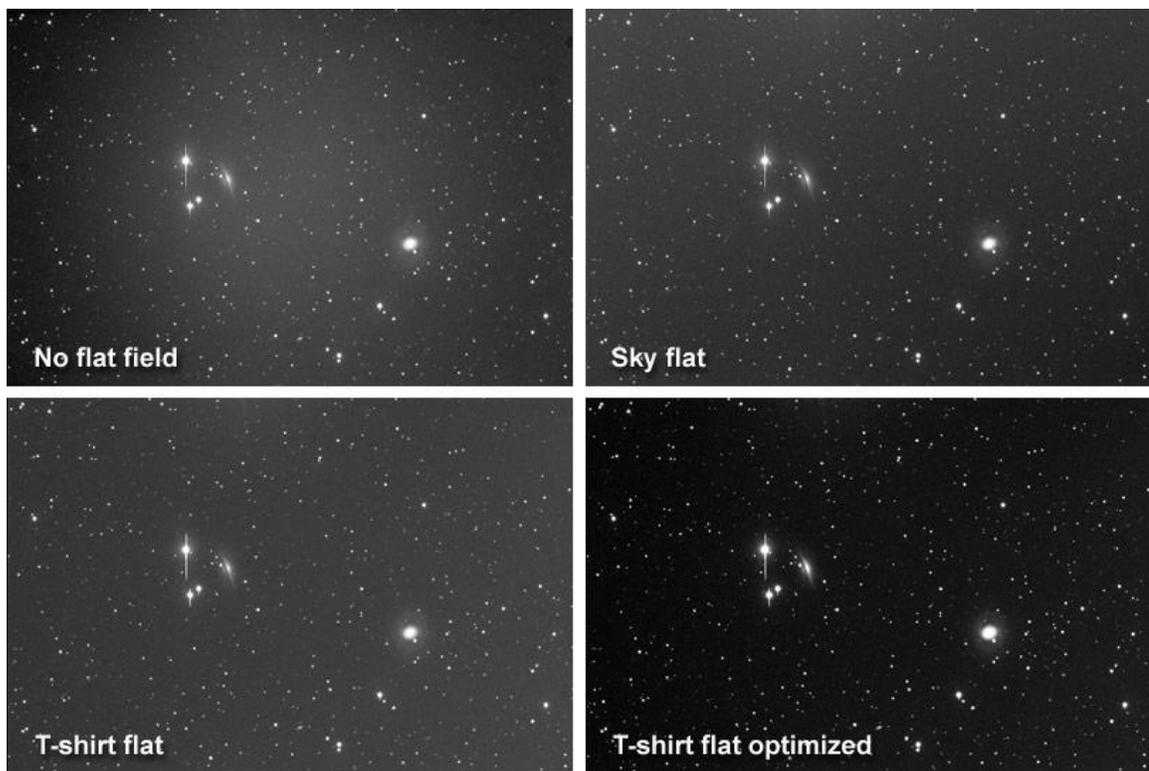


Figure 236: A comparison of results from applying two different flat fields.

Ultimately, it's a good idea to take lots and lots of flats using different methods and different equipment attached to your telescope. There is no substitute for having a deep knowledge of how light passes through your telescope. For example, the telescope used for this example does not have one edge brighter than the other; any such variation is due to off-axis light. Typically, off-axis sources are well off-axis, and it's easy to miss them, yet they can have a noticeable effect on your results. The more flat fields you take under different conditions using different techniques, the sooner you will develop the skills you need to take and apply flat-fields to your images effectively.

You can apply a single flat-field frame to an image, or you can apply multiple flat-field frames as part of a group. Unlike a dark frame, which is simply subtracted from a light frame, the flat-field frame is applied to the light frame in a more complex manner. A dark frame represents simple offsets from the accurate value, and is therefore simply subtracted from the light frame. For example, if a light frame pixel has a value of 800, and that same pixel in the dark frame has a value of 500, then the corrected value of the pixel after dark frame subtraction is 300.

For a flat field, the pixel values in the light image are adjusted using a more complex formula based on the average brightness level and the corresponding pixel in the flat-field frame. There isn't a simple relationship between the pixels in the light frame and the pixels in the flat-field frame; the entire image is used to effectively apply the flat field.

## Using Calibration Groups

A single bias, dark, or flat-field frame helps considerably in improving your images. But the improvements come at a cost. Everything you do to the original image adds noise even as it removes various system effects. The ideal situation would be to take bias, dark, and flat-field frames that have as little noise as possible.

You can accomplish this by taking multiple bias, dark, and flat-field images. TheSkyX Camera Add On can combine these images in ways that reduce overall noise. It can even apply the combined images automatically when you are taking images with the camera (see the next section).

### ***Creating Calibration Groups***



Before you can create a group, you must take the bias, dark, and flat-field frames you plan to include in the group. To build the group, click choose the ***Image Calibration Library*** command

from the **Input** menu (note that this command visible only when the *Camera Add On's* trial period is in effect, or when it has been activated). Figure 239 shows the **Image Calibration Library** window. By default, there are two groups: **Imager** and **Autoguider**. You can add bias, dark, flat-field, and darks for flat-field frames to these groups, or create your own groups.

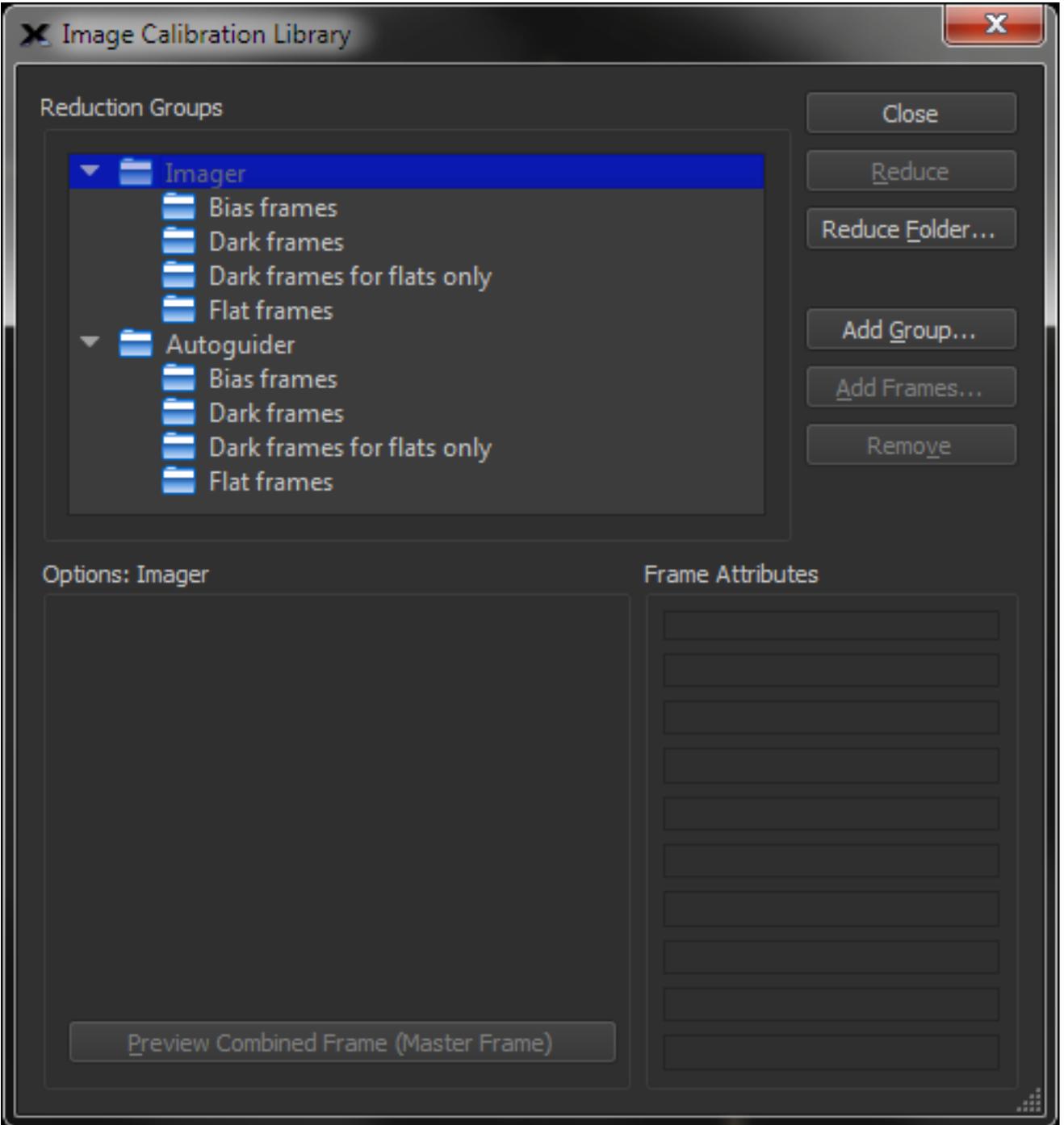


Figure 237: The Image Calibration Library window.

To create a new group, click **Add Group**. This displays the **Add Group** window (see figure 25). Type in the new group name, and click **OK** to add the group to the list. The new group will

automatically contain sub folders for bias frames, dark frames, dark frames for flats only, and flat frames.

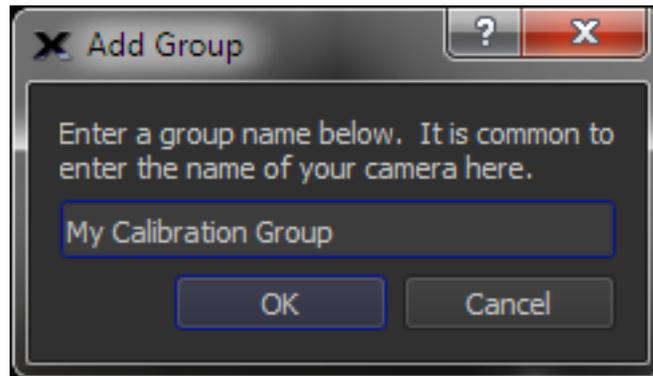


Figure 238: Adding a new group.

To add individual images to your group, click on the sub-group name (***Bias Frames***, ***Dark Frames***, ***Flat Frames***) to highlight it, and click ***Add Frames***. This opens the appropriate Select Frames window. Navigate to the folder that contains the desired files, and click to highlight them. You can add more than one frame at a time; use **Shift+Click** and/or **Control+Click** (**Command+Click** on the Mac) to select multiple photos. Click ***Open*** to add the files. Figure 239 shows multiple files added to all four sub-groups. You can resize the ***Image Reduction*** window to see long filenames, or you can hold the mouse cursor over a specific file to view the entire name.

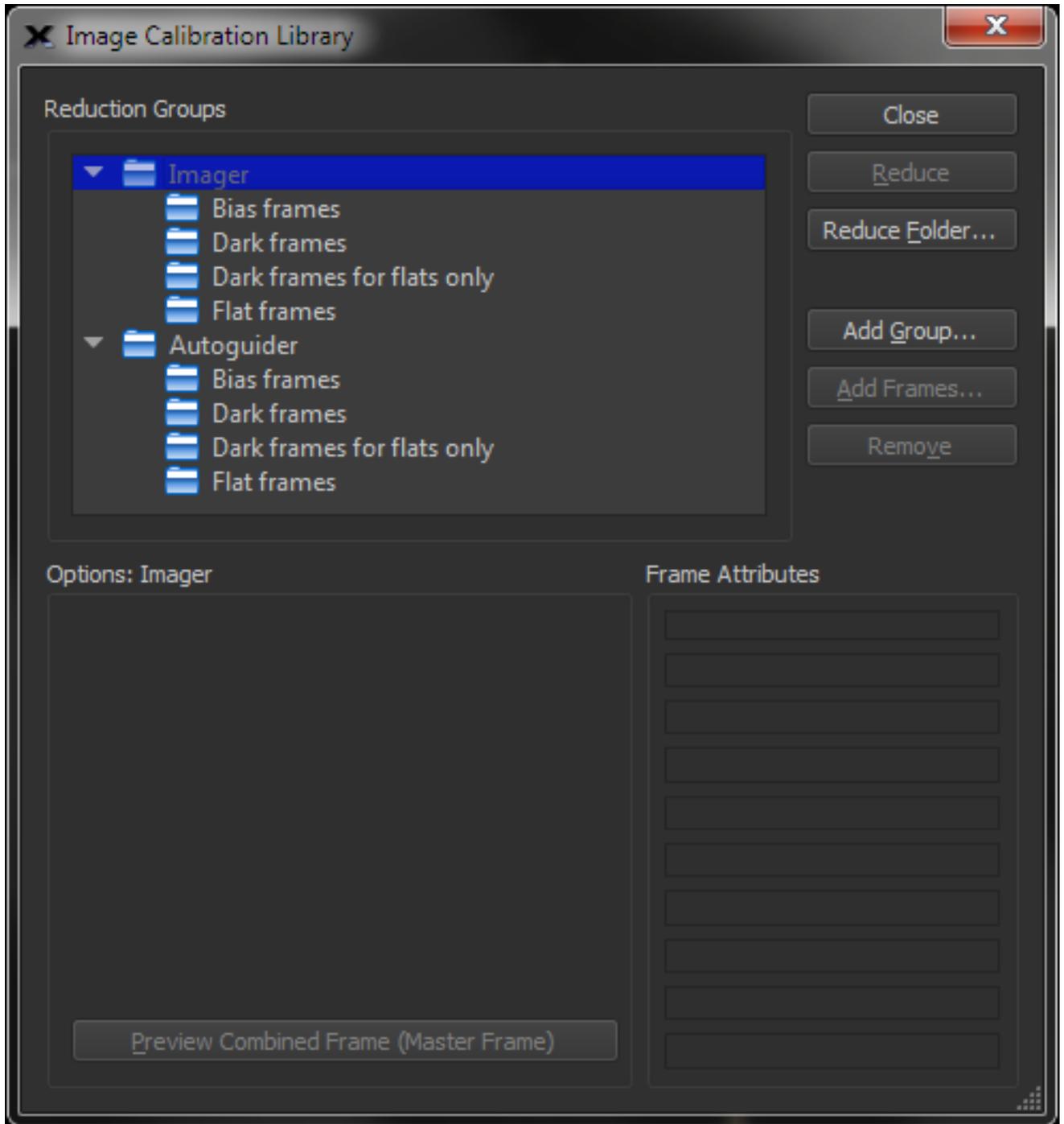


Figure 239: Files added to the bias, dark, sub-groups.

When you apply a reduction group to an image or a folder of images, the *Camera Add On* will create master frames by combining the images. A master frame is the result of combining all of the frames of a given type. There is a master frame for the bias frames, a master frame for the dark frames, etc. The master frames are created automatically the first time you use a reduction group. The master frames are also updated automatically the first time you use a reduction group after adding, deleting, or otherwise changing the frames in a reduction group.

You can create a copy of the master frame for any one sub-group at any time by clicking **Preview Combined Frames (Master Frame)** near the bottom of the Image Reduction window. A copy of the master frame appears in a window, and you can examine it to make sure it meets your requirements.

The **Remove** button acts differently depending on what you highlight in the Image Reduction window:

- If a single frame is highlighted, the frame is removed from the group.
- If a sub-group is highlighted, the frames in the sub-group are removed. The sub-group itself remains.
- If a group name is highlighted, the frames in all sub-groups of the group are removed. If the group is a default group (Imager and Autoguider are the default groups), the empty group remains. If the group is one you created, the group is also removed.

If you double-click on a file in a sub-group, the file opens in a new window.

### Setting Calibration Group Properties

You can specify how TheSkyX Camera Add On should combine frames in a sub-group. For example, if your sub-group contains 4 dark frames, you can choose how to combine them: average or median.

**Average** – The brightness of each pixel in the combined image is the average of the values in the same pixel in all of the images in the group. Summing the pixel values, and dividing by the number of images in the sub-group calculate the average.

**Median** – The brightness of each pixel in the combined image is the median of the values in the same pixel in all of the images in the group. The median is the value in the middle of the distribution of brightness levels. There are equally many values larger than the medium as there are smaller.

In addition, the **Photo Calibration Library** window contains options for how dark frames are applied to your light images and flat frames:

| Option                          | Values/Description   |
|---------------------------------|--|
| <b>Dark Exposure Correction</b> | <p><b>None</b> – No exposure correction occurs. The dark frame is simply subtracted from the light frame. It's up to you to make sure that the exposure times for light and dark frames are the same.</p> <p><b>Automatic</b> – TheSkyX Camera Add On reads the file header to obtain exposure and temperature information, and uses this information to scale the dark frame before applying it to the light frame. Only file types that contain header information, such as FITS and SBIG files, work with this option.</p> <p><b>Manual</b> – The dark frame is scaled using numeric values that you supply, using either duration or a multiplier.</p> |

To set the options for Bias, Dark, and Flat Frames, click to highlight the group or any file in the group; the options appear in the area below the list of files in the group (Figure 239). Note that, when an individual filename is highlighted, the attributes for the file appear in the Frame Attributes area at lower right. The attributes can help you identify which file is which, and can help you determine whether you have the correct files included in the group. The Frame Attributes are especially helpful long after you take images or create reduction groups.

Note: the dark frames you add to a group should all have approximately the same exposure duration. If you try to combine dark frames with very different exposure durations, you will add a lot of noise to your images. For the cleanest, lowest-noise reduction, use dark frames with identical exposures.

### Calibrating a Single Photo

To calibrate a single photo, open the image in the *Camera Add On* and then open the *Image Reduction* window (**Input > Photo Calibration Library**). Click the **Calibrate** button to open the **Calibrate Photos Now** window (Figure 240). If this is the first time you have used the group for reduction, there will be a delay while the *Camera Add On* builds the master bias, dark, dark for flat, and flat-field frames.

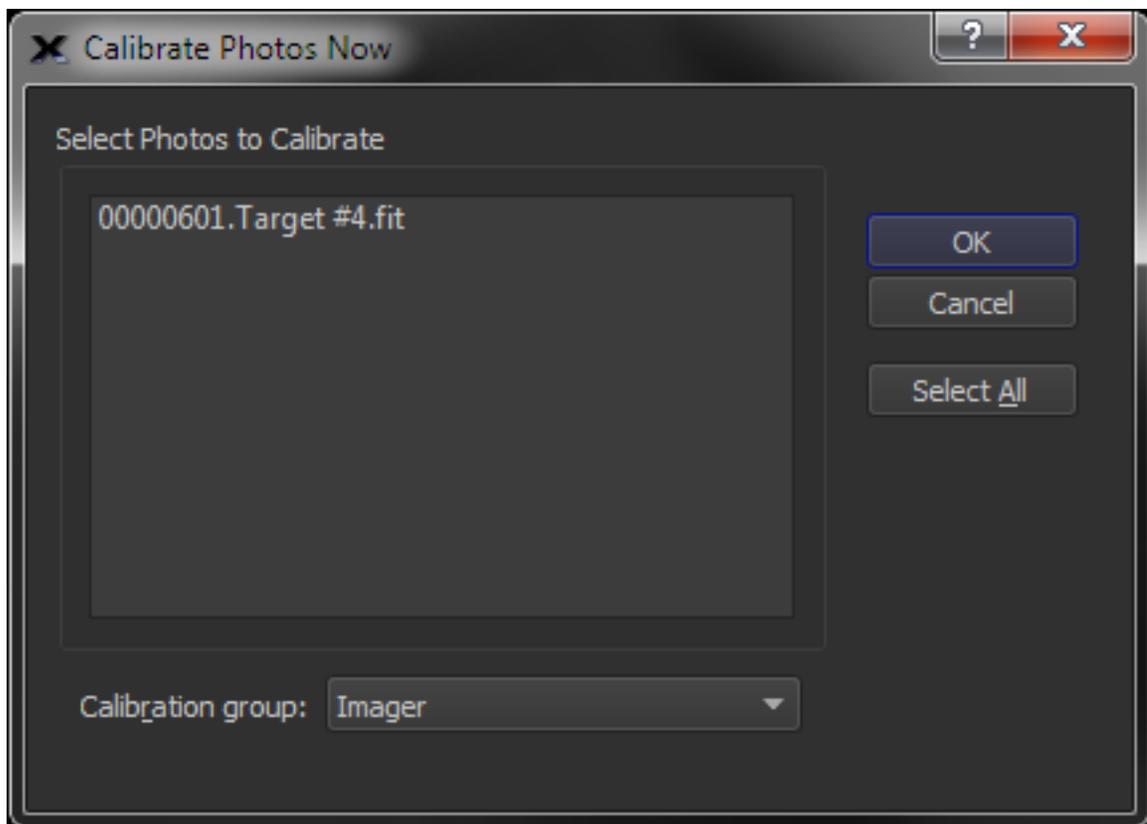


Figure 240: Calibrating photos using the *Calibrate Photos Now* window.

As with a single flat field, you can evaluate the correction of an image reduction group by examining the background brightness values. Pass the mouse cursor over the image, and look for consistent brightness levels in the background. Gradients due to sky glow, moonlight, or light

pollution make it harder to evaluate the quality of a reduction. Use an image that has a known flat background to evaluate the quality of your reduction, such as an image from a dark site taken near the zenith.

### Calibrating a Folder of Images

You can also use the Image Reduction window to reduce all of the images in a folder. This is convenient for many imaging situations – color images with many images taken at the same time and temperature, for example, or an evening’s worth of images when hunting for supernovas, comets, or minor planets. Click the **Calibrate Folder** button to open the window shown in Figure 241.

- Click the **Choose Folder** button under **Folder of Photos to Calibrate** to locate the folder with the photos you want to calibrate.
- Click the **Choose Folder** button under **Folder to Save Calibrated Photos** to specify the folder where the calibrated photos are to be saved.
- Choose the **Calibration Group** from the pop-up menu at the bottom of the window.
- Click **Calibrate** to start the reduction process.

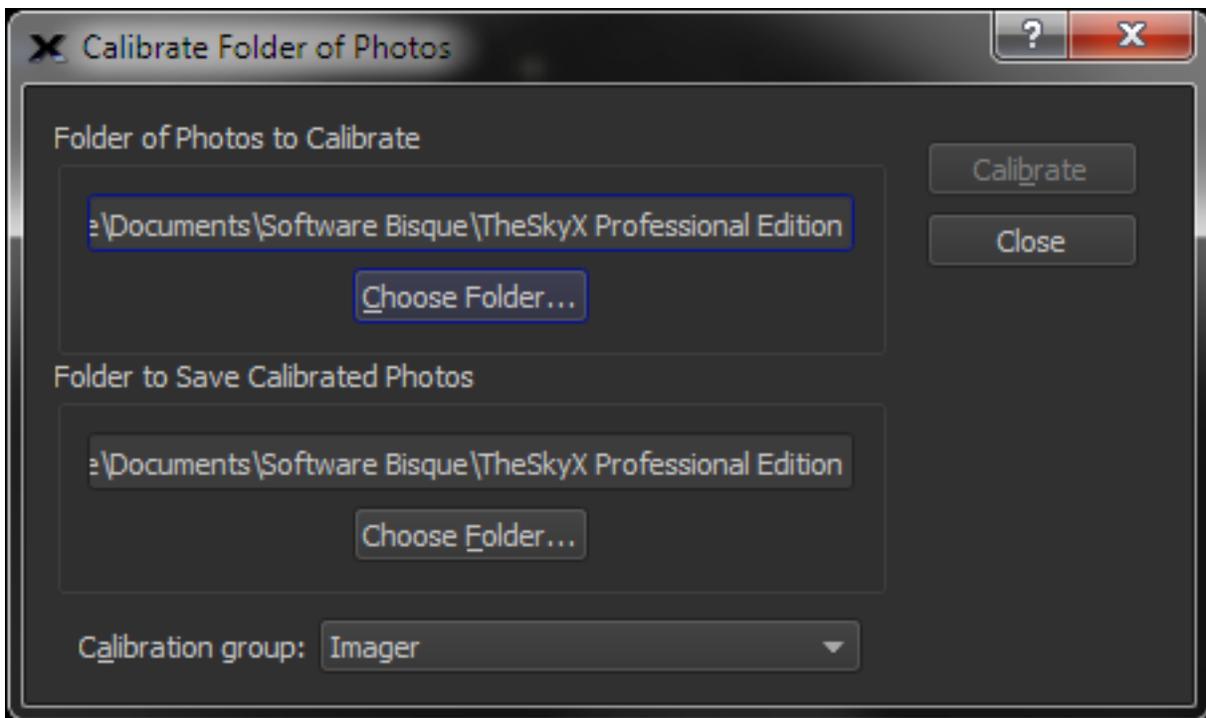


Figure 241: Reducing all of the images in a folder.

### Calibration Group Strategies

A calibration group is simply a collection of bias, dark, flat-field, and dark-for-flat-field frames. You can use dark frames taken at any exposure or temperature, so it is up to you to make sure that the right files go into each group you create. It is typical to create a number of groups for a given night’s images, with each group being used for one or more of your light photos.

For example, suppose you took the following photos in one night:

- Ten one-minute photos of M51.
- Ten two-minute photos of the Owl Nebula.
- Four 10-minute photos of M101.

You could create two or three calibration groups. If you created two groups, you would use 90-second darks in one group, and 10-minute darks in the second group. You could calibrate both your M51 and Owl Nebula photos with the first group, and your M101 photos with the second group. The *Camera Add On* would scale the dark frames in the first group for the differences in exposure times. The 90-second exposure for dark frames is halfway between the exposure times of the M51 and Owl Nebula images.

Note: Bias frames are optional. However, if you scale dark frames, you should include bias frames in your calibration groups. The bias frames allow the *Camera Add On* to scale the dark frame more accurately.

Flat fields typically require exposures that are different from light frame exposures. As a result, you will often use a separate dark frame for your flat fields. There is a special heading in the Calibration window where you can add dark frames that are for flat fields only. If you do not add any dark frames for the flat-field frames, no dark is subtracted from the flat fields.

Color imaging often involves taking images that have different exposure times. You should normally use several reduction groups for a single set of color images. The ST-7E camera with a CFW-8 color filter wheel, for example, generally works best with exposures having a ratio of 1:1:1.6. If you intended to image the galaxy M101 in color, you might plan to take the following images:

- 5 luminance images with an exposure of 5 minutes each, binned 1x1.
- 3 red and 3 green images with exposures of 10 minutes each, binned 1x1.
- 3 blue images with exposures of 16 minutes each, also binned 1x1.
- 4 flat-field images at 40% of saturation, with exposures of 10 seconds each.

You could create one, two, or three reduction groups for these images. The difference between the groups would be the exposure time for the dark frames:

### **Method #1**

Create one group, with an average dark frame exposure time suitable for all light images. Use dark frames with an exposure time between the shortest and longest exposures: 10 minutes, for example. Your darks would not perfectly match all of the light images, and there would be some additional noise in the final image as a result. A good reduction group using this approach could include:

- 3 dark frames at 10 minutes each.
- 3 bias frames.
- 3 dark frames at 10 seconds each for the flat-field frames.
- 4 flat-field frames at 10 seconds each.

### **Method #2**

Create two groups, with each having an average dark frame exposure time suitable for some of the light images. Use darks of 5 minutes in one group (for the luminance images), and 13 minutes in a second group (for the red, green, and blue images). The two groups could look like this:

Group one:

- 3 dark frames at 5 minutes each.
- 3 bias frames.
- 3 dark frames at 10 seconds each for the flat-field frames.
- 4 flat-field frames at 10 seconds each.

Group two:

- 3 dark frames at 13 minutes each.
- 3 bias frames.
- 3 dark frames at 10 seconds each for the flat-field frames.
- 4 flat-field frames at 10 seconds each.

### **Method #3**

Create three groups, with each having a dark frame exposure matched to specific light images.

Which method should you choose? It depends on your needs. If you want to get the greatest possible benefit from your dark frames, then use method #3 with three groups. If you are working at very cold temperatures (for example,  $-33^{\circ}\text{C}$ ), you might feel that the noise levels are low enough to use Method #1 with a single group of darks. The *Camera Add On* scales the darks to match the actual exposures, but this scaling introduces some inaccuracies into the process. If you are imaging at a warmer temperature (for example,  $-22^{\circ}\text{C}$ ), then you might choose Method #2.

## **Automatic Reduction**

There is a third way to do image reduction: automatically when you acquire an image. The **Take Photo** tab in the **Camera** tab (see figure 31) provides a **Reduction** pop-up menu in the options for:

- No automatic reduction (choose **None**).
- Take a single dark frame (choose **AutoDark**) and apply it to each image.
- Apply a reduction group to images as they are downloaded (choose **Bias, Dark, Flat**).

If you select **Full Calibration**, the Group option appears. Pick a reduction group from the list of available groups.

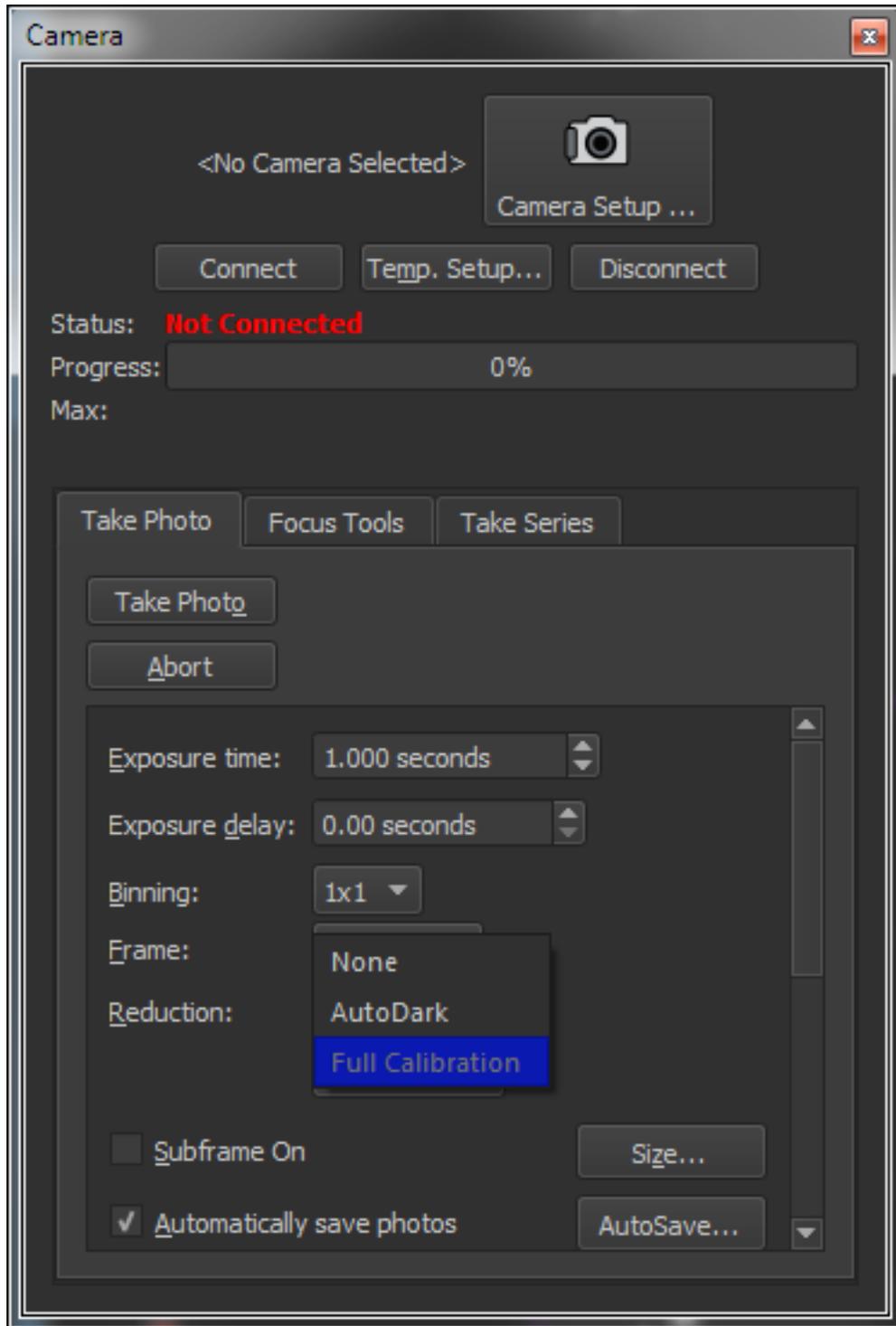


Figure 242: Setting up automatic image reduction.

We recommend turning the **Automatically Save Photos** checkbox on if you are automatically applying a reduction group to your images as they are downloaded. If **Automatically Save Photos** is turned on, two versions of the file are saved: the raw image, and the reduced image. If an error occurs during reduction, the raw data is still saved to disk.

For example, if you were imaging the Antennae galaxies, then the two filenames could be:

0000045.Antennae.FIT

0000045.Antennae.REDUCED.FIT

# Focuser Control

PROFESSIONAL



The *Camera Add On* can be used to manually adjust the camera’s focus using pulse focusers or other motorized focusers. The @Focus (pronounced “at focus”) algorithm provides a means to automatically move an optimal focus using star brightness or half-flux diameter.

Automated focus adjustments can further be made based on the current optical filter, or by monitoring the ambient temperature using external temperature sensor.

The *Camera Add On* can natively control the focusers listed in the table below.

| Focuser Manufacturer/Model  |  |  |  |  |
|---|---|---|---|---|
| Astro-Physics/CP3 and CP4 built-in pulse focuser controller interface (a pulse focuser, sold separately, is also required)              | ✓   | ✓   | ✓   | ✓   |
| Finger Lakes Instruments/All models   | ✓   | ✓   | ✓   | ✓   |
| Gemini Astronomical Positioning System/Built-in pulse focuser controller interface (a pulse focuser, sold separately, is also required) | ✓   | ✓   | ✓   | ✓   |
| Meade Instruments/Autostar or LX200 built-in pulse focuser controller interface (a pulse focuser, sold separately, is also required)    | ✓   | ✓   | ✓   | ✓   |

| Focuser Manufacturer/Model   |  |  |  |  |
|--|---|--|---|---|
| Moonlite Telescope Accessories/Moonlite NiteCrawler Focus Controller   | ✓   | ✓  | ✓   | ✓   |
| Officina Stellare ATC-02 (OTA-based secondary mirror control to adjust the position of back focus, not specifically designed to adjust the optical focus position) | ✓   | ✓  | -   | -   |
| Officina Stellare RotoFocus Focuser  | ✓   | ✓  | ✓   | ✓   |
| Optec/FocusLynx Focuser  | ✓   | ✓  | ✓   | ✓   |
| Optec/TCF-S3 and TCF-S Temperature Compensated Focusers  | ✓   | ✓  | -   | -   |
| Rigel Systems/nSTEP  | ✓   | ✓  | ✓   | ✓   |
| Starizona/MicroTouch AutoFocuser   | ✓   | ✓  | -   | -   |
| QSI/All models   | ✓   | ✓  | -   | -   |
| Software Bisque/Paramount, MKS 3000, MKS 4000 and MKS 5000 built-in pulse focuser controller interface (a pulse focuser, sold separately, is also required)        | ✓   | ✓  | ✓   | ✓   |
| Software Bisque/Focuser Simulator  | ✓   | ✓  | ✓   | ✓   |
| Starlight Instruments FeatherTouch Focuser   | ✓   | ✓  | ✓   | ✓   |
| Starlight Xpress/All models  | ✓   | ✓  | -   | -   |

The *Camera Add On* can also control any ASCOM-compliant focuser on Windows.

Serial port-based focusers, just like serial port-based telescopes, require a USB to serial adaptor to connect the focuser's serial port to the computer's USB port. See "USB to Serial Adaptors" on page 358 for details about this additional hardware device.

## Focuser Setup

Use the Imaging System Setup window to choose, setup, and connect to the focuser. The Focuser Setup pop-up menu provides commands to do so.

### Focuser Setup Pop-up Menu

The Focuser Setup pop-up menu on the Imaging System Setup window includes the following commands.

- **Choose:** Shows the **Choose Focuser** window to select your model focuser.
- **Settings:** Displays a focuser-specific settings window for the selected focuser.
- **Connect:** Use this command to establish communications with, or connect to the selected. Make sure to configure the focuser port settings by choosing the Settings command first.
- **Disconnect:** Terminate communication with the focuser.

To configure *TheSkyX* to control a focuser:

1. Choose the **Telescope Setup** command from the **Telescope** window to display the **Imaging System Setup** window.
2. Highlight **Focuser** in the **Hardware** list.
3. From the **Focuser Setup** pop-up menu, select the **Choose** command.
4. On the **Choose Focuser** window, select the desired focuser from the **Focuser** list and click **OK**.
5. For serial port-based focusers, choose the **Settings** command from the **Focuser Setup** pop-up menu to configure the focuser's settings.



Figure 243: The Focuser Settings window (Mac)

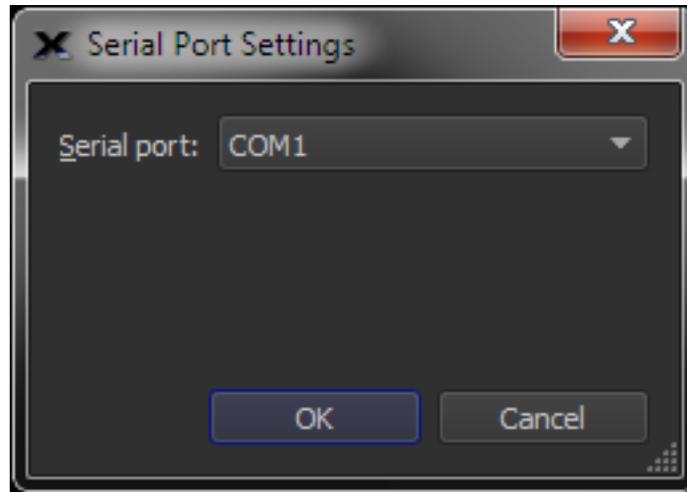


Figure 244: Focuser Settings window (Windows)

### **Serial Device/Serial Port**

Select the serial device name (Mac) or COM port (Windows) for the focuser.

### **TCF-S More Settings**

Click the **More Settings** button on the **Serial Port Settings** window to configure focuser step size, backlash compensation and temperature compensation, when applicable

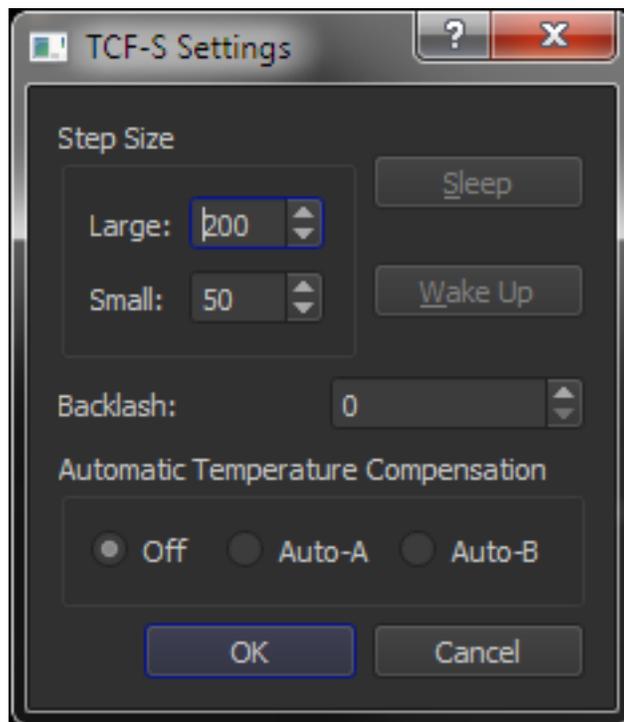


Figure 245: The Optec TCF-S Settings window.

### **Step Size (Large and Small)**

The **Large** and **Small** focuser steps are applied when focusing a camera with @Focus and @Focus2 automated focusing algorithm (page 572). The step size number represents the relative

motion of the focuser; the larger the number the more focuser motion. The large step is used to get close to focus, the small step size is used to get “optimal” focus.

### **Backlash**

Enter a number for the relative amount of backlash compensation (gear slop) in the focuser. Consult the focuser hardware documentation for more information on this setting.

### **Automatic Temperature Compensation**

Choose the Automatic Temperature Compensation setting for the Optec focuser. Consult the focuser hardware documentation for more information on this setting.

## **Starizona MicroTouch Focuser Installation**

The MicroTouch™ Autofocuser unit can be used to adjust the focus on FeatherTouch™ focusers from Starlight Instruments. The Camera Add On can control this device through its USB interface.

### **Minimum Requirements**

- TheSkyX Professional Edition for Mac or Windows, version 10.5.0 and later and the Camera Add On.
- MicroTouch firmware version 4.4 or later.
- MicroTouch Windows USB driver (Windows only).
- SiliconLabs VCP driver (Mac only).

### **MicroTouch Driver Installation**

1. Verify that the firmware version 4.4 or later is installed on the MicroTouch focuser hand controller box. See Upgrading Firmware in the MicroTouch AutoFocuser Operating Instructions for details. This document can be downloaded from the [MicroTouch product web page](#).
2. Install the MicroTouch USB driver.

|  |  |
|--|--|
|  | The Mac driver can be downloaded from the Silicon Labs web site under <b>Download for Mac OS X:</b><br><a href="https://www.silabs.com/products/mcu/Pages/USBtoUARTBridgeVCPDrivers.aspx">https://www.silabs.com/products/mcu/Pages/USBtoUARTBridgeVCPDrivers.aspx</a>   |
|  | The Windows driver can be installed from the MicroTouch web page:<br><a href="http://starizona.com/acb/MicroTouch-Autofocuser-Wired-Version-P2715C745.aspx">http://starizona.com/acb/MicroTouch-Autofocuser-Wired-Version-P2715C745.aspx</a><br><br>There are several downloads available on this page. The <a href="#">download link</a> you're after is labeled: <b>“Download same drivers (updated for Windows 10) and install files above, without ASCOM and FocusMax (for users who already have those programs installed). 18MB ZIP file.”</b> |

Follow the installer’s instructions to complete the installation of this driver.

3. From TheSkyX Professional Edition, verify that version 10.3.0 (Build 8649), or later, is installed. If not, choose the **Check for Updates** command from TheSkyX's **Help** menu to download the latest version from Software Bisque web site. Once downloaded, run the installer, and launch TheSkyX Professional Edition. Next, choose the **About TheSkyX** command from **TheSkyX** menu on the Mac or the **Help** menu on Windows to verify the correct version has been installed.
4. Connect the MicroTouch to the computer and turn it on.
5. From *TheSkyX Professional Edition*, choose the **Telescope Setup** command from the **Telescope** menu.
6. Double-click **Focuser** under **Imaging System** on the left side of the **Imaging System Setup** window and choose **Starizona MicroTouch Focuser** and click **Close**.
7. Choose the **Settings** command from the **Focuser Setup** pop-up menu, and choose the name of the port the focuser is connected to.

See "Controlling the Focuser" on page 567 for details how to adjust focus.

## **Moonlite Focuser and Mac OS X**

On Mac OS X, if you encounter Moonlite focuser connection errors, or slow/sluggish communication between TheSkyX Pro and the Moonlite focuser, install the latest Future Technology Devices International (FTDI) USB driver: <http://www.ftdichip.com/FTDrivers.htm>.

## **Focuser Options**

Once the focuser is selected, the right side of the Imaging System Setup window displays focuser options.

### **Timeout**

Enter the number of seconds to wait for a response from the focuser before displaying a communication failure error. Consider increasing the number of seconds to wait if repeated "error due to poor communications" errors occur when connected to a focuser.

### **Temperature Source**

To perform temperature-compensated focus adjustments, the focuser hardware can get the ambient temperature from a variety of sources.

- **Focuser (Default)** Use the focuser's built-in temperature sensor.
- **Partnered Focuser** Choose this option if an imaging system with two focusers uses the temperature reading from the second focuser.
- **Paramount Mount** Read the ambient temperature from the Paramount's built-in temperature sensor.
- **OTA** Read the temperature from the optical tube assembly's weather/temperature sensors.
- **Weather Station** Get temperature from a weather station (optional Weather Add On required; this Add On is not available to the general public at this time).

## Controlling the Focuser

Figure 246 shows the **Focuser** controls on the **Telescope** window that can be used to adjust the focuser's position.

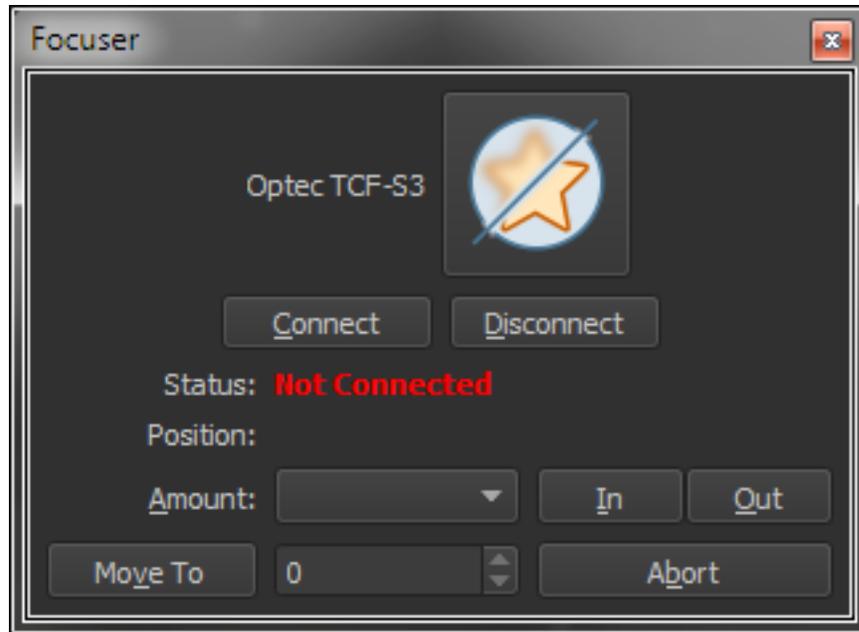


Figure 246: Focuser controls on the Telescope window.

### Move In/Move Out Buttons

Click these buttons to adjust the position of the focuser.

### Amount

Select the relative amount of focuser travel that will be applied to each **Move In/Move Out** button click.

### Pulse Focuser Adjustments

- **Slow:** Adjusts the position of the focuser using a slow motor speed for adjusting final focus.
- **Fast:** Adjusts the position of the focuser using a fast motor speed for making significant changes to focus.

### Optec Focuser Adjustments

- **100:** Adjusts the position of the focuser using the **Small** step size (page 564).
- **1000:** Adjusts the position of the focuser using the **Large** step size (page 564).

### Status

Shows the status of the focuser connection.

- **Not Connected:** The focuser is currently not connected to *TheSkyX*.
- **Connected:** The focuser is connected to *TheSkyX*.

## **Focusing Principles**

The human eye is a marvelous instrument. Not only can it follow rapidly moving objects, but it can also adjust focus in real time, compensating for minor focus drift or out of focus conditions. The eye is a very forgiving focuser, in other words.

The CCD camera, on the other hand, is a very unforgiving measurer of focus. Cameras require very precise focus to get sharp, detailed images. Precise focus is also important for research (astrometry and photometry).

The *Camera Add On* has features that will allow you to achieve the best possible focus. But there are also mechanical considerations about focus that play a role in how effectively you can achieve that “sweet spot” called *critical focus*.

“Critical focus” is a range of focal positions, not just a single point along the focuser's range of travel. Even at critical focus position, stars are not usually imaged as single points of light; atmospheric turbulence and other factors spread out the star's image on the CCD detector. Critical focus is the range of focus positions that provides the best possible focus and is dependent upon the focal ratio of your telescope.

The focal ratio alone determines the size of your critical focus zone. The zone of critical focus becomes shorter with lower, “faster” focal ratios. For the purposes of focusing, a fast focal ratio is  $f/6$  or lower; a slow focal ratio is greater than  $f/6$ . The focal ratio is the ratio of the telescope focal length to the aperture. For example, a telescope with an aperture of 100mm and a focal length of 500mm has a focal ratio of  $f/5$ . Lower-numbered focal ratios are said to be “fast” because they require shorter exposure times.

Figure 248 shows light cones for fast ( $f/5$ ) and slow ( $f/10$ ) telescopes. The front of a hypothetical telescope is at left. Light enters from the left, and is brought to a focus where the converging lines cross.

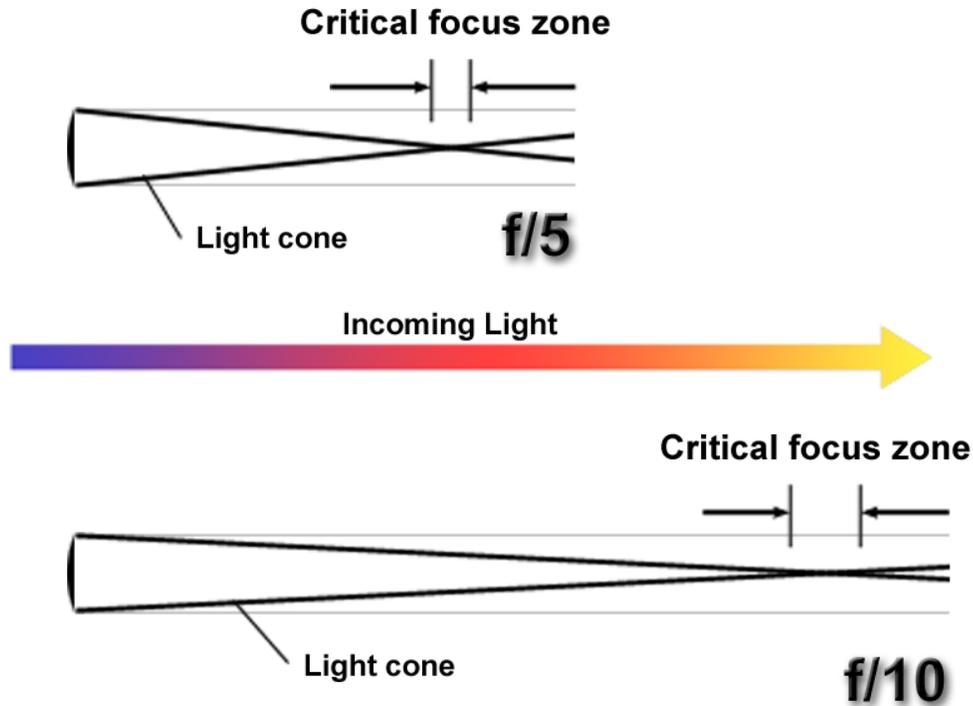


Figure 247: The focal ratio of your telescope determines the length of the critical focus zone.

The f/5 light cone is very steep; as you move away from the front of the telescope, the light converges to focus very quickly. The f/10 light cone is shallow, and does not converge as rapidly as you move away from the front of the telescope. For all telescopes, the light diverges again past the focal point. The telescope's focuser, manual or motorized, moves the CCD camera back and forth. The CCD detector inside the camera must sit within the critical focus zone to get a sharp image. To bring the CCD camera to focus, the focuser moves the camera so that the CCD detector is within the critical focus zone, as shown in Figure 248.

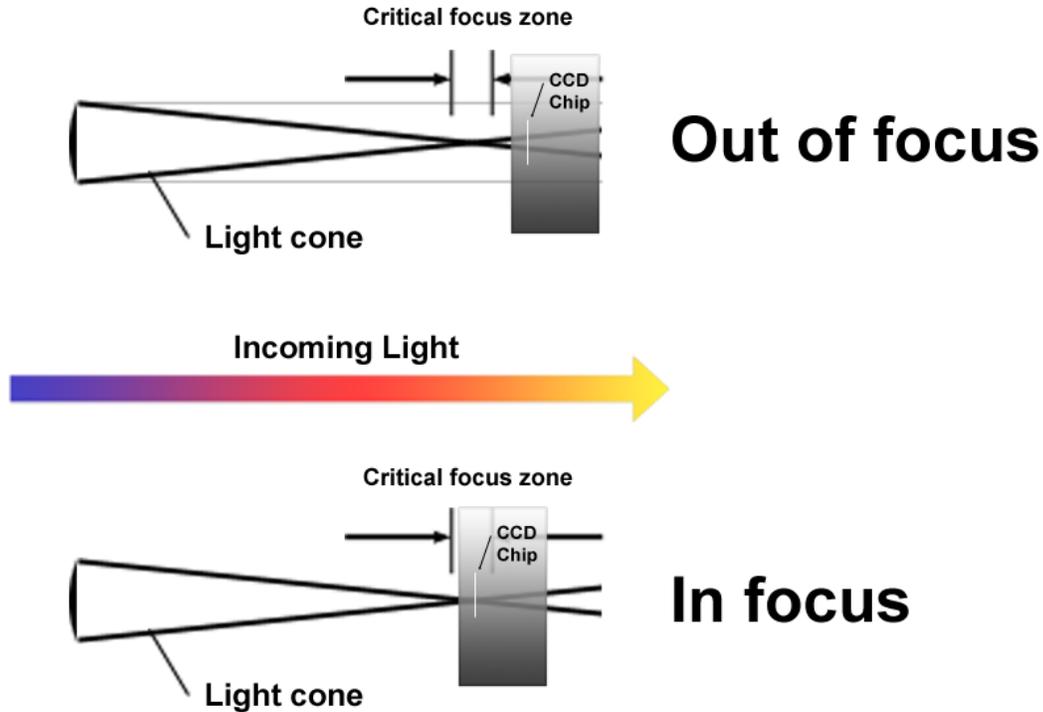


Figure 248: Moving the camera into the critical focus zone.

This means that telescopes with fast focal ratios have a shorter critical focus zone, and thus they are more challenging to focus manually. You can improve your ability to focus a fast telescope by adding a motorized focuser. The Camera Add On includes a focusing utility, *@Focus2* (pronounced “at focus two”, which can make extremely small focuser movements limited only by the minimum step size of a motorized focuser. Fast telescopes are also more susceptible to anything that will cause focus drift, such as falling or rising temperatures. A motorized focuser can also help you adjust focus throughout a long imaging session.

The slower your focal ratio, the longer the critical focus zone and the easier it will be to find focus.

When the seeing is very good (that is, the atmosphere is stable), star images hold steady and are very small and sharp. As the seeing deteriorates, star images begin to bloat and lose their hard edge. This makes measuring focus more difficult, and *@Focus2*, may not converge on the best focus position under poor seeing conditions. Manual focusing is also harder to achieve under poor seeing conditions (turbulent atmosphere).



If the zone of critical focus is very short, you may find it difficult to achieve critical focus reliably or easily using a manual focuser. You can purchase various types of motorized focusers that can help with this problem, including some that have digital readout of focus position.

A motorized focuser can provide smaller adjustments in many cases than you can do by hand, and is thus better at making the small adjustments that position the CCD detector inside the critical focus zone. To get useful results from a motorized focuser, it should enable you to make movements that are at least one-half the size of your zone of critical focus on nights of optimal seeing conditions. For optimal focusing, look for a focuser that will move in increments that are one-quarter or less the size of your critical focus zone.

The equation below computes the size of the critical focus zone (CFZ) in microns for a “perfect” optical system that is perfectly collimated:

$$CFZ = focal\_ratio^2 * 2.2$$

So, for a C-14 that is f/11:

$$CFZ = 11^2 * 2.2 = 266$$

266 microns is 0.266 millimeters or 0.01 inches. Here’s an example with an f/5 focal reducer on the C-14, making it effectively an f/5.5 system:

$$CFZ = 5.5^2 * 2.2 = 66.5$$

66.5 microns is 0.0665 millimeters or 0.0026 inches. Note that the critical focus zone is now one quarter that of the longer f-ratio system. This means that if you reduce the focal ratio by half, you reduce the close focus zone to one quarter. Note: real world values are approximately 10%-30% greater than the theoretical values above.

TheSkyX includes two methods of focusing: automatic using @Focus2, and manual focusing. To use @Focus2, you must have a computer-controlled focuser (for example, RoboFocus, Optec TCF-S, RCOS Focuser or JMI Smart Focus), or a motorized focuser controlled by your mount (for example, JMI NGF-S, Meade Zero Image Shift Focuser or MotoFocus connected to a Paramount, LX200, or Astro-Physics GTO, etc.).

To access @Focus2, click the **Focus Tools** tab on the *Camera* tab. Figure 249 shows the layout of the **Focus Tools** tab.

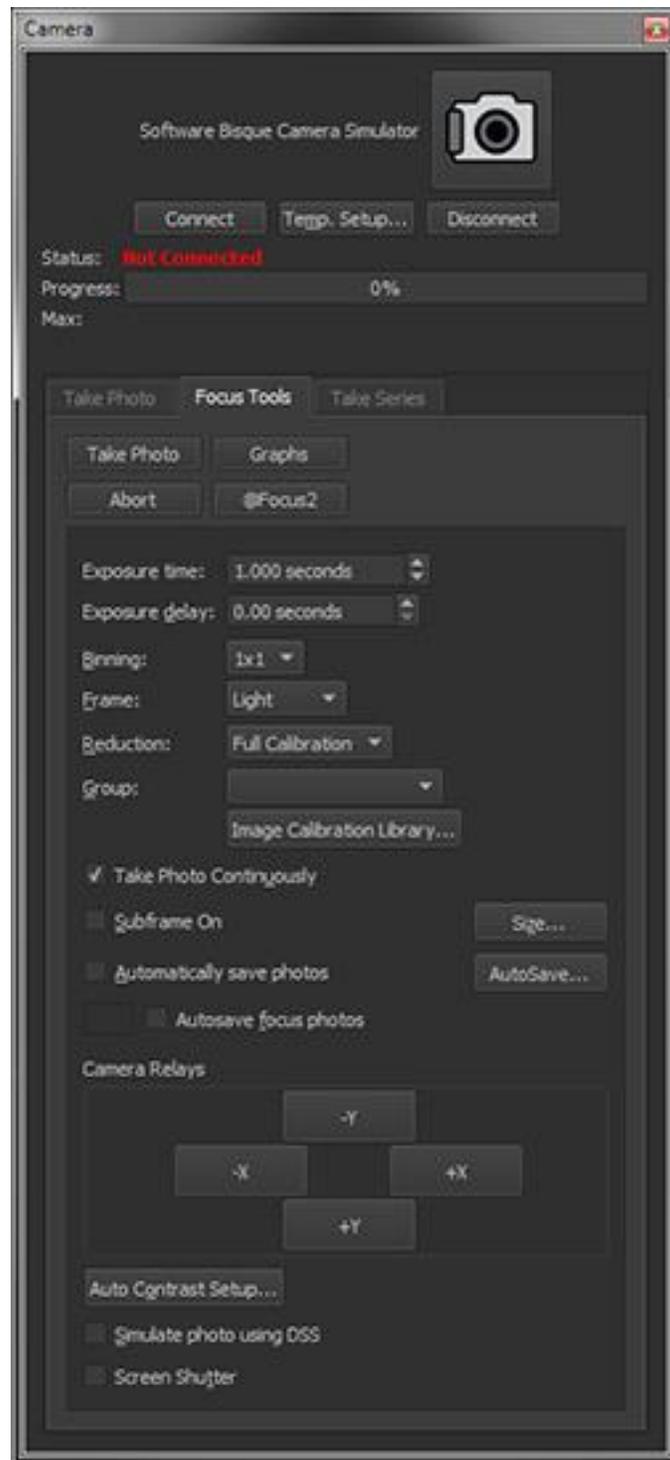


Figure 249: The Focus Tools pane of the Camera window.

## Using @Focus2

@Focus2 is the version 2.0 of Software Bisque’s automated focusing algorithm. First use manual focusing methods to get close to focus and then @Focus2 does the hard part by optimizing the position of CCD detector in the critical focus zone. @Focus2 requires an automated focuser that can be controlled by the *Camera Add On*. The list of supported focusers is available by clicking

**Telescope > Telescope Setup**, highlight **Focuser** in the **Hardware** list, then click the **Choose** command from the **Focuser Setup** pop-up menu.

@Focus2 is designed to be an end-to-end, fully automatic focus routine. It will:

1. Slew to an appropriate focus star.
2. Automatically place a sub-frame around the focus star.
3. Compute an appropriate exposure time
4. Find critical focus.

@Focus2 is flexible enough to use even if you have manually sub-framed a candidate focus star, you can simply configure @focus to skip steps 1, 2, and 3 and “jump” to finding critical focus.

@Focus2 is a single star focus algorithm that requires focus data on either side of critical focus in order to work. It requires being “close to” focus initially. @Focus2 starts by moving the focuser in one half of the **Focus Range** setting and proceeds to move the focuser out by **Focus Range/(Samples-1)** while measuring focus. Provided the **Range** is an appropriate value, @Focus2 will have crossed critical focus and will have the necessary data to compute and move to an accurate, critical focus.

The basic steps involved in using @Focus2 are:

- Step 1:** Manually get near focus.
- Step 2:** Click **@Focus2** on the **Focus Tools** tab of the **Camera** tab. Set the @Focus2 parameters to match your equipment’s capabilities.
- Step 3:** Run @Focus2, and verify that it finds the best focus position.

@Focus2 automates the focusing process and needs an accurate focuser and appropriate settings to be successful. At a minimum, @Focus2 requires a starting point near focus and a **Range** value that is appropriate for your system.

| Condition                         | Description  |
|-----------------------------------|--|
| Mechanical quality of the focuser | <p><b>Best case:</b> The focuser should have virtually no backlash, and can be positioned with an accuracy of one half or less the size of the critical focus zone. (Backlash is free play in the focuser mechanism.)</p> <p><b>Potential issues:</b> Poor mechanical quality in the focuser results in an inability to position the point of focus accurately. Typical mechanical quality issues include:</p> <ul style="list-style-type: none"> <li>• Backlash (looseness) in the focuser, which results in varying movement when reversing direction.</li> <li>• Varying voltage levels in the mount or the focuser; this results in variable movement of the focuser.</li> </ul> |

| Condition                                 | Description   |
|---|---|
|   | <ul style="list-style-type: none"> <li>• Non-orthogonality (focuser does not hold camera square to the optical path), which results in image distortions that make it harder to define the best focus position.</li> </ul>  |
| <p>Position feedback from the focuser</p> | <p><b>Best case:</b> If the focuser reports its actual physical position to TheSkyX, this allows TheSkyX to position the focuser with a very high degree of accuracy. The TCF-S focuser, for example, matches numeric values to specific focuser positions. Zero always means that the focuser is fully in; 3,500 is exactly halfway; and 7,000 always means the focuser is fully out.</p> <p><b>Potential issues:</b> Focusers that do not report their position do not allow TheSkyX to reliably position the focuser. These include the NGF-S, RoboFocus, etc. Some focusers, such as the NGF-S with DRO and RoboFocus, report a number but the number does not necessarily correspond to a physical focus position. For example, if the focuser reaches its end of travel, and the motor continues to turn, the numbers continue to change but focus position does not. See the section on “Focuser Types” below for additional information.</p> <p>There can also be delays within the device that communicates with the focuser. Some mounts, such as the LX200, introduce variable delays while processing focus commands. Because the length of the delay cannot be predicted, the effects on @Focus2 are variable and do not allow @Focus2 to reliably position the focuser.</p> |
| <p>No movement in the optical system</p>  | <p><b>Best case:</b> Nothing in the telescope/camera system moves, other than the motorized focuser controlled by TheSkyX.</p> <p><b>Potential issues:</b> If you have a moving primary mirror, a movement of the mirror (even a very small one) will not only change focus, but will change the field of view as well. A mount that tracks poorly, or that is not well aligned to the celestial pole, can also change the field of view. Both effects confound the data collected by @Focus2, and that may make it impossible for @Focus2 to get into the critical focus zone. Locking down the mirror in an SCT, and adding something like an NGF-S Crayford-style focuser, usually helps. Focusers that focus by moving the primary may or may not have sufficient accuracy to work well with @Focus2. If any part of the focuser has backlash, it becomes very difficult for @Focus2 to move the focuser reliably. Experiment with different backlash settings in the Setup window for your focuser to see which works best.</p>  |
| <p>@Focus2 parameter settings</p>         | <p><b>Best case:</b> @Focus2 must be tuned to the focal length of your telescope, the focal ratio, the speed of your focuser, and other factors to perform</p>  |

| Condition                            | Description  |
|--------------------------------------|--|
|                                      | <p>effectively. These factors are described in detail in the section “Set @Focus2 Parameters” later in this chapter.</p> <p><b>Potential issues:</b> If the Focus Range is too small, @Focus2 will not see much difference from one focus position to the next, and may not judge focus. If the Range is too large, @Focus2 may miss focus entirely by passing over it without generating enough data to know where best focus is. See the “Set @Focus2 Parameters” section for additional information.</p>  |
| <p>Very good to excellent seeing</p> | <p><b>Best case:</b> Steady seeing with minimal changes in apparent focus quality allows @Focus2 to converge upon focus quickly and easily.</p> <p><b>Potential issues:</b> If the seeing is poor, the noise level in the focusing data makes it difficult to measure focus. A high noise level tends to make it more difficult for @Focus2 to determine focus. The averaging parameter allows @Focus2 to accommodate nights with poor seeing by averaging images and effectively averaging the noise. @Focus2 will take longer to find focus when averaging is high. @Focus2 will often work under surprisingly poor seeing, but we recommend that you monitor focus quality when the seeing is average or worse.</p> |
| <p>Dark skies</p>                    | <p><b>Best case:</b> Dark skies without serious light pollution, moon glow, or sky glow.</p> <p><b>Potential issues:</b> Any kind of sky illumination can decrease the signal to noise ratio in your images. The ultimate impact of a bright sky depends on whether you are using a light pollution filter, how bright the objects in the image are, and other factors. A bright sky by itself is usually not enough to confound focusing, but it can team up with other issues and make those problems harder to deal with.</p>   |

### ***Focuser Types***

@Focus2 must be able to communicate with a motorized focuser. There are two types of motorized focusers available:

- Focusers that have positional feedback. The Optec TCF-S is an example of this type of focuser. These focusers can be positioned with repeatable accuracy. They are the best type of focuser for critical focusing because when @Focus2 says, “go to a specific position for best focus,” the focuser goes to ***exactly*** that position.
- Focusers that do not have positional feedback. Typically, the focuser is pulsed for a brief period by the mount. These focusers can be positioned with variable success, depending on how accurate the mount’s pulse length is; how long it takes the mount to send the pulse (latency); how much backlash the focuser has, and other electrical and mechanical

factors. When @Focus2 says, “go to a specific position for best focus,” the focuser **may or may not** be able to go to that position.

@Focus2 is extremely reliable with focusers that provide positional feedback. Other types of focusers, and various combinations of focusers and mounts, provide varying degrees of success with @Focus2. The current list of compatible focusers, in roughly the order of quality of focus provided, includes (your results may vary):

- **Best:** Optec TCF-S model focusers that have a serial-port.
- **Very Good:** JMI SmartFocus, RCOS Focuser, or RoboFocus attached to a Paramount mount.
- **Good:** JMI NGF-S attached to an Astro-Physics GTO series mount. Small delays may occur in making position changes; verify quality of final focus.
- **Fair:** JMI NGF-S or Meade Zero Image Shift Focuser attached to a Meade LX200. Key problems include delays in carrying out focus position changes, and variable voltage applied to the focuser motor. Both problems result in random errors in positioning. You should use the methods described later in this chapter to evaluate the quality of focus before imaging. If you cannot achieve focus with a non-positional focuser, bypass the LX200 and use a focuser than can be controlled by your computer’s serial port.
- **Variable:** RoboFocus attached to your computer’s serial port. Since the RoboFocus controls the existing focuser on your telescope, the results you get with a RoboFocus depend heavily on the quality of your telescope’s focuser.

In addition to those listed above, other focusers from third parties will become available over time. Software Bisque has a standardized, cross platform device driver architecture to allow the *Camera Add On* and *TheSkyX Professional Edition* to control most any USB- or serial port-controllable focuser ([www.bisque.com/x2](http://www.bisque.com/x2)).

### **Keys to @Focus2 Success**

There are some things you can do to get the best possible results with @Focus2. Keep in mind that not all motorized focusers are accurate enough to work with @Focus2. @Focus2 may use extremely small movements to achieve critical focus, and not all focusers can make such small adjustments accurately.

Here are some suggestions for getting the most out of @Focus2:

1. Use a focuser with an absolute minimum of backlash. The greater the backlash (free play or looseness), the less likely the focuser is to achieve accurate, repeatable focus. @Focus2 attempts to correct for backlash problems, but the less backlash, the better the results. If your focuser has too much backlash or other problems, @Focus2 should get you close, and you can manually refine focus following the @Focus2 run.
2. Use a focuser that provides accurate, absolute position feedback to @Focus2 (for example, Optec’s TCF-S).

3. If your telescope uses a moving primary mirror for focus, lock down the primary mirror and use a motorized focuser such as the JMI NGF-S. Motorized focusers that move the primary mirror are among the least likely to be successful with @Focus2.
4. Make sure that focus can be reached within the travel of the motorized focuser controlled by @Focus2.
5. Set the correct **Focus Range** for focuser movement (see “Step 2: Set @Focus2 Parameters” for details on step sizes). The range must be large enough for @Focus2 can detect changes in focus, and yet small enough so that @Focus2 does not completely move through focus in less than the number of **Samples**. See the information on **Range** in the section “Set @Focus2 Parameters” below.
6. Your mount must be well aligned to the celestial pole. Software Bisque’s TPoint software, sold separately, can quantify polar alignment and is ideal for imaging. If objects drift in and out of the field of view during @Focus2ing, this will affect the measure of focus and could lead to spurious results.
7. There must be a single focus star in the photo. A single star usually leads to successful focus,

### Step 1: Get Close to Focus

@Focus2 is designed to handle the hardest part of focusing: getting into the critical focus zone. Before you use @Focus2, you need to get the focus position close to the critical focus zone.

Here are some techniques you can use to get close:

- Move the focuser to a known good focus position. This technique works best with telescopes that allow you to physically see the position of the focuser tube, such as a refractor with rack and pinion focusing. Telescopes with internal focusers, such as many stock Schmidt-Cassegrains (SCTs), cannot use this method.
- Use an eyepiece that is parfocal with your CCD camera. (A parfocal eyepiece comes to focus at the same position as your CCD camera.)
- Manually adjust focus while using the Camera tab’s **Focus Tools** tab in continuous mode and maximize peak value and or minimize HFD values.



How close should you be to perfect focus before running @Focus2? If the focus star looks like a large “doughnut” focus is not yet good enough.

Figure 250 shows an example of an OK starting point for an @Focus2 run. The medium-bright stars are clearly small doughnuts with central holes. Brighter stars often don’t display doughnut holes because the default image histogram settings.

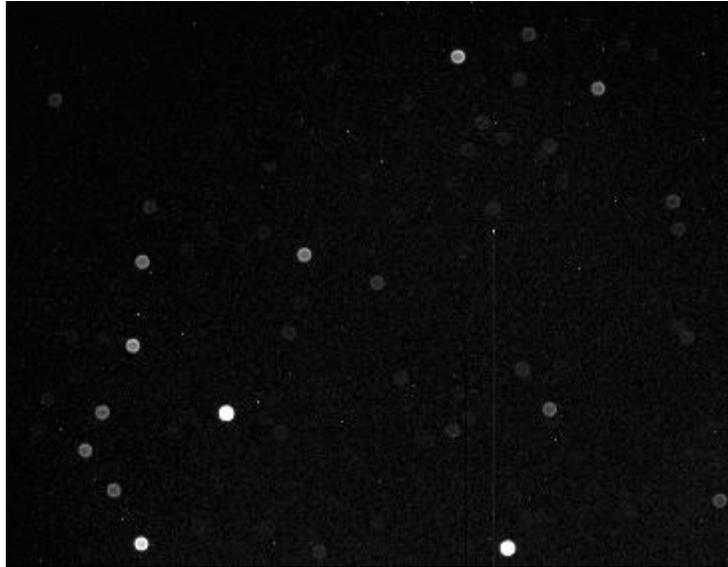


Figure 250: An example of an acceptable starting point for @Focus2.



Seeing conditions may have a significant impact on your ability to use faint stars for evaluating focus quality. This is especially true at longer focal lengths (greater than about 1500mm). The seeing may reach a point where fluctuations from turbulence scatter the light so much that it appears that you aren't at good focus. However, @Focus2 will still be able to find the best possible focus for the seeing conditions. Even on nights with very poor seeing there is a position of optimal focus. If the seeing is poor, and the best focus you can reach isn't good enough, switch to a shorter focal length if possible or image when the seeing is better.

### **Step 2: Set @Focus2 Parameters**

If you have followed the guidelines in the “Keys to @Focus2 Success” section, you are ready to configure @Focus2 for optimal focusing with your system.

Parameter settings that change more frequently are included on the **@Focus2 Automated Focus** window, which opens each time you click on the **@Focus2** button on the **Focus Tools** tab of the **Camera** window (Figure 251). When you click **OK**, @Focus2 starts a focusing run. We suggest you review the detailed information about the various parameters below before you try your first focusing run, as you may need to adjust some of these parameters to suit your system.

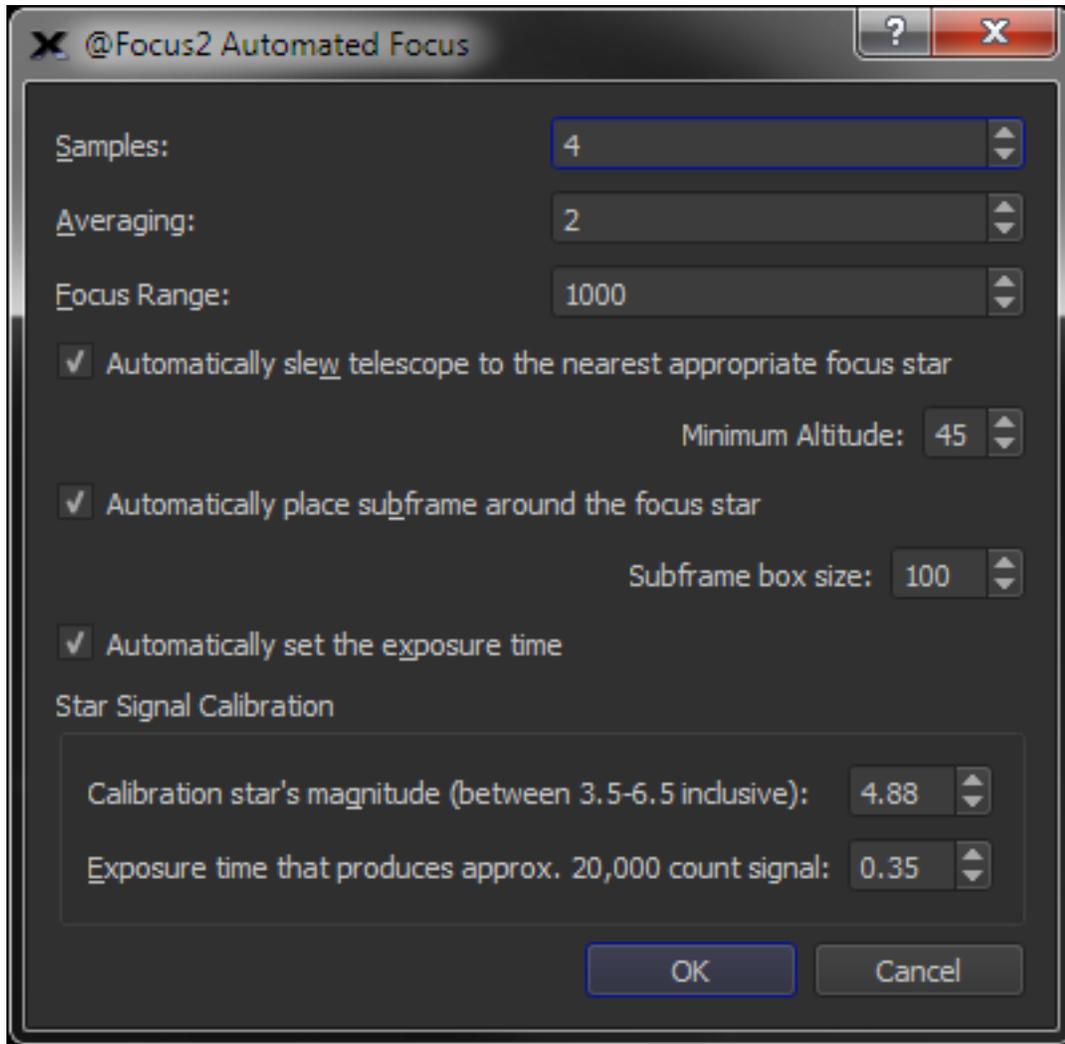


Figure 251: Setting @Focus2 parameters.

@Focus2 settings are described in this section. The following list includes the parameters you may encounter using @Focus2. Depending on the focuser you are controlling, however, some parameters may not be available.

### **Samples**

This is the number of photos @Focus2 uses to achieve best focus position. The available range is 4 to 50. For most applications, the default value of 4 gives good results (two samples on each side of focus). @Focus2 requires at least 2 samples on each side of the critical focus zone. For critical applications, you can increase the Samples number.

### **Averaging**

This is the number of photos to take per focus sample. Averaging can help when seeing is poor. For good to excellent seeing conditions with a high-quality focuser, a value of 1 is usually satisfactory. For poor to average seeing, a value of 2 or 3 is a good compromise between speed and quality. When the seeing is creating serious problems, averaging 5 or higher will smooth out the focus curve significantly, although it will take longer for @Focus2 to converge upon focus. You can also use averaging when the seeing is good to reduce the overall noise level in the

focusing data. Experiment to determine the optimal setting for your system. Generally, the smallest setting that regularly achieves excellent focus is the right value to use. We recommend starting with the default values, then change settings one at a time to see what affect that has on focus quality.

### ***Focus Range***

This is the focus range that will be sampled when performing a focusing run, half below and half above whatever focus position is at the start of the run. Setting the ***Focus Range*** requires some analysis of the behavior of your telescope/mount/focuser system, and is covered in detail below.

The key parameter for success with @Focus2 is getting the ***Focus Range*** value correct.

A rough starting point for your Range is approximately 40 times the size of your critical focus zone. For example, an initial Range for an f/5 scope with the TCF-S would be  $(40 * 55) = 2200$  microns. At 2.18 microns per step, that would give an initial Range of about 1000.

Experience with your camera and using the ***Focus Graphs*** also helps determine the ***Focus Range***. The focus V-Curve graph should end up being a V shape where the vertex of the V points to the critical focus position.

### ***Automatically Slew Telescope to the Nearest Appropriate Star***

When *TheSkyX Pro* is being controlled through the user-interface, or via script, and this checkbox is turned on, clicking the ***@Focus2*** button, and then clicking ***OK*** on the ***@Focus2 Automated Focus*** window, slews the telescope to the nearest available star (that is, the star located the shortest angular distance from the telescope's current position, not the star closest in terms of light years!) to use for focusing the telescope.

### ***Minimum Altitude***

Enter the lowest permissible altitude of the focus star to slew the telescope, in degrees. Stars below this altitude are considered "inappropriate" and are not used.

### ***Automatically Place Subframe Around Focus Star***

When *TheSkyX Pro* is being controlled through the user-interface, or via a script, and this checkbox is turned on, clicking the ***@Focus2*** button, and then clicking ***OK*** on the ***@Focus2 Automated Focus*** window, a subframe is placed around the focus star. When the subframe is present, only the region within the subframe box is download from the camera to make the focus process more efficient.

### ***Subframe Box Size***

Enter the size of the subframe, in pixels, that is placed around the focus star.

### ***Automatically Set the Exposure Time***

When *TheSkyX Pro* is being controlled through the user-interface, or via a script, and this checkbox is turned on, clicking the ***@Focus2*** button, and then clicking ***OK*** on the ***@Focus2***

**Automated Focus** window, the following two parameters are used to set the exposure time of the focus star photo.

***Star Signal Calibration***

@Focus2 can use *any star* to find focus, but stars vary in brightness. If the calibration star is saturated because the exposure time is too long, the HFD of the star will not be accurate, and @Focus2 will fail.

In general, you want to take an exposure that is long enough to get a good star signal for measuring the HFD, but not so long that the star's signal saturates the camera. Use the following two parameters to define the magnitude of the calibration star, and the exposure time for your optical system that produces a signal of approximately 20,000 counts or ADUs.

***Calibration Star's Magnitude (Between 3.5-6.5 Inclusive)***

Enter the magnitude of the calibration star that is used to achieve focus. The star's magnitude must be from 3.6 to 6.5.

***Exposure Time that Produces Approximately 20,000 Count Signal***

Enter an exposure duration, in seconds, that produces approximately 20,000 ADUs for your camera and optical system.

**Focuser Training**

The Focuser window shows focuser status, with options for adjusting the focuser's position, and training the focuser offsets to apply for a given light filter when acquiring photos.

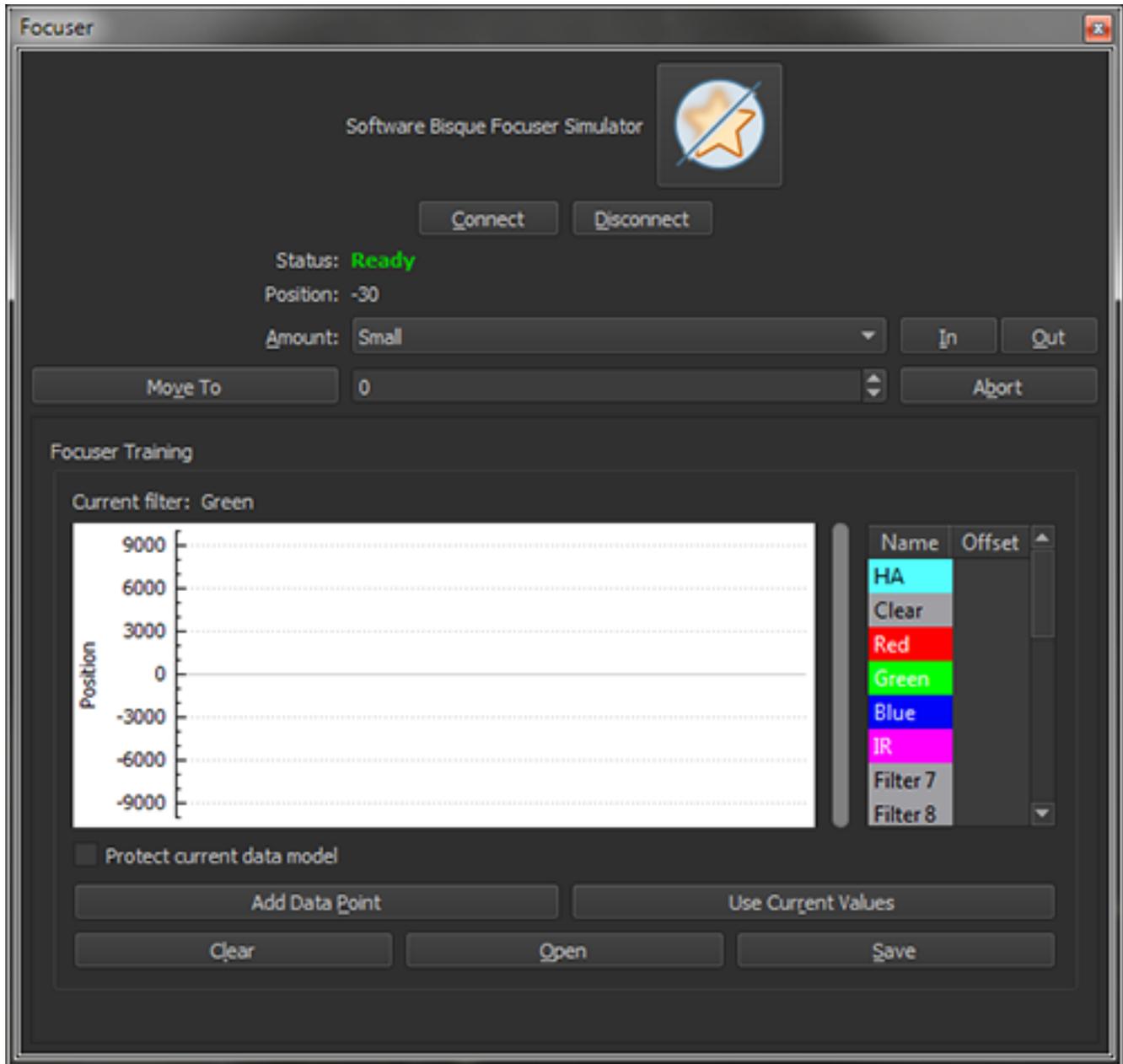


Figure 252: Focuser Training controls.

The currently selected focuser is displayed at the top of the **Focuser** window. Click the gear icon to display the **Choose Focuser** window and select your focuser, if necessary.

**Connect**

Click this button to establish connection to the selected focuser.

**Disconnect**

Click this button to terminate connection to the selected focuser.

**Status**

The connection status for the selected focuser is displayed next to the **Status** text.

***Position***

Shows the current position of the focuser. Depending on the model focuser, this value may be relative to an absolute focuser position, or relative to the starting focuser position.

***Temperature***

For focusers that report ambient temperature, the focuser's current temperature is displayed next to the ***Temperature*** text.

***Amount***

This pop-up menu can be used to select the relative amount of travel in the focuser's position when moving it in or out, ***Small, Medium*** or ***Large***.

***In/Out***

Click these buttons to move the focuser in or out.

***Move To***

Click this button to move to the focuser position that is entered in the text box to the right of this control.

***Abort***

Click this button to stop an in-progress focuser position adjustment.

***Current Filter***

The Focuser Training section of the Focuser window shows the currently selected filter wheel filter when one is present. If no filter is shown, click the ***Move Now*** button on the ***Camera*** or ***Video*** window to rotate the filter wheel to a known position.

***Focuser Training Graph***

Shows the data points that will be used to make adjustments to the position of the focuser for each filter.

***Filter and Offsets Table***

This table lists each filter wheel in the ***Name*** column, and the focuser offset in the ***Offset*** column. Double-click on each filter name to select the background color.

***Protect Current Data Model***

Turn this checkbox on to prevent changes to the filter offsets that are currently assigned to each filter.

***Add Data Point***

Click this button to add a focuser offset for the current filter.

### **Use Current Values**

Click this button to create a temperature compensation curve based on the current filter offset values.

### **Clear**

Click this button to clear the data points from the existing model, and reset the graph.

### **Open**

Click this button to open a Focuser Data file that contains

## **Focuser Training Details**

Motorized focusers can be “trained” so that focus adjustments can be made while imaging. In the context of focuser training, there are two different types of focus:

- **Closed Loop Focus:** Focus is adjusted, and the results are verified (either automatically by software, or visually).
- **Open Loop Focus:** Focus is adjusted based on previously measured characteristics of the system.

In both cases, closed loop focus generally yields better results than open loop, but open loop can keep maintain critical focus for a good deal longer than would normally be possible.

@Focus2 provides automated closed loop focusing. The *Focuser Training Tool* attempts to characterize your system so that open loop focusing can be used effectively.

The *Camera Add On* attempts to compensate for two separate sources of defocus:

1. Defocus due to filters that are not, or are not *quite*, parfocal.
2. Defocus caused by temperature variations.

To successfully characterize the open loop movements that must be performed to compensate for these sources of focus “error”, the *Camera Add On* must acquire a number of “known valid points” (KVPs). These data points record:

- Focuser position
- Current temperature
- Current filter

When enough KVPs have been acquired, the *Camera Add On* is able to perform open loop focusing to compensate for different filters and varying temperatures.

There are two ways to acquire KVPs:

- **Automatically:** Successfully completing an @Focus2 run records a KVP (unless the **Protect Current Data Model** checkbox turned on in the training tool). An unsuccessful @Focus2 run will not record a KVP.
- **Manually:** Clicking the **Add Data Point** button in the training tool adds a KVP using the current system parameters.

The total number of KVPs needed to maintain focus is subjective. While more KVPs produce a more accurate model, in practice, a small number of KVPs for each filter will generate good results if the KVPs are collected over a wide temperature range.

Once a data model contains a good number of KVPs, click the **Use Current Values** button to make use of the collected data. If you have already characterized your system using another software package, you can also manually edit the focus compensation values.

The Filter and focus offsets may be entered in the **Filter Names Setup** window. The temperature compensation slope for your system may be entered in the **Temp Compensation, Adjust C** text box. These fields will automatically be filled out when you click the Use **Current Values** button on the focuser training tool.

Once these values have been filled out, they will remain in your imaging system profile. The focuser will automatically adjust itself each time a new filter is selected.

Turn on the **Activate** checkbox under **Temp. Compensation** to command the **Camera Add On** to automatically adjust the focuser's position as temperature changes. Note that at least one valid KVP must be recorded before temperature compensation can be performed.

The KVP data model can be refined over the course of several imaging sessions. Data models may be saved and loaded at any time, although their parameters will not become active until the **Use Current Values** button is clicked.

Some focusers do not return to the same physical position each time they are activated (examples would be a relative focuser that always comes up at position 0, or an inline focuser on the end of a drawtube). Special care must be taken when loading models generated by these sorts of focusers. Rather than simply loading a model generated by this sort of system, generate a new model with a few data points instead, then select **Merge** when loading the previously saved data set. This will ensure that the old data set makes use of the system's current focuser offsets.

## Focusing Manually

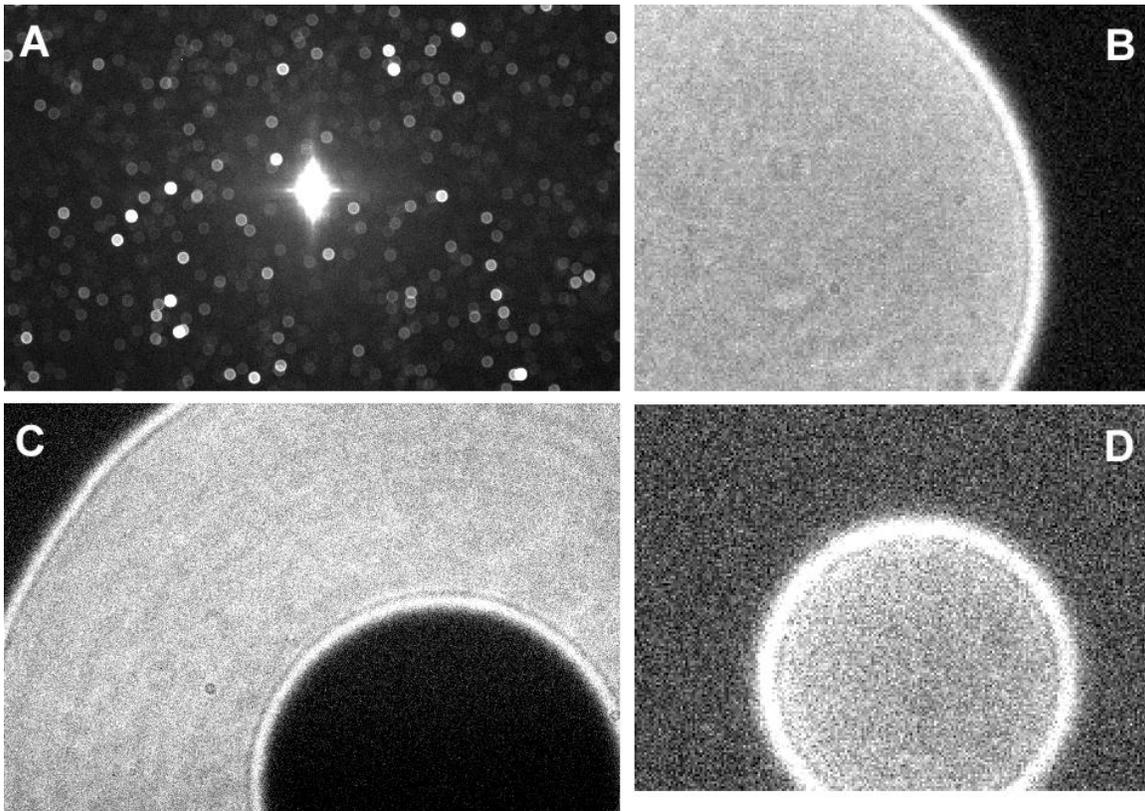
The **Camera Add On** can assist you in achieving manual focus. You can get close to focus in several ways:

- If you found the correct focus position previously, mark the focuser position so you can move the focuser into position at the start of your imaging sessions. This will not work with scopes that have internal focusers, such as most Schmidt-Cassegrain telescopes.

- If you can get a very bright star in the field of view of the CCD camera, it will show a very large out of focus image of a star. The star should be magnitude 2 or brighter, or the out of focus image will be so dim that you might not recognize it. Center the star, and adjust focus until the star is close to focus.

Figure 253 shows four examples of images that are out of focus. Image A is just slightly out of focus. If you have a parfocal eyepiece or can position the focuser in the same place on subsequent nights, this is the type of focus quality you might see. Image B shows a star image very far out of focus, as it appears in a refractor. You can adjust focus to reduce the size of the star image, but you will likely have to make a large change in focus position to get close to focus. Image C shows a similar very far out of focus star image, but taken with an SCT. Note the shadow of the central obstruction. Image D shows an out of focus star image that is underexposed. The image is very grainy, and the default image settings had to be changed to show the star clearly.

The histogram or the background and range settings are used to make these changes. You will generally need longer exposures to show out of focus stars, even very bright ones. You can reduce exposure time during focusing as the star's image becomes smaller and brighter. If you are sure you have a star in the field of view, but think it might be very far out of focus, try a much longer exposure to see if the star's out of focus image comes into view.



**Figure 253: Various stages of focus. A: slightly out of focus with a wide-field refractor; B: far out of focus with a refractor; C: far out of focus with an SCT; D: moderately out of focus with a refractor and underexposed.**

You may find it useful to center the out of focus star so that it will still be on the CCD detector when you get close to focus.

The idea behind manual focus is to take photos continuously while changing the focus position to maximize, maxim pixel value or minimize HFD.

**Step 1: Get your focusing tools ready**

You can use the **Focus Tools** tab to focus manually (Figure 254). To use the **Move Focus** buttons, you must have selected a focuser from Telescope, Setup. There are two types of focus adjustment outside of TheSkyX: manually changing the focus of your telescope, or controlling a motorized focuser with a hand paddle, such as a JMI MotoFocus.

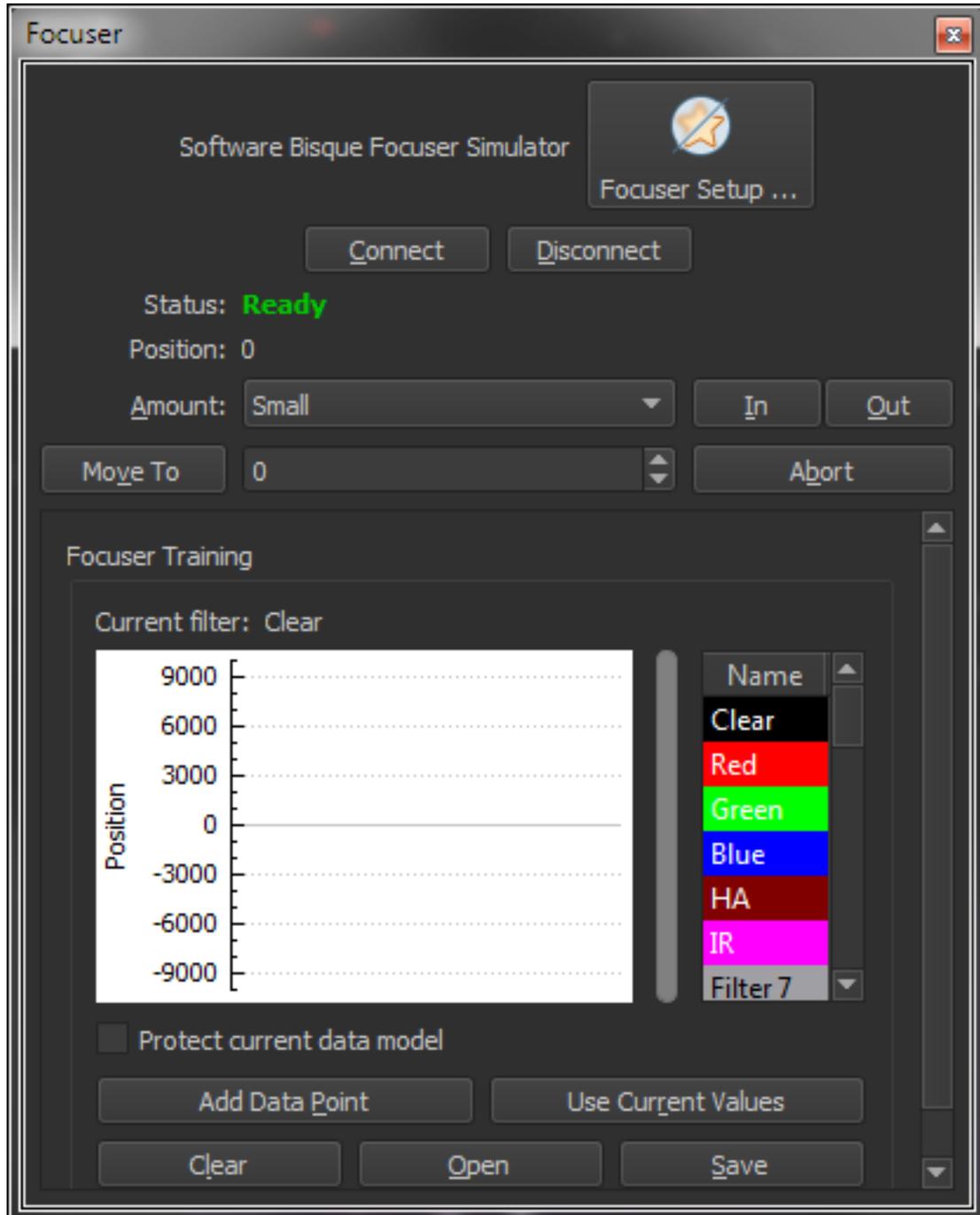


Figure 254: Most of the tools you'll need for focusing are on the Focuser window (Focuser command, Display menu).

### **Step 2: Verify Initial Settings**

The initial focus exposure is often taken using the largest possible binning mode on your camera. Binning provides a faster download time, and lets you check your focus quality quickly. For example, with an ST-8E, the maximum binning is 3x3.

Typical initial settings should be: **Image Frame** set to **Light**, and **Image Reduction** set to **AutoDark**. The *Camera Add On* will automatically take dark frames with the same exposure length as the light frames. This removes hot pixels from the focus images, and makes it easier to tell when dim stars are properly focused. If you have a filter wheel installed, set it to the Clear filter for focusing.

Make sure **Subframe On** is not checked, and also make sure. For a quick test of your current focus position, start with a **Bin** setting of **3x3**. Set the **Delay** to 0.00. Click **Graphs** to provide the most accurate assessment of focus quality.

### **Step 3: Enter an Exposure Time**

Enter an exposure time in the **Exposure Seconds** box. This will typically be about 5 to 30 seconds, depending on how bright you expect the stars to be in your field of view, the aperture and focal ratio of your telescope, the quantum efficiency of your camera, the current state of focus, etc. Experience will show you what exposure lengths will work well for focusing with your setup. We suggest that you use 10 seconds as a starting point for your first attempt at focusing. You can increase or decrease this value based on the results you get from your system. If you have a non-antiblooming CCD detector, make sure your exposure is short enough that there are no blooming stars. Figure 253b shows an example of a blooming star. A bloom occurs when pixels have filled up with electrical charge and spill over (bloom) into their neighbors. Blooming only occurs in one axis, so a bloom is always a line extending from a star in two directions.

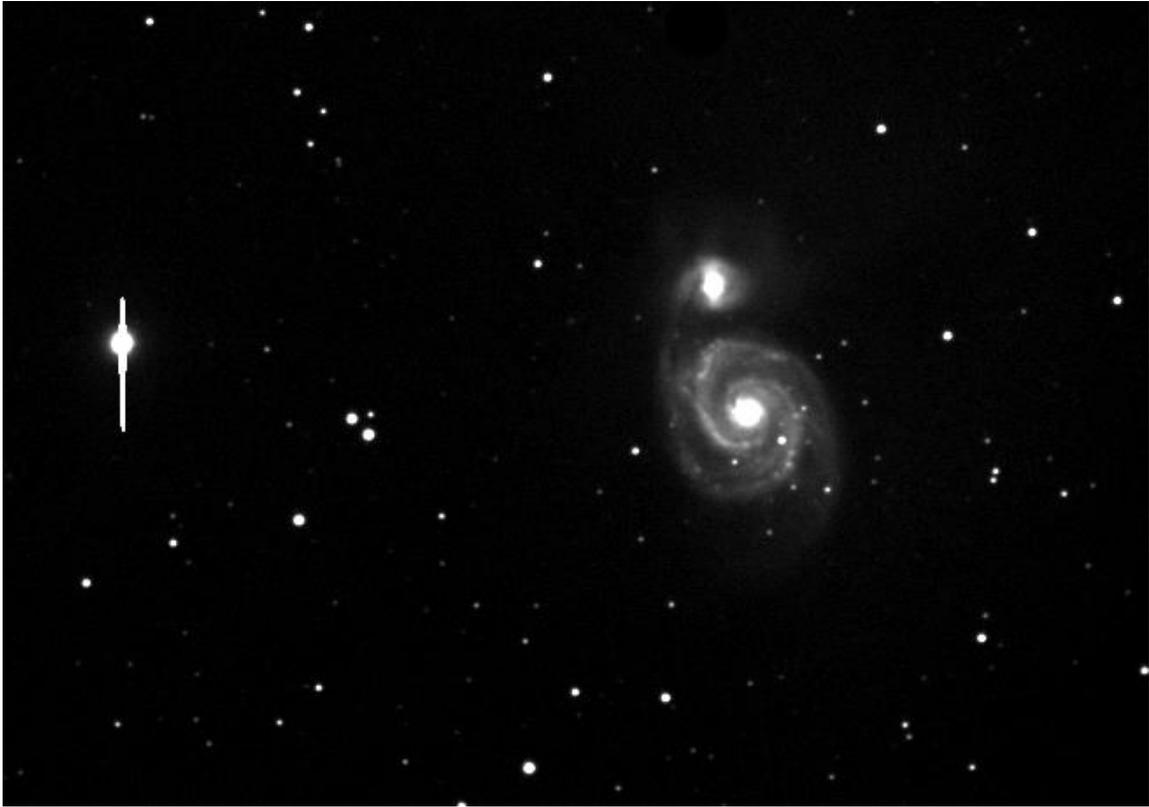


Figure 255: An example of a star that is bright enough to bloom.

#### **Step 4: Take a Photo**

Click **Take Photo**. You will see various messages in the Status area at the top of the Camera window:

- **Selecting Filter** (appears only if you have a color filter wheel).
- **Exposing Light** (appears during exposure, with a timer showing time remaining).
- **Downloading Light** (appears while the frame is being downloaded from the camera to your computer).
- **Exposing AutoDark** (appears during the dark frame exposure, taken with the shutter closed).
- **Downloading AutoDark** (appears while the dark frame is being downloaded from the camera to your computer).

The light frame will appear first. Do not be concerned if it has many bright pixels; these will go away when the dark frame is downloaded and subtracted from the light frame.



The use of an AutoDark frame is optional for focusing. If you are using a very bright star for focusing, or if you are taking very long focus exposures, you can choose not to use AutoDarks. However, accurate focusing is critical to getting sharp images and useful photometry, and we recommend that you use AutoDark when focusing. A new

AutoDark is taken only when the exposure length or image size changes, so you only have to wait for the first one.

If the stars are not small, round, and numerous in the image, adjust focus until stars appear as small round dots. Aim for somewhere close to focus. Don't try to achieve optimal focus in 3x3-binned mode. You need to switch to 1x1 using sub-frames, covered below in step 5.



Make a mental note of the direction you are moving the focuser knob during step 4. Your goal is to approach focus from one side until it is optimum. In the next step, you'll be making very small changes, and it helps to know the direction you should be moving in to improve focus. Seeing conditions may interfere with clear evaluation of focus quality, and knowing the direction to move will help you keep track.

### **Step 5: Select a Star and Put It in a Sub-Frame**

Another tool for speeding up your focusing is the sub-frame. This is a small portion of the image immediately around the star you will be using for focusing. To select a sub-frame, click and drag around a bright star in your 3x3 binned photos, as shown.

Which star should you select? The ideal star meets these criteria:

- It is one of the brighter stars in the frame, but it is not saturated. Move the cursor over the star and observe the brightness value in the status bar; make sure it's not saturated. That is, make sure it does not have a brightness level anywhere near the maximum value for your camera.
- There are other, dimmer stars close to the focus star. You can use these dim stars to assist you in accurately evaluating focus quality. When you are imaging in the Milky Way, this is easy to do. At other times, dim stars may not be available.



In general, the better your polar alignment, the smaller your focusing sub-frame can be. With a good polar alignment, the stars will move very little between exposures, and you can use a small sub-frame without worrying about losing the star after a few exposures. The smaller your sub-frame, the faster it will download and the more efficiently you can focus. If the star gets close to the edge of the sub-frame, you can use the **N/S/W/E** buttons in the **Move telescope** section to make adjustments if you are having an autoguider connected to your telescope.

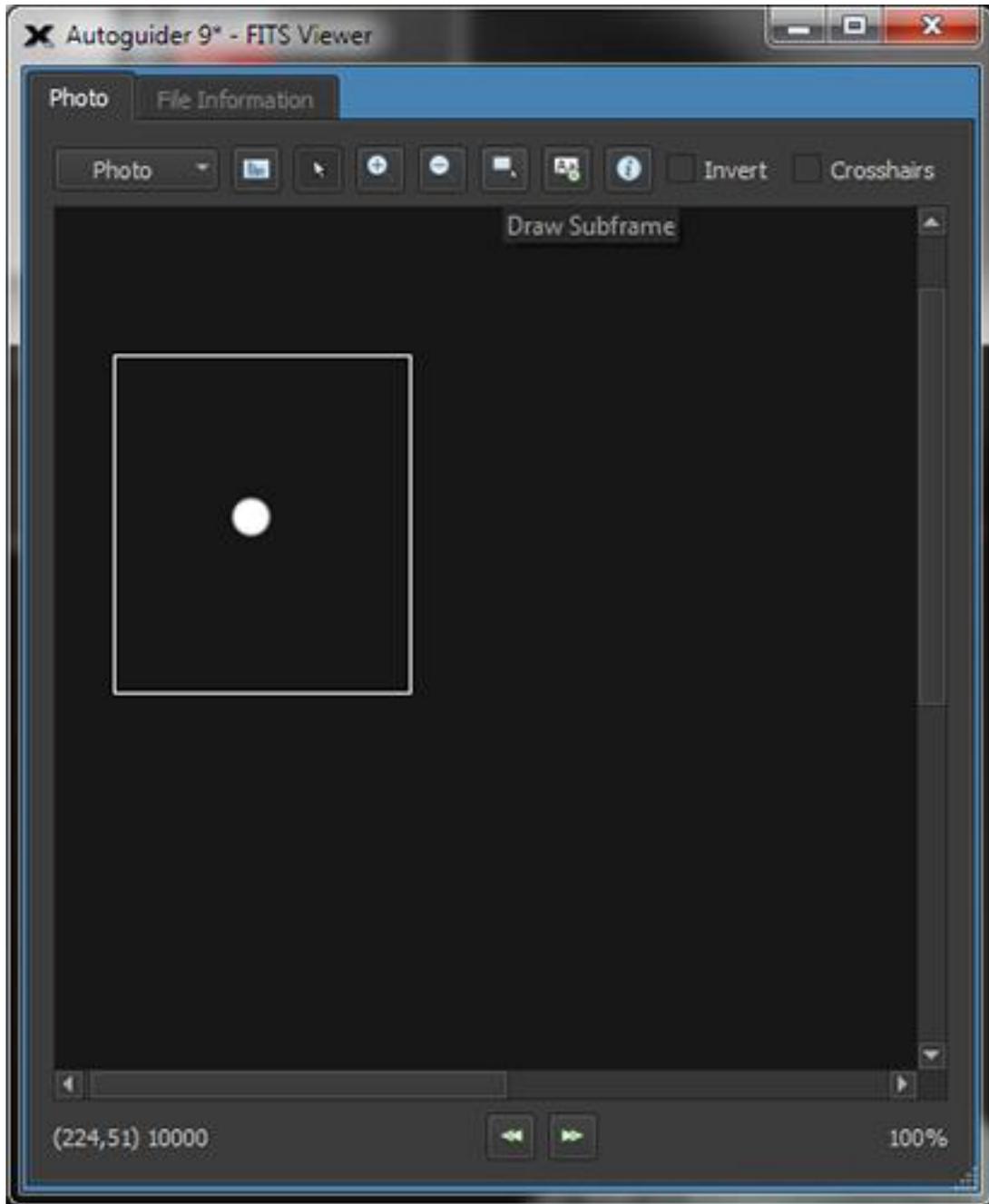


Figure 256: Select a focusing sub-frame by clicking the Sub-frame button and dragging a sub-frame in the FITS Viewer window.

Note that the **Subframe** checkbox in the Camera Control Panel gets turned on automatically when you select a sub-frame using click and drag. You can also click **Size**, and enter the position and size of the subframe numerically, but for most focusing needs a click and drag will be your best bet. For best results, you want a small sub-frame so that you don't spend a lot of time waiting for focus images to download. Allow room around the star for any dim background stars to show up. These dim stars can be an effective asset when focusing.

### **Step 6: Adjust Focus Using Continuous Focus Mode**

Click on the **Take photos continuously** checkbox on the **Focus Tools** tab. This activates continuous focus mode. The **Camera Add On** will take focus exposures one after another while you adjust focus. If the star you are using for focusing becomes too bright as you improve focus (that is, it becomes saturated and/or blooms), you can abort, adjust exposure time, **Abort**, and resume in continuous focus mode.

Use the **1x1** (unbinned) bin mode to get best focus. Use the **Bin** pop-up menu at top center of the **Focus Tools** tab to select the **1x1** option.

If you need some time between exposures to make manual (or motorized) adjustments to focus position, enter an appropriate delay in the **Delay** box at upper left. We suggest 7-10 seconds when you are getting started. As you gain experience, you can use shorter delays to speed up your focusing process. No delays can work once you are familiar with the manual focus process.



If you have an electric focuser that is controllable from *TheSkyX Professional Edition* software, but not accurate enough to work with @Focus2, you can use the **Move In** and **Move Out** focuser control buttons on the **Telescope** window.

You can visually observe the sub-frame window to help you decide when you have reached optimal focus. The **Focus Tools** tab also provides several types of feedback that will help you identify when you are in the critical focus zone. These include a graph showing a history of HFD or brightest-pixel values, and a numeric readout below the graph. If TheSkyX is connected to a focuser the **Focus Graphs** will also display Focus V-Curve graph of HFD vs. Focus Position (the HFD is at a minimum when in focus).

If connected to a focuser that doesn't have digital readout, TheSkyX maps focuser **Move In**, **Move Out** to relative numeric focus values so that the Focus V-Curve Graph may be valid provided the numeric focus values somewhat relate to reality and the focuser physically moves consistently.

To start fine focusing, continue focusing in the direction you established during your initial, very rough focusing procedure. The star image will get smaller, and the value of the brightest pixel in the image will increase.

The brightest pixel gets brighter because, as you get closer to optimal focus, you are concentrating more light energy from the star on the central pixels of the star image. This value rises steadily as you improve focus, but turbulence frequently causes it to become somewhat erratic as you get very close to focus.

The HFD value is a great tool for judging the quality of focus. HFD tracks the quality of focus more accurately than brightest-pixel values. You can always check the current brightest pixel value in the information lines at the top the Camera tab, under the heading Max.

The trick when focusing is to know what to expect at the point of best focus. The simplest way to find this out is to go past best focus and observe what happens with the appearance of the

image and the Focus Graphs. As you move toward focus, the star's image gets smaller and brighter, and the HFD trends downward. Past best focus, the star image will begin to get fuzzy again, and the HFD will start to trend upward. Strong atmospheric turbulence makes the graph values especially erratic near optimal focus, but HFD is less susceptible to this compared to brightest pixel value.

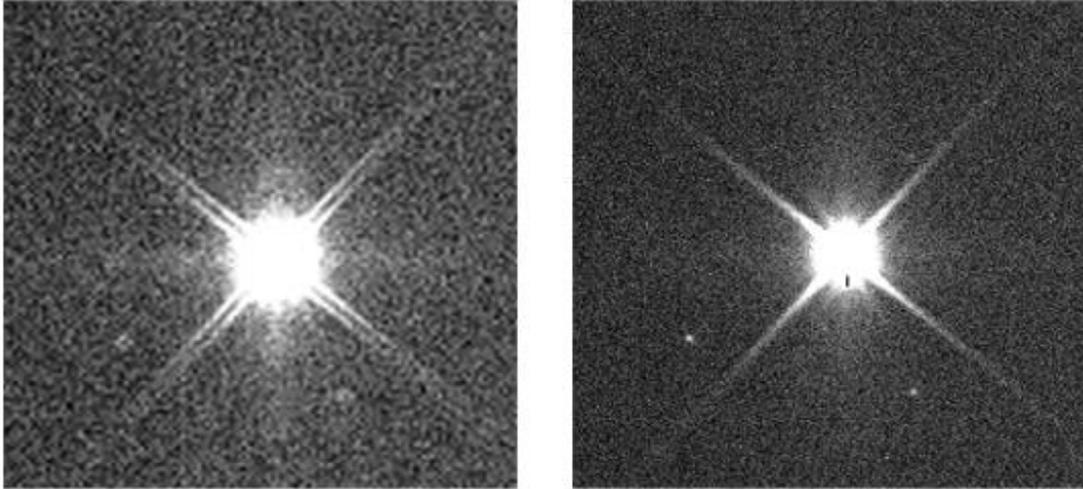
Dim stars in your sub-frame are one of the best methods you can use to assist you in determining focus. The reason for this is simple: when you are out of focus, even by a little bit, dim stars will be invisible or extremely fuzzy. When you reach optimal focus, dim stars suddenly jump into view.

Several things indicate optimal focus. The minimum HFD and the brightest pixel value is now much higher than in the previous photos.

Some additional methods of focus include:

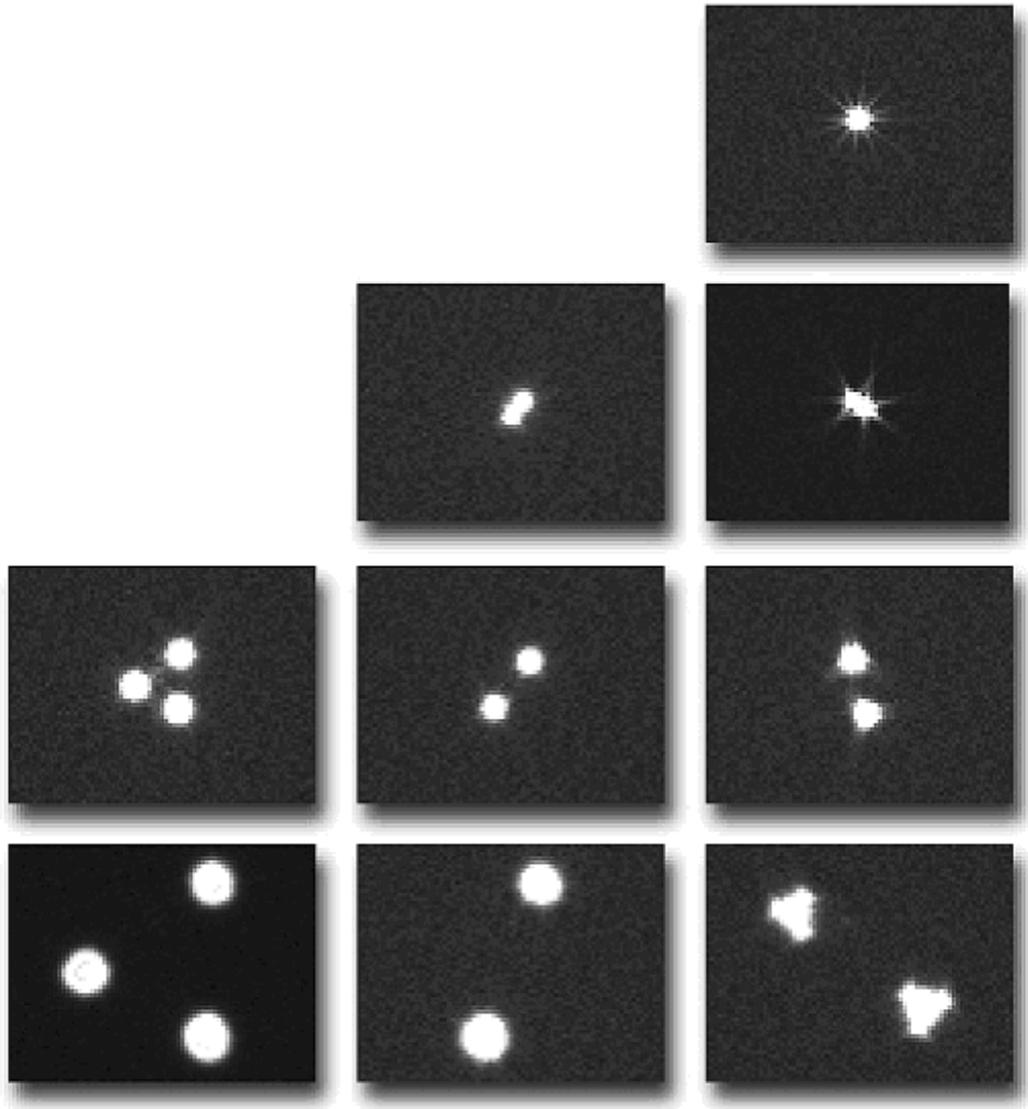
- Observing sharpness of diffraction spikes, such as from a Newtonian's spider or masking tape across the front of the telescope. These will appear double when you are out of focus, and will get closer together as you approach the critical focus zone. When they merge and become a single, bright diffraction spike, you know you are at the optimal focus position.
- Various kinds of masks, such as a Hartmann mask, can be used to assist in determining best focus. Such masks cover the aperture of your telescope, and have two or more holes cut in them. The holes cause multiple star images, which merge when you reach the critical focus zone.
- You can also create diffraction spikes using artificial spiders. For example, you can make a cross of wooden dowels to put across the front of your telescope, or you can make a cross of masking tape quickly and easily across the front of your scope.

Figure 257 shows two examples of spikes from a Newtonian spider: slightly out of focus on the left, and in focus on the right. Masking tape will produce the same kind of diffraction pattern. Note the two dim stars in both images, and how they also come into sharp focus at the same time as the diffraction spikes.



**Figure 257: Diffraction spikes can be used to determine the point of best focus.**

Figure 258 shows three examples of diffraction spikes created by three types of mask. From left to right, they are a three-hole mask, a two-hole mask, and a two-triangular hole mask. The advantage of the triangular-hole mask is that each triangle throws off diffraction spikes. When all the spikes have a common center, you are focused.

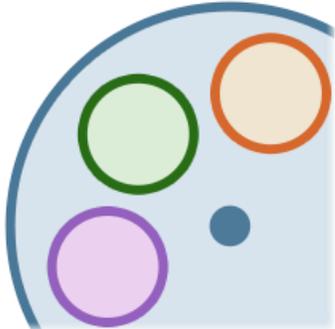


**Figure 258:** Focusing masks show bright spots with the same shapes as the holes in the mask. The holes converge as focus improves. The two-triangle mask (right) is easy to use because it has diffraction spikes; round holes do not have diffraction spikes.

When you have reached focus, you can proceed to capture images. The *Camera Add On* offers several opportunities for productive imaging and guiding using the **Camera** tab and **Autoguider** tab.

# Filter Wheel Control

PROFESSIONAL



The *Camera Add On* can natively control the filter wheels listed in the table below.

| Filter Wheel Manufacturer/Model        |  |  |  |  |
|--|---|---|---|---|
| Apogee Instruments/All models          | -   | ✓   | -   | -   |
| ATIK/All models                        | ✓   | ✓   | -   | -   |
| FLI/All models                         | ✓   | ✓   | ✓   | ✓   |
| Orion/All models                       | -   | ✓   | -   | -   |
| QSI (Embedded)                         | ✓   | ✓   | ✓   | ✓   |
| SBIG/All models                        | ✓   | ✓   | ✓   | -   |
| Software Bisque/Filter Wheel Simulator | ✓   | ✓   | ✓   | ✓   |
| Starlight Xpress/All models            | ✓   | ✓   | ✓   | ✓   |
| Xagyl Filter Wheels <sup>1</sup>       | ✓   | ✓   | ✓   | ✓   |

<sup>1</sup>This open-source X2 Plug In must be [downloaded and installed separately](http://www.rti-zone.org) from [RTI-Zone.org](http://www.rti-zone.org).

The *Camera Add On* can also control any ASCOM-compliant filter wheel on Windows.

## Filter Wheel Setup

Choose the **Telescope Setup** command from the **Telescope** menu to display the **Imaging System Setup** window. On the **Imaging System Setup** window, highlight **Filter Wheel** in the **Hardware** list to display filter wheel specific options.

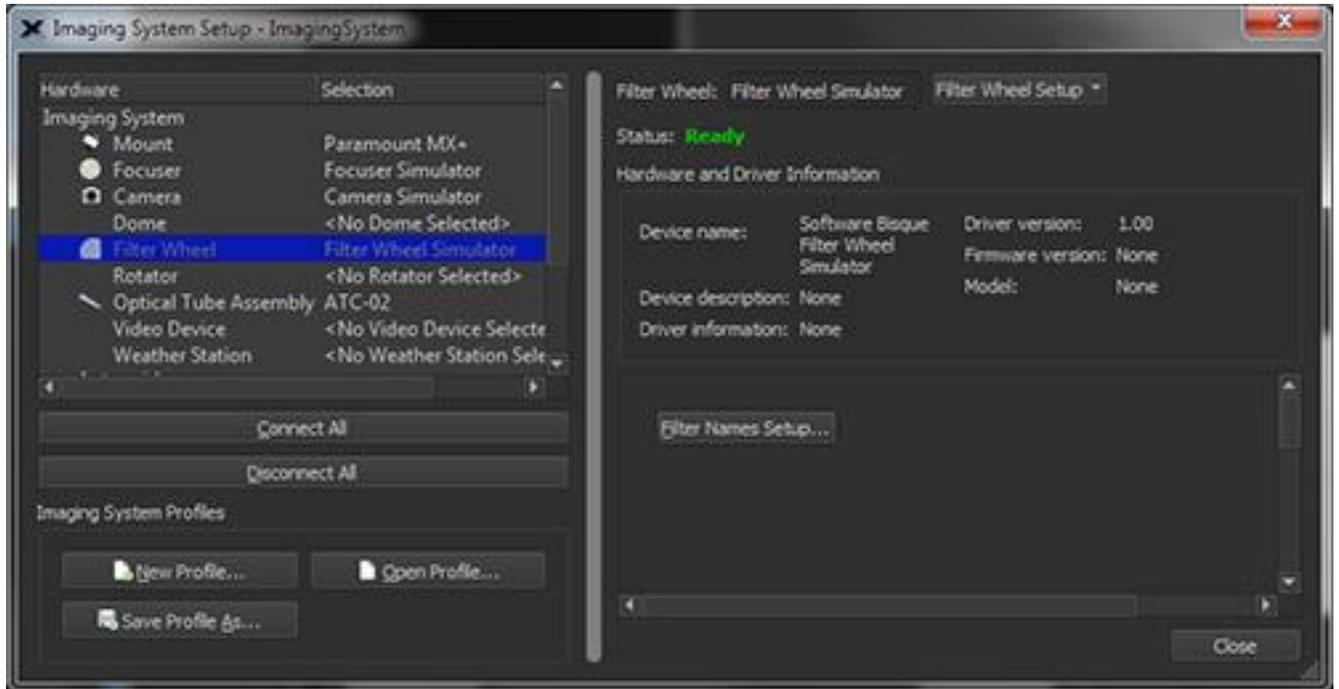


Figure 259: The Filter Wheel options on the Imaging System Setup window.

### **Currently Selected Filter Wheel (Filter Wheel text)**

The **Filter Wheel** text at the top of the **Imaging System Setup** window shows the manufacturer and model of the currently selected filter wheel.

### **Hardware and Driver Information**

When **Filter Wheel** is highlighted in the **Hardware** list on the **Imaging System Setup** window, the following hardware and driver-specific information is displayed.

### **Filter Wheel Names Setup Pop-Up Menu**

The **Filter Wheel Setup** pop-up menu provides commands for choosing, setting up, connecting to and disconnecting from a filter wheel.

### **Choose**

Click this command to display the **Choose Filter Wheel** window. The **Filter Wheel** list shows all supported models.

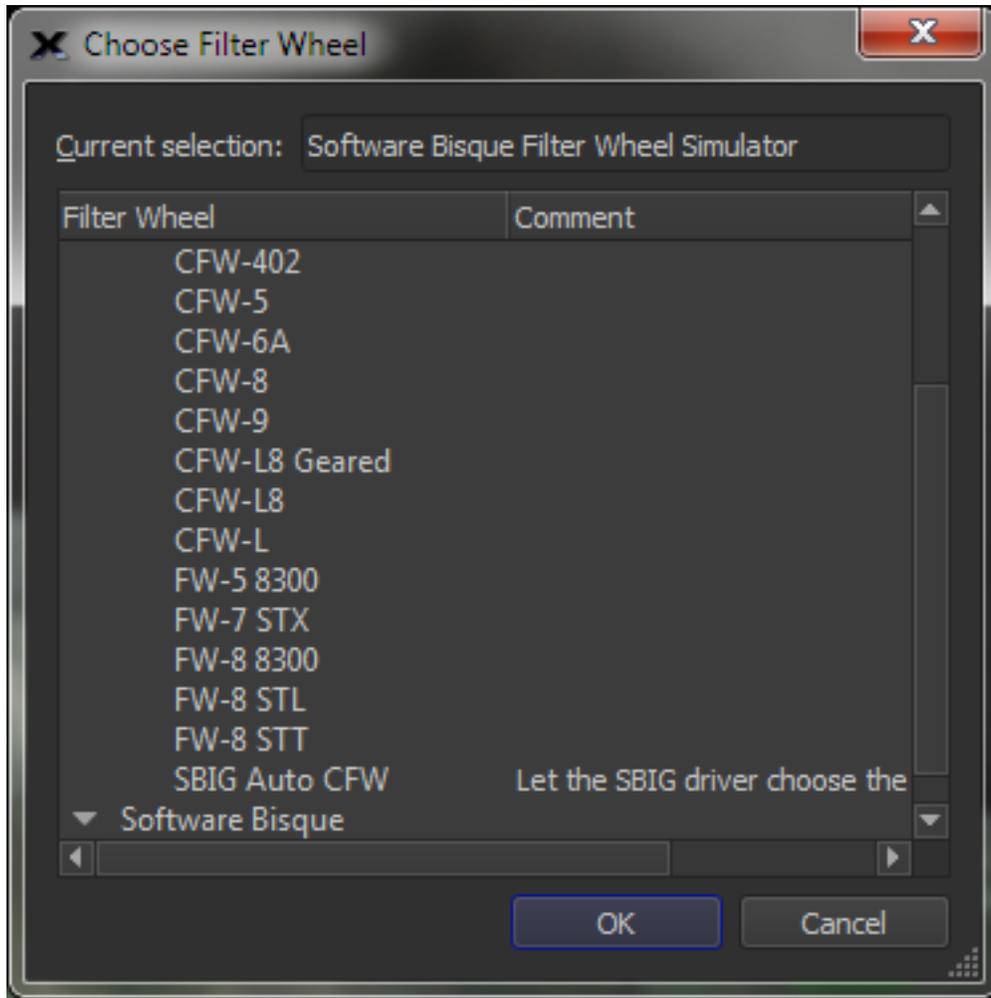


Figure 260: The Choose Filter Wheel window.

### Settings

Click this command to display filter wheel-specific port setup and driver options, when available.

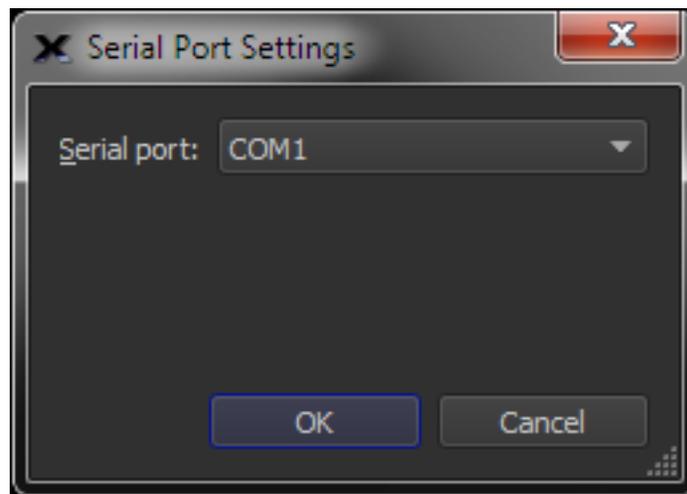


Figure 261: The Filter Wheel Settings window.

***Connect***

Choose this command to establish a connection to the filter wheel.

***Disconnect***

Choose this command to stop communicating with the filter wheel.

***Filter Wheel Status (Status text)***

This text box displays the filter wheel status.

***Device Name***

Shows the name of the selected device.

***Device Description***

Shows a short driver-specific description of the device.

***Driver Information***

Shows additional information about the driver for this device.

***Driver Version***

Shows the version of the software driver used to control this device.

***Firmware Version***

Lists the version of the device's firmware, when available.

***Defining Filter Names (Filter Names Setup Button)***

Click the ***Filter Names Setup*** button to show the ***Filter Names Setup*** window so that each filter can be assigned a custom name.



Figure 262: The Filter Names Setup window.

**Filter 1-<Number of Filter Wheel Positions Reported by Filter Wheel Driver>**

Enter the name of the filter in each filter position. The number of filter wheel positions that appear on **Filter Names Setup** window changes based on the number of filter wheel positions that are reported by the filter wheel driver. The **Filter Wheel Simulator** shown in Figure 262 has a simulated “125-position filter wheel.”

Use the **Filter Wheel** window to connect to and select different filters.

If your camera does not have a shutter, but you want to use a blocking (or dark) filter for taking auto-dark exposures, enter the name, “!Shutter!” (that is, the word *Shutter* immediately preceded and followed by an exclamation mark, with no quotes) for the filter position that contains the blocking filter.

When a dark frame is required, and a filter wheel is connected, the filter is automatically changed to this position.

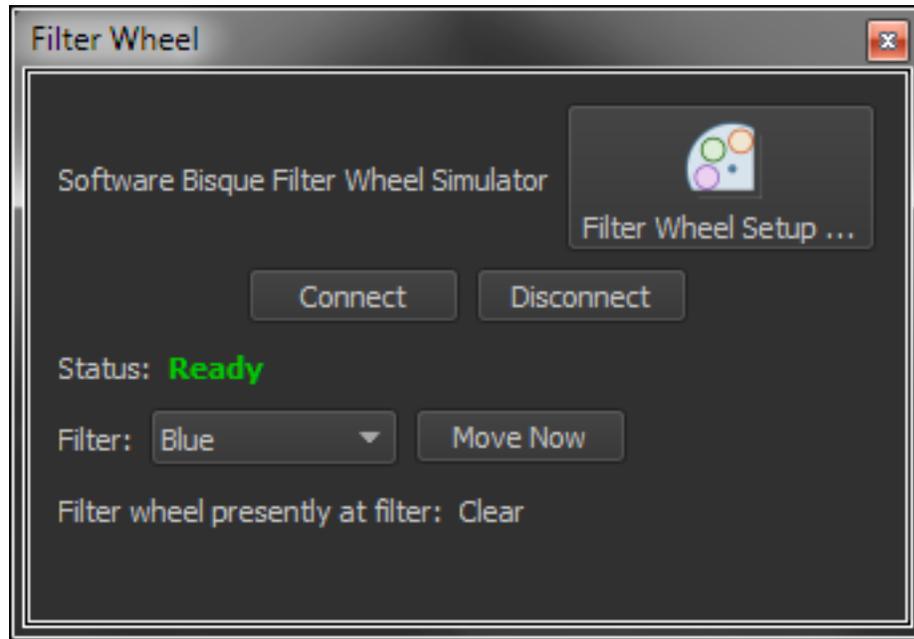


Figure 263: The Filter Wheel window (click the Filter Wheel command from the Display menu to show it).

The top of the **Filter Wheel** window lists the name of the currently selected filter wheel. Click the **Filter Wheel Setup** button to show the Image System Setup window to configure the filter wheel.

#### **Connect**

Click this button to establish a connection to the filter wheel.

#### **Disconnect**

Click this button to stop communicating with the filter wheel.

#### **Filter Wheel Status (Status text)**

This text box displays the filter wheel status.

#### **Filter Wheel Presently at Filter**

This status text shows the name of the current filter.

## **Changing Filters**

To change the current filter, choose the desired filter name from the **Filter** pop-up on the **Camera Setup** window.

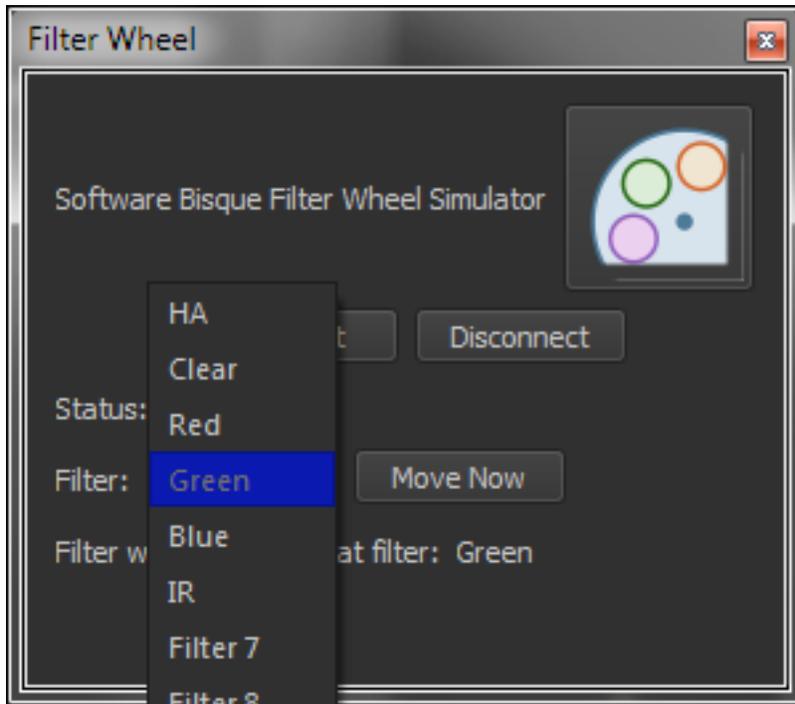
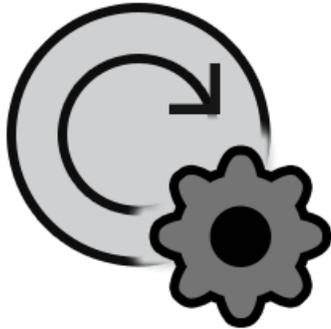


Figure 264: Change the position of the filter wheel on the Filter Wheel window.

# Rotator Control

PROFESSIONAL



The *Camera Add On* can natively control the rotators listed in the table below.

| Rotator Manufacturer/Model          |  |  |  |  |
|-------------------------------------|---|---|---|---|
| Moonlite NiteCrawler                | ✓   | ✓   | ✓   | ✓   |
| Officina Stellare RotoFocus/Rotator | ✓   | ✓   | ✓   | ✓   |
| Optec/Pyxis LE                      | ✓   | ✓   | -   | -   |
| Optec/Gemini                        | ✓   | ✓   | ✓   | ✓   |
| Software Bisque/Rotator simulator   | ✓   | ✓   | ✓   | ✓   |

The *Camera Add On* can also control any ASCOM-compliant rotator on Windows.

## **Rotator Setup**

Choose the **Telescope Setup** command from the **Telescope** menu to display the **Imaging System Setup** window. On the **Imaging System Setup** window, highlight **Rotator** in the **Hardware** list to display rotator-specific options.

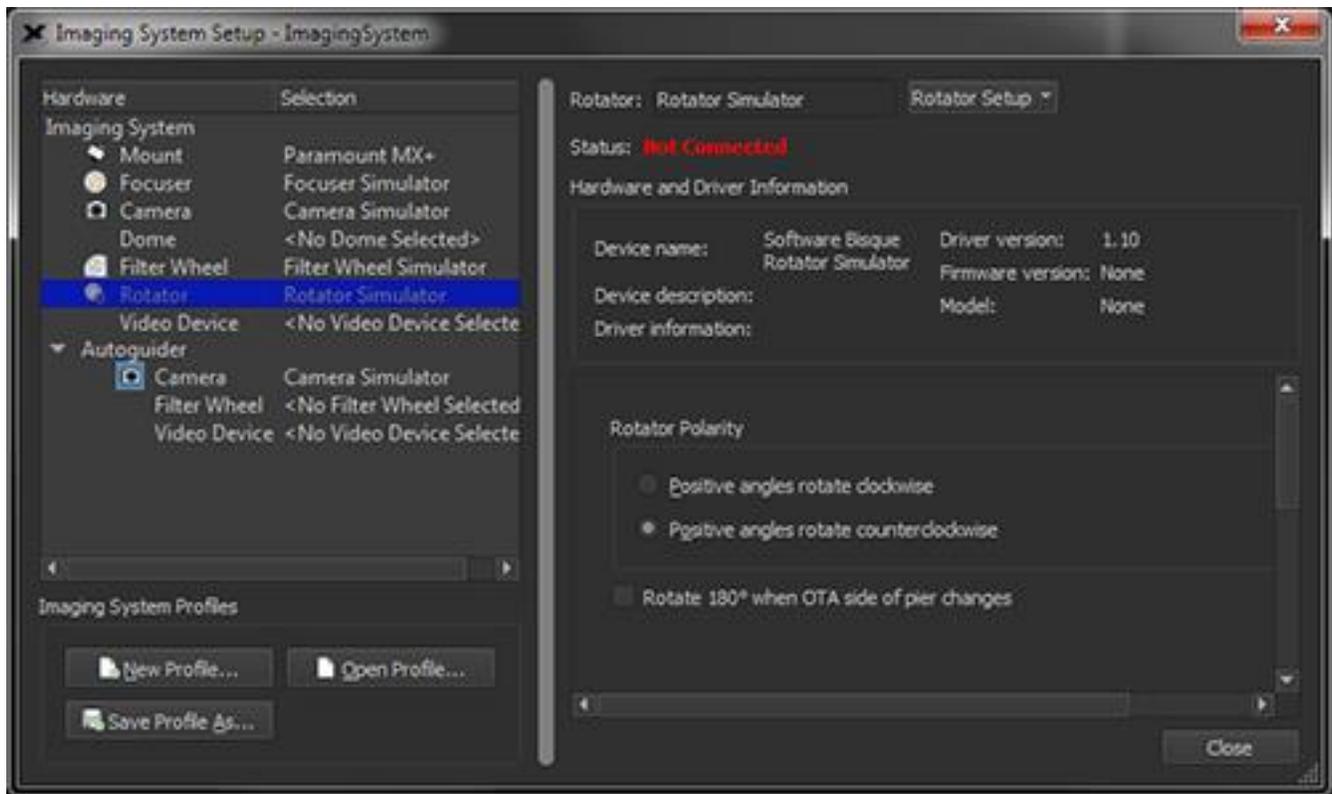


Figure 265: The Rotator options on the Imaging System Setup window.

### **Currently Selected Rotator (Rotator text)**

The **Rotator** text at the top of the **Imaging System Setup** window shows the manufacturer and model of the currently selected rotator.

### **Rotator Setup Pop-Up Menu**

The **Rotator Setup** pop-up menu provides commands for choosing, setting up, connecting to and disconnecting from a rotator.

### **Choose**

Click this command to display the **Choose Rotator** window. The **Rotator** list shows all supported models.

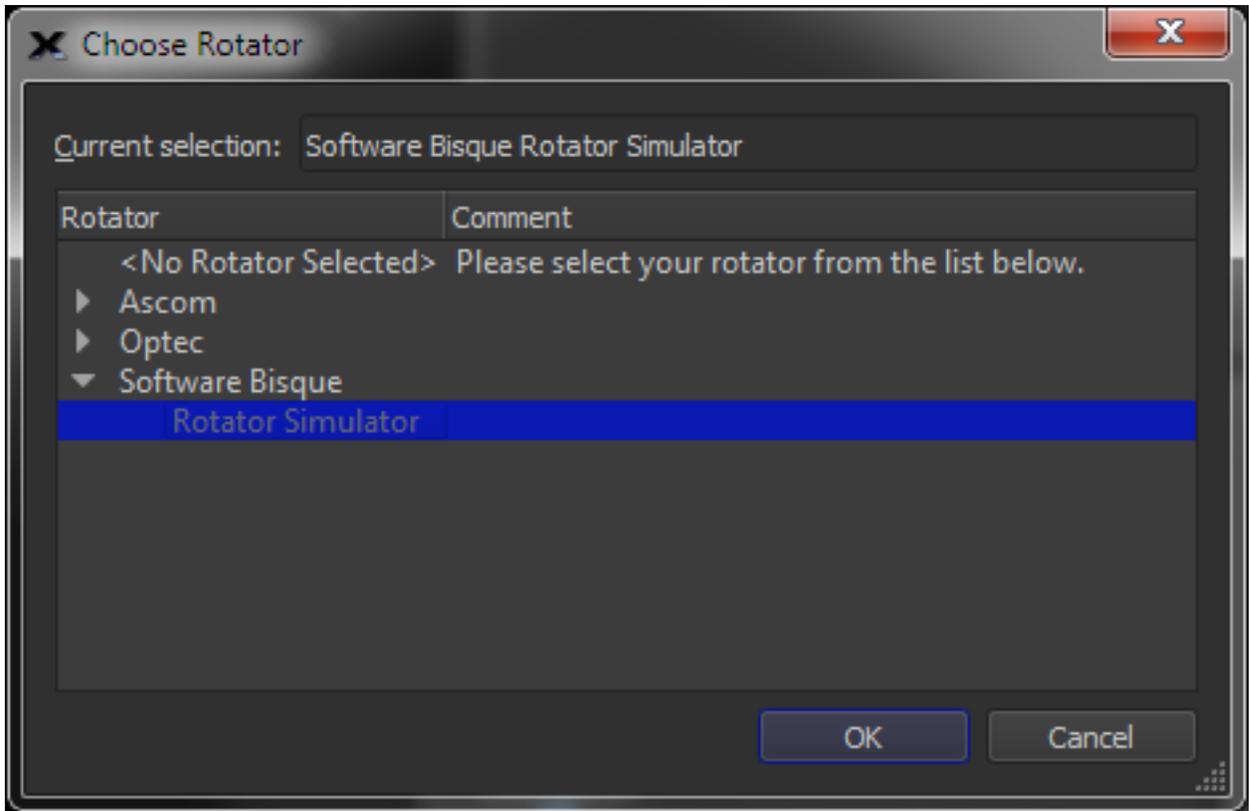


Figure 266: The Choose Rotator window.

### Settings

Click this command to display rotator-specific port setup and driver options, when available.

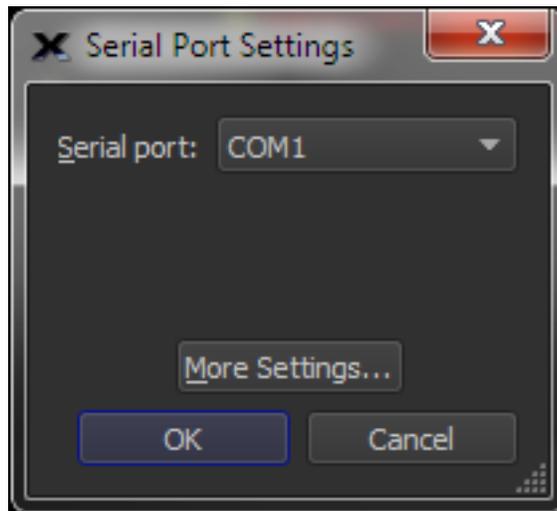


Figure 267: The Rotator Serial Port Settings window (Windows).

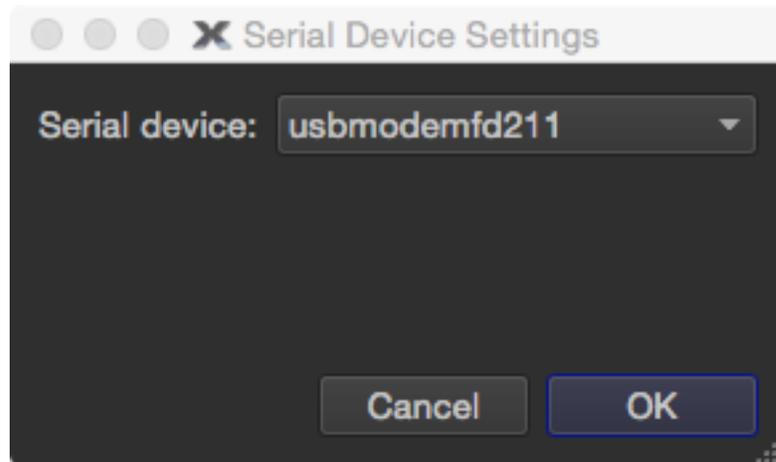


Figure 268: The Rotator Serial Port Settings window (Mac).

**Connect**

Choose this command to establish a connection to the rotator.

**Disconnect**

Choose this command to stop communicating with the rotator.

**Rotator Status (Status text)**

This text box displays the rotator status.

**Hardware and Driver Information**

When **Rotator** is highlighted in the **Hardware** list on the **Imaging System Setup** window, the following hardware and driver-specific information is displayed.

**Device Name**

Shows the name of the selected device.

**Device Description**

Shows a short driver-specific description of the device.

**Driver Information**

Shows additional information about the driver for this device.

**Driver Version**

Shows the version of the software driver used to control this device.

**Firmware Version**

Lists the version of the device's firmware, when available.

**Rotator Polarity**

Some rotators move clockwise as their angular position increases, some move counterclockwise. Select the orientation that corresponds to your rotator's movement polarity.

This setting will correctly convert your rotator's reported angular position into an absolute position angle against the sky.

**Positive Angles Rotate Clockwise**

Choose this option if the rotator hardware reports positive angles for clockwise rotation.

**Positive Angles Rotate Counterclockwise**

Choose this option if the rotator hardware reports positive angles for counterclockwise rotation.

**Move Rotator 180° on Mount Pier Flip**

When this field is checked, your rotator will automatically move 180 degrees when your equatorial mount reports that its slew has caused it to execute a meridian flip. This feature is only available for mounts capable of reporting their current side-of-pier status. Automatic rotator movement is disabled during any form of TPoint calibration.

## Controlling the Rotator

Use the controls on the **Rotator** window (**Display** menu) to control the rotator.

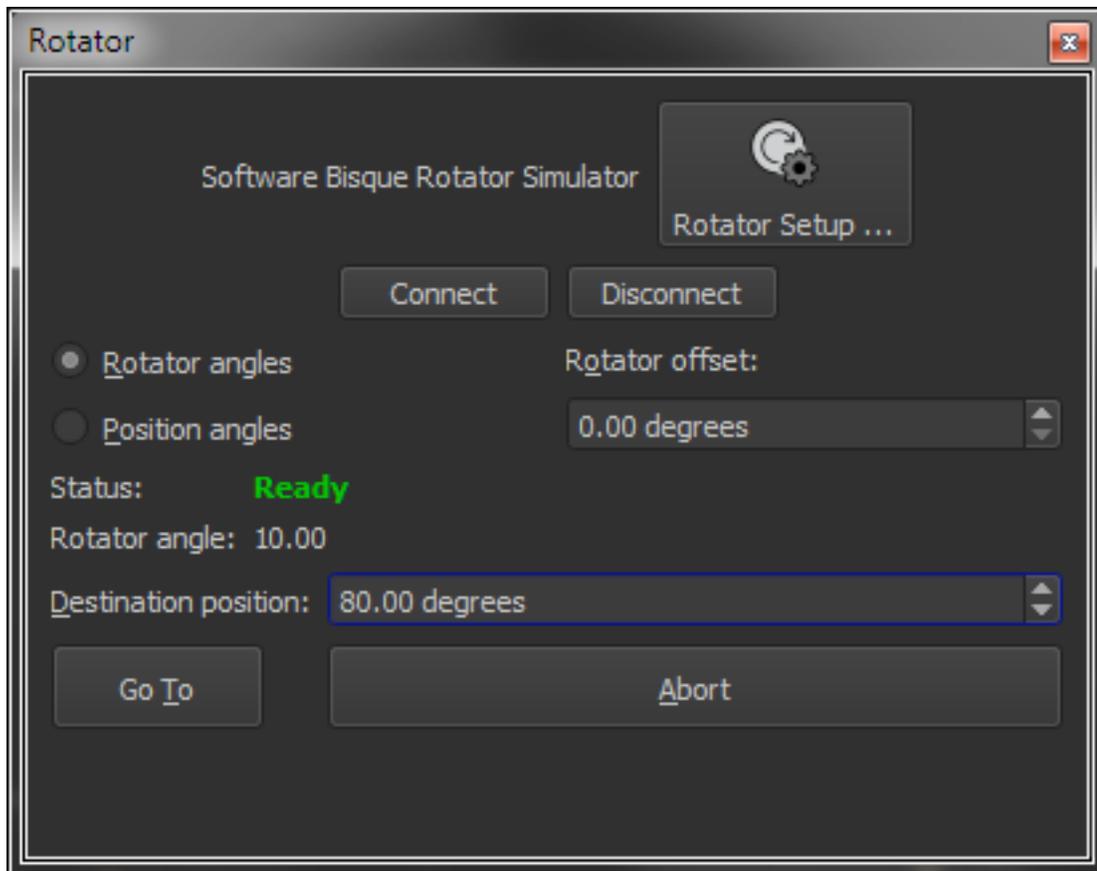


Figure 269: The Rotator window.

The name of the rotator is displayed at the top of the **Rotator** window. Click the **Rotator Setup** button to select a different model, or to configure the rotator hardware.

### **Connect**

Click this button to establish communication with the rotator hardware. Make sure to choose the correct serial or other interface port for your rotator hardware and that the hardware is plugged in turned on and connected to the computer before proceeding.

### **Disconnect**

Click this button to terminate communication with the rotator hardware.

### **Status**

Shows the current status of the rotator.

| <b>Status Text</b> | <b>Description</b>  |
|--------------------|---|
| <b>Not</b>         | The red text indicates there is no connection between <i>TheSkyX</i> and the rotator. |
| <b>Connected</b>   |   |

To connect to the rotator:

Choose your rotators from **Rotator List** window on the **Rotator Setup** pop-up menu from the **Telescope Setup** window.

Choose the communication port by clicking the **Settings** command on the **Rotator Setup** pop-up menu.

Click the **Connect** command from the **Rotator Control** window to connect to the rotator.

|                   |  |
|-------------------|--|
| <b>Connecting</b> | This message is displayed while <i>TheSkyX</i> attempts to establish communication with the rotator. |
|-------------------|--|

If connection fails, double check:

- The rotator is powered on.
- The communication cable is plugged into the correct port on the rotator and computer.
- When using the device's RS232 communications port (serial port), make sure the USB to Serial Adaptor driver for your operating system are installed. Under Windows, check the Device Manager to ensure the driver is recognized and functioning properly.
- Click the **Settings** button on the **Telescope Setup** window to make sure *TheSkyX Professional Edition's Rotator* settings are correct.
- Make sure the cable (RS232 or USB cable) is not frayed, damaged or otherwise compromised.

|              |   |
|--------------|---|
| <b>Ready</b> | This message appears after <i>TheSkyX</i> has successfully established communication with the rotator and the device is ready to use. |
|--------------|---|

| <b>Status Text</b>   | <b>Description</b>   |
|----------------------|--|
| <b>Rotating</b>      | This message is displayed while the rotator is changing position.                    |
| <b>Disconnecting</b> | This message appears while <i>TheSkyX</i> terminates communication with the rotator. |

### **Rotator Angles vs. Position Angles**

You have the option of displaying and commanding the rotator either in terms of a rotator angle or a position angle.

- Rotator angles are the raw angular values reported by the rotator hardware and firmware.
- Position angles are an angular measurement from the north, through east.

Choosing either option not only changes what value is shown in the rotator **Position** field, but also changes how the rotator's "destination position" is interpreted.

### **Rotator Offset**

No matter how carefully a rotator is installed in an imaging system, the zero position generally does not exactly correspond to a zero-degree position angle. The **Rotator Offset** value accounts for the difference between these two values. Combined with the **Rotator Polarity** (page 606), the imaging system's true position angle can be predicted, based on your rotator's current position.

*TheSkyX Pro* will automatically populate this field if you click the **Synchronize Rotator Angle to Position Angle** button following a successful Image Link (page 323). For any linked FOVIs, this value is additive with the FOVI's own position angle.

### **Position**

The current position of the rotator, in degrees.

### **Destination Position**

Enter the destination position for the rotator, in degrees.

### **Go To**

Click this button to rotate the rotator to the destination position.

### **Abort**

Click this button to stop rotation.

## **Linking Rotator to Field of View Indicator**

The position of the rotator can be tied or "linked to" the position angle of a field of view indicator. See "Link to Rotator" on page 122 for details how to perform this step.

When a field of view indicator is linked to the rotator and the field of view indicator is rotated, the following window appears.

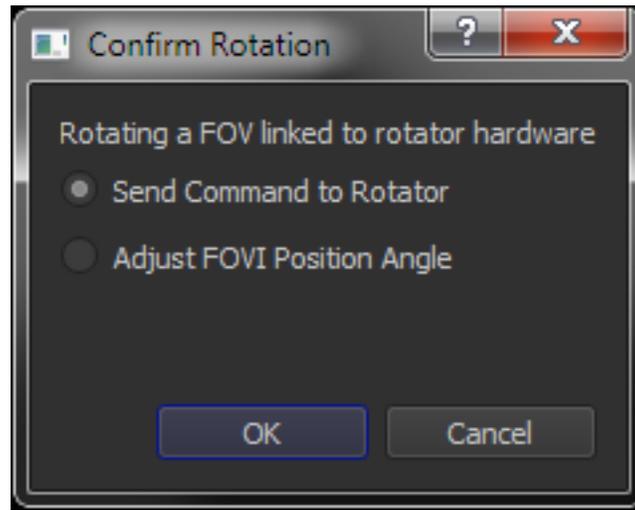
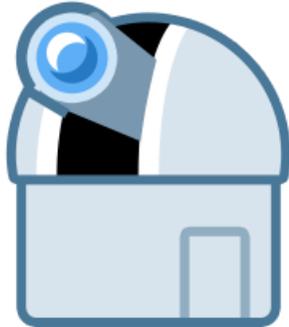


Figure 270: Rotating hardware based on the FOVI position angle.

Choose the **Send Rotate Command To Rotator** option to change the position of the rotator hardware to match the FOVI. Choose the **Adjust FOVI Position Angle** option and click **OK** to change the FOVI's position angle.

# Dome Control

PROFESSIONAL



The *Dome Add On* can control the astronomical domes listed in the table below.

| Dome Manufacturer/Model                                |  |  |  |  |
|--|---|---|---|---|
| ACL-compatible dome controllers                        | -   | ✓   | -   | -   |
| Software Bisque/Rotator simulator                      | ✓   | ✓   | ✓   | ✓   |
| NexDome Rotation Kit <sup>1</sup>                      | ✓   | ✓   | ✓   | ✓   |
| m1OASYS Roll-off Roof Automation System <sup>1</sup>   | ✓   | ✓   | ✓   | ✓   |
| MaxDome II <sup>1</sup>                                | ✓   | ✓   | ✓   | ✓   |
| Rigel Rotation Drive Unit for Pulsar Dome <sup>1</sup> | ✓   | ✓   | ✓   | ✓   |
| SkyRoof Roll-off Roof Automation                       | ✓   | ✓   | ✓   | ✓   |

<sup>1</sup>This open-source X2 Plug In must be [downloaded and installed separately](#) from [RTI-Zone.org](#).

On Windows, the *Dome Add On* can also control all ASCOM-compatible domes, including the popular Digital Dome Works (DDW) from Technical Innovations and MaxDome II from Diffraction Limited.

As you slew the telescope using *TheSkyX*, the *Dome Add On* automatically rotates the dome's aperture to the correct azimuth considering the telescope-dome geometry.

The position of the dome's opening is displayed on the Sky Chart for reference.

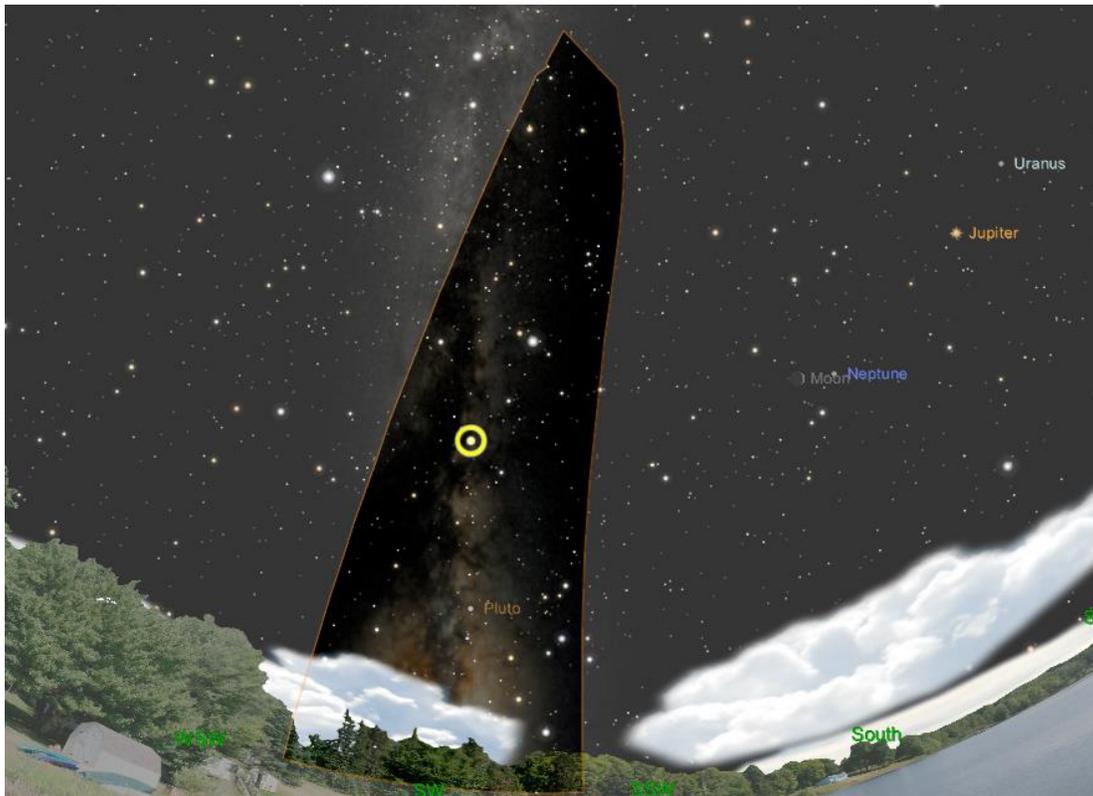


Figure 271: Sky Chart showing dome slit and telescope cross hair.

### **Minimum Requirements**

- One of the supported dome or roof controllers listed above.
- Any ASCOM-compatible dome hardware (Windows only).

*TheSkyX Professional Edition* for Mac and Windows, stand alone, can control astronomical domes with the *Dome Control Add On*.

## **Activating the Dome Add On**

When you purchase *TheSkyX Professional Edition Dome Add On*, a Dome Add On serial number is automatically registered and can be viewed on your Software Bisque account's [Subscriptions](#) page.

The Dome Add On serial number is used to activate the dome software directly from *TheSkyX Pro*. **No additional installers, software or software downloads are required for Dome Add On activation.**

To access your serial number and activate the *Dome Add On*:

1. Sign in to the [Software Bisque web site](#) by clicking the **Sign In** link in the upper right corner of the site. After you are signed in, your *Sign In Name* appears in the upper right corner of the site.
2. Navigate to your subscriptions page by clicking your **Sign In Name**, then click the [Subscriptions](#) link.
3. From *TheSkyX Pro*, click the **Telescope Setup** command on the **Telescope** menu.
4. Highlight **Dome** on the **Imaging System** list.
5. Click the **Enter Serial Number** command on the **Dome Setup** pop-up menu.
6. Enter your **Name** and **Serial Number**.
7. Click **OK**.

The *Dome Add On* is now activated and ready to use. You'll need to repeat the above procedure on each computer that is running a licensed copy of *TheSkyX Professional Edition*.

## **Configuring the Dome Control Add On**

Follow the steps below to configure *TheSkyX Professional Edition* to directly control a dome.

1. Make sure your dome controller is ready.
2. From *TheSkyX*, select the **Telescope Setup** command from the **Telescope** menu.
3. Select **Dome** from the **Imaging System** list.
4. Click the **Choose** command on the **Dome Setup** pop-up menu. If you have not purchased the *Dome Control Add On*, you can click the **Run Trial** button to use begin the 90-day trial period.
5. Select your dome controller and click **OK**.
6. Select the **Connect** command from the **Dome Setup** pop-up menu. If the dome drivers are installed properly, after about 15 seconds, the green **Connected** status text appears on the **Imaging System Setup** window and on the **Dome** window.

## **Using AutomaDome for Windows (Legacy)**



The *Dome Add On* supersedes *AutomaDome for Windows*. The section immediately below remains for legacy reference only.

In addition to the *TheSkyX*'s standalone support for domes, any dome that can be controlled by *AutomaDome for Windows* can also be used. Please double-check that you have installed the latest release of *AutomaDome for Windows* before continuing.

## **Configuring TheSkyX to Use AutomaDome**

- Make sure *AutomaDome*, standalone, can connect to control the dome. If *AutomaDome* does not work to control the dome, *TheSkyX* can't use it to control the dome either.
- From *TheSkyX*, select the **Telescope Setup** command from the **Telescope** menu.
- Select **Dome** from the **Imaging System** list.
- Click the **Choose** command on the **Dome Setup** pop-up menu. If you have not purchased the *Dome Control Add On*, click the **Run Trial** button to use begin the 90-day trial period.

- Expand **Software Bisque**, then select **AutomaDome Dome** and click **OK**.
- Select the **Connect** command from the **Dome Setup** pop-up menu. The green **Connected** status text appears on the **Imaging System Setup** window and on the **Dome** window.

## Dome Preferences

Dome preferences are configured on the **Imaging System Setup** window. Click the **Telescope Setup** command from the **Telescope** menu to show this window. Next, highlight **Dome** in the Imaging System list on the left side of the window to reveal the dome-specific settings.

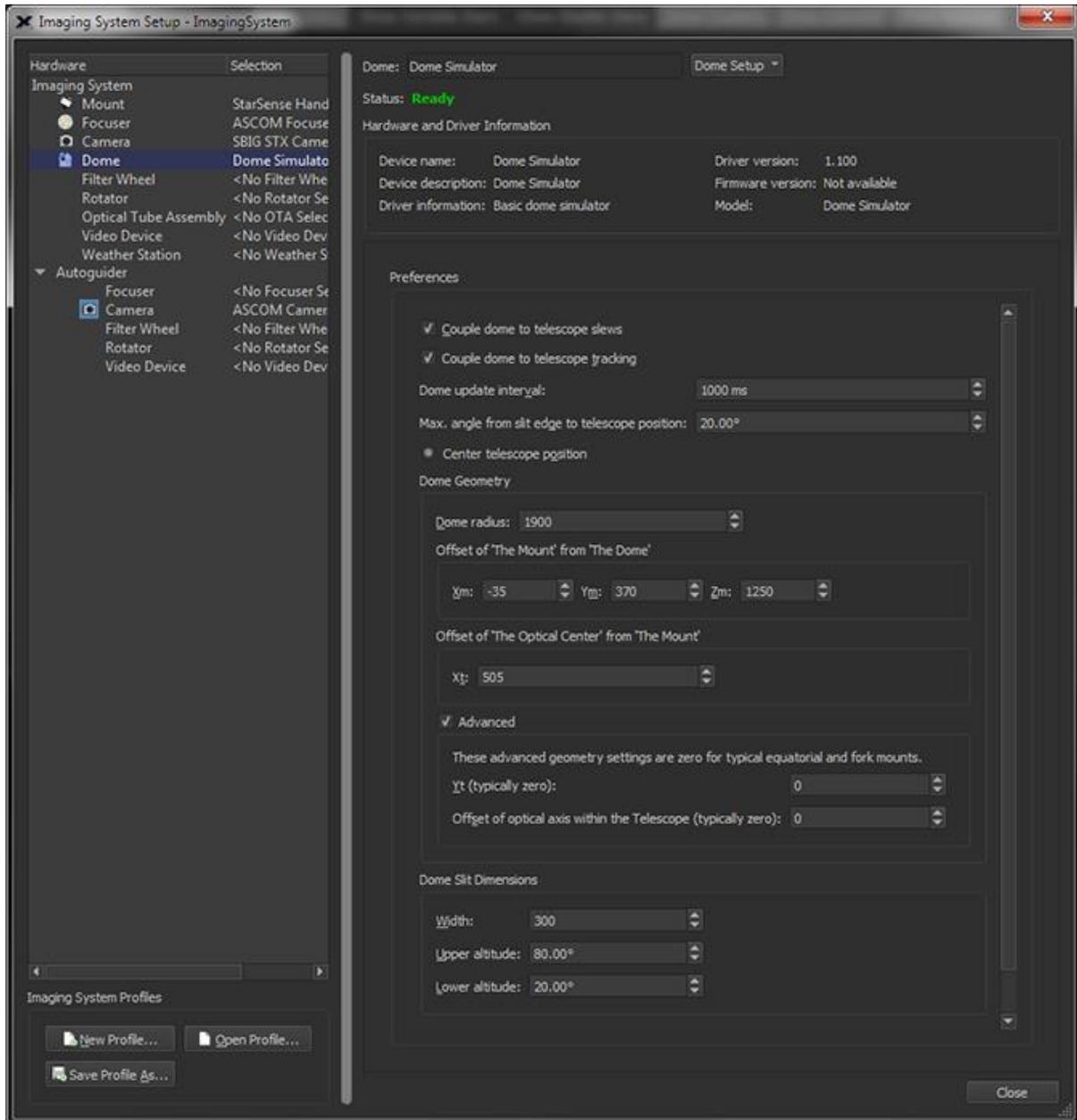


Figure 272: The dome Preferences on the Imaging System Setup window.

### **Dome**

Shows the name of the selected dome hardware driver. Choose the **Setup** command from the **Dome Setup** pop-up menu to change the current selection.

### **Dome Setup Pop-up Menu**

Click this pop-up menu to access dome-specific commands.

### **Choose**

Click this command to show the **Choose Dome** window and select the dome driver for your dome controller.

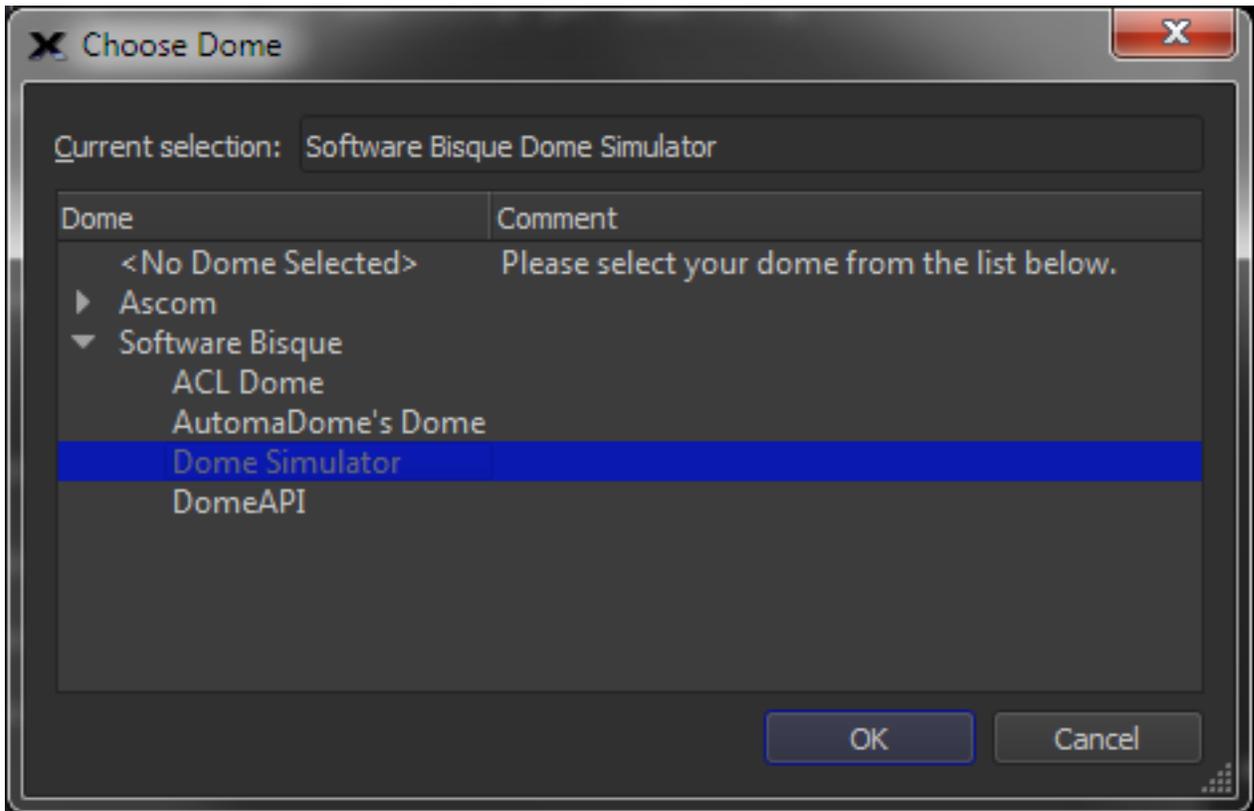


Figure 273: The Windows Choose Dome window.

### **ASCOM Dome**

On Windows, choose **ASCOM Dome** under **Ascom** in the **Dome** list if to use an ASCOM driver to control your dome hardware. You must install the ASCOM platform and the ASCOM-specific dome driver first. See the ASCOM site for details about how. Next, click the **Settings** command from the **Dome Setup** pop-up menu to display the **ASCOM Chooser** window. If you have installed the ASCOM platform and the ASCOM-compatible dome driver for your dome hardware, the driver name will appear in the list of supported domes. Choose it, then click the **Properties** button to configure the ASCOM dome settings. TheSkyX Professional Edition should now be able to connect to and control the dome.

### **ACL Dome**

Choose ACL Dome if your dome hardware is compatible with the Astronomy Command Language (ACL).

### **DomeAPI**

If your dome hardware has a custom-written dome driver based on Software Bisque's legacy *DomeAPI* framework. Dome driver developers are strongly encouraged to update these drivers to conform to the X2 Standard (page 657) instead.

### **Dome Simulator**

The Dome Simulator can setup, connect to, and use a "simulated" dome without connecting to any physical dome hardware. This can be useful to get familiar with how *TheSkyX Professional Edition* and the telescope interact with a dome.

## **Dome Information**

The Dome Information controls let you configure dome-specific options.

### ***Couple Dome to Telescope Slews***

When this checkbox is on, and slew commands are issued from a telescope that is controlled by *TheSkyX Professional Edition*, the dome will be rotated to keep the two aligned. Note that the geometry of where the telescope is mounted inside the dome must be configured using the dome geometry controls below.

### ***Couple Dome to Telescope Tracking***

When this checkbox is on, as the telescope tracks, the dome will be rotated to keep the two aligned. Note that the geometry of where the telescope is mounted inside the dome must be configured using the dome geometry controls below.

### ***Dome Update Interval***

Enter the number of milliseconds that must elapse before the dome's position is updated.

### ***Maximum Angle from Slit Edge to Telescope Position***

Enter the maximum number of degrees that the edge of the dome slit can be separated from the telescope before the dome's position is updated.

### ***Center Telescope Position***

Turn this option on so that the telescope will be kept near the center of the dome slit.

## **Dome Geometry**

The next step is to determine your dome's geometry so that the dome opening can be coupled to, and follow the telescope. Figure 274 shows a mount and telescope inside an astronomical dome.

The center of the dome represents the origin of the coordinate system from which the dome geometry measurements should be taken. The intersection of the mount's right ascension and declination axis is labeled in Figure 274. The dome radius is the distance from the center of the dome 'sphere' to the inside edge of the dome.

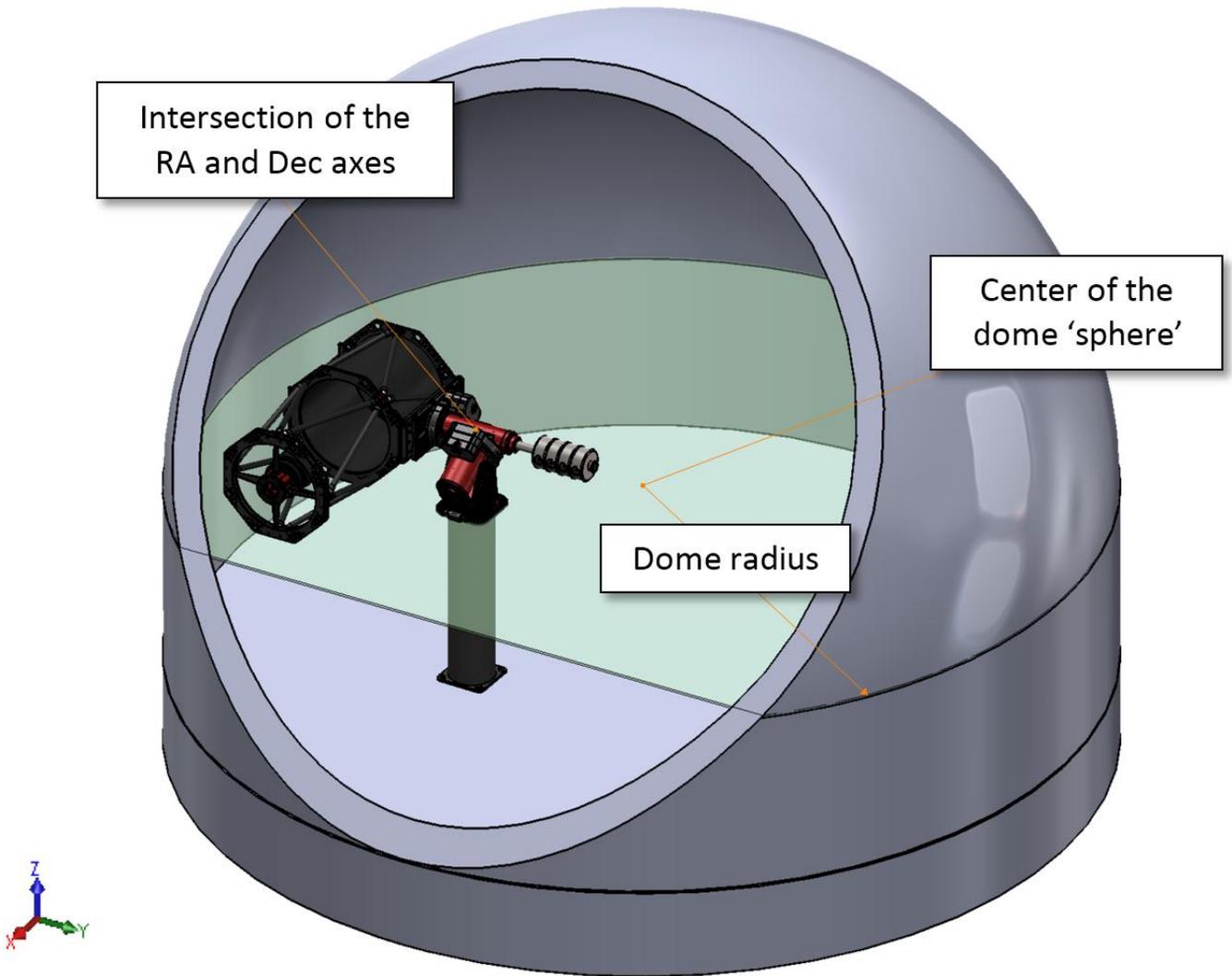


Figure 274: The positions of the dome geometry parameters in a hemispherical dome.

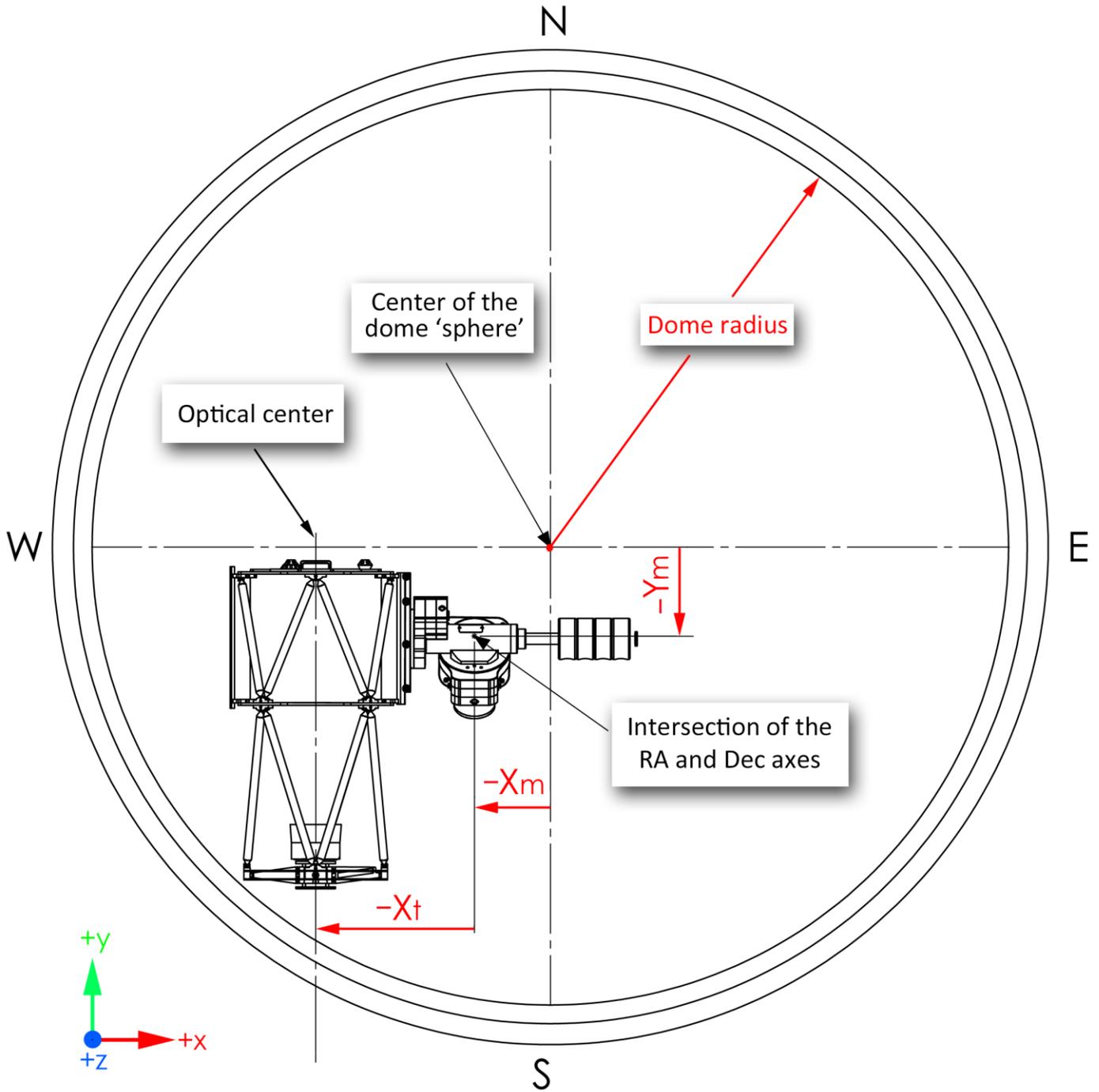


Figure 275: An overhead view of the dome. Note that in the example shown,  $X_t$ ,  $X_m$  and  $Y_m$  all happen to be negative quantities

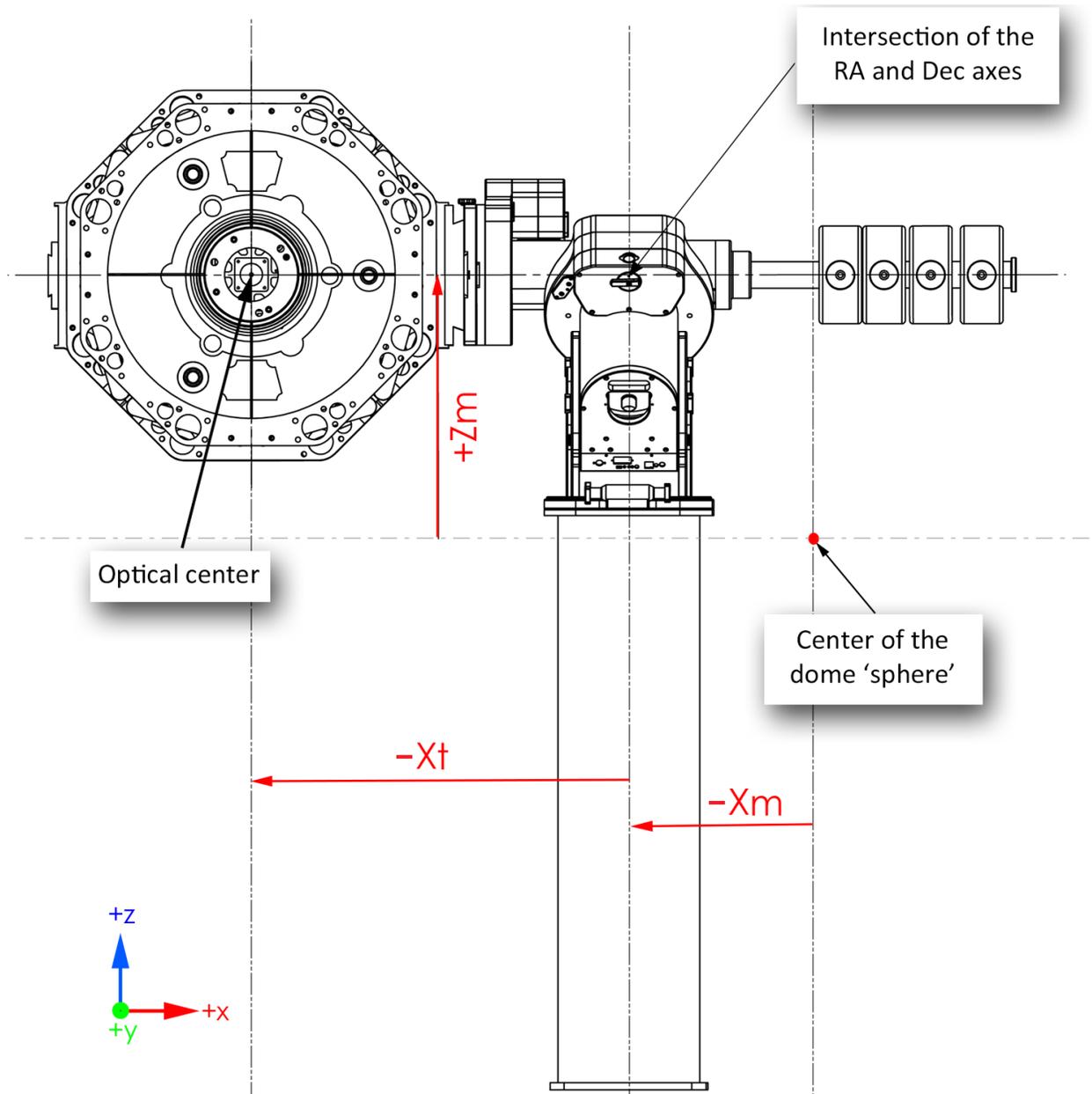


Figure 276:  $Z_m$  is the vertical distance from the dome center to a horizontal line through intersection of the RA and Dec axes.

The red text and red lines in Figure 275 and Figure 276 show the five dome geometry measurements that are required for most amateur mounts. All measurements should be the same units.

### ***Dome Radius***

Enter the radius of the dome (Figure 275).

### ***Offset of Mount from Dome***

The values of  $X_m$ ,  $Y_m$  and  $Z_m$  define the offset of the intersection of the RA and Dec axes from the center of the dome 'sphere'.

### ***Xm***

Enter the distance from the N-S centerline of the center of the dome 'sphere' to the intersection of the RA and Dec axes (Figure 275). This value is usually negative.

### ***Ym***

Enter the distance from the E-W centerline of center of the dome 'sphere' to the intersection of the RA and Dec axes (Figure 275). This value is usually negative.

### ***Zm***

Enter the vertical distance from the center of the dome 'sphere' to the intersection of the RA and Dec axes.

The Paramount User Guide (page 423) describes how to compute the latitude-dependent height of Paramount mounts.

### ***Offset of Telescope from Mount***

The arguments  $X_t$ ,  $Y_t$  specify the offset of the telescope from the mount.

### ***Xt***

Enter the distance from the N-S centerline of the intersection of the RA and Dec axes to the optical center. This value is typically negative.

Based on customer feedback, the  $X_t$  parameter seems to be the most difficult to determine out of the box, especially for German equatorial mounts.

One way to determine whether  $X_t$  is correct is to slew the telescope low on the horizon, close to due south and note the position of the telescope relative to the dome's slit. Next, reverse the sign of  $X_t$ , then repeat this test.

## **Advanced Dome Geometry Settings**

Turn on the ***Advanced*** checkbox to enter the geometry for non-standard telescopes.

### ***Yt***

Enter the distance from the E-W centerline of the intersection of the RA and Dec axes to the optical center. This parameter is not defined in the above diagram, and is normally zero. See the section "Technical Description of Dome Geometry Parameters" on page 621 for more information.

### ***Offset of Optical Axis from Telescope (Yo)***

Enter the offset of the optical axis within the telescope. This value is typically zero for most amateur telescopes.

## Dome Slit Dimensions

These options define the dome width, and the lower and upper limits of the dome shutter.

### **Width**

Enter the width of the dome slit. Be sure to use the same units of measure for all dome geometry parameters.

### **Upper Altitude**

Enter the highest allowable altitude, in degrees, for the dome shutter.

### **Lower Altitude**

Enter the lowest possible altitude, in degrees, for the dome shutter.

## Technical Description of Dome Geometry Parameters

| Parameter  | Description)             |
|------------|--------------------------|
| Rdome      | Radius of dome           |
| Xm, Ym, Zm | Offset of mount          |
| Xt, Yt     | Offset of telescope      |
| Yo         | Offset of optical center |

### **Notes:**

- The dome is presumed to be hemispherical (or some other portion of a sphere). The radius of the sphere is specified through the Rdome parameter. Any desired units can be used as long as all the other parameters (namely Xm, Ym, Zm, Xt, Yt, Yo) are in the same units.
- The parameters Xm, Ym, Zm specify the offset of the mount from the center of the dome. The "mount" in this context is that point along the polar axis (and hence fixed in space) that lies nearest to the declination axis. The x,y,z coordinate system is oriented east, north, up.
- The parameters Xt, Yt and Yo form a sequence of offsets linking the polar axis, the declination axis and the telescope's optical axis:
  - \* Xt is the distance along the declination axis to where the telescope assembly turns, starting from the point on the declination axis closest to the polar axis. For fork mounts Xt is zero, but for GEMs Xt is a substantial distance.
  - \* Yt is the separation between the polar and declination axes at their closest approach. For most GEMs, the two axes intersect and hence Yt is zero. Occasionally (some horseshoe mounts for example) the two axes do not intersect and Yt is non-zero.
  - \* Yo is the separation between the declination and optical axes. It is usually zero. Very occasionally, for example where a second telescope is mounted on the "side" of the main telescope, the declination axis and optical axis do not intersect and so Yo is non-zero.

The offsets  $X_t$  and  $Y_t$  are at right angles, and the offsets  $X_t$  and  $Y_o$  are at right angles, but the angle between the offsets  $Y_t$  and  $Y_o$  varies with declination.

The sign conventions for  $X_t$ ,  $Y_t$  and  $Y_o$  are such that with the telescope pointing at HA,Dec (0,0),  $X_t$  is positive towards (-6h,0d),  $Y_t$  is positive towards (12h,0d), and  $Y_o$  is positive towards Dec +90d.

## Dome Commands

Select the **Dome** command from the **Display** menu to show the Dome window. This window is normally “docked” to the left side of the Sky Chart, but can be positioned elsewhere by dragging the caption.

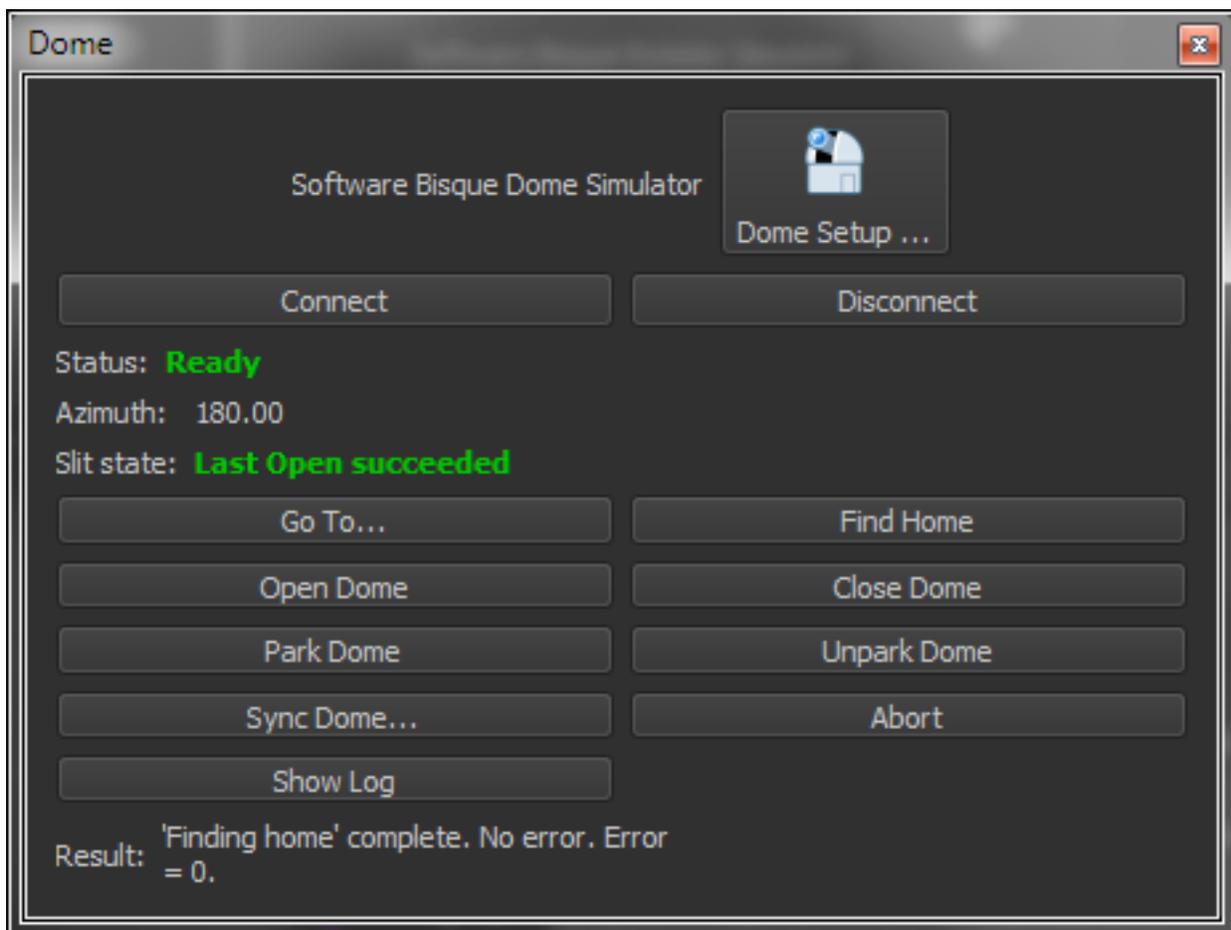


Figure 277: The Dome commands window (Dome window, Display menu).

### Dome Driver Name

The name of the currently selected dome driver is listed at the top of the **Dome** window.

### Dome Commands Pop-up Menu

Click this button to display the Dome-specific settings on the Imaging System Setup window.

**Status**

Shows the status of the dome connection.

**Azimuth**

Shows the azimuth of the dome opening.

**Connect**

Click this button to establish communication with the dome controller.

**Disconnect**

Click this button to terminate communication with the dome controller.

**Go To**

Click this button to enter the azimuth to position the dome opening.

**Find Home**

Click this button to locate the dome's home position.

**Open Dome**

Click this button to open the dome shutter.

**Close Dome**

Click this button to close the dome shutter.

**Park Dome**

Click this button to send the dome to its park position.

**Unpark Dome**

Click this button to perform any necessary initialization when starting up the dome for the night.

**Sync Dome**

Click this button to synchronize the dome opening to a specific azimuth.

**Abort**

Click this button to terminate in any dome command that is currently in progress.

**Result**

Shows the results of the dome command reported by the dome controller hardware.

## Appendix A: Databases and Cross References

*TheSkyX Professional Edition* and *Serious Astronomer Edition* include databases of celestial objects from the standard astronomical catalogs listed in the tables below.

If you want to use a specific set of databases, select the **Database Manager** command from the **Input** menu to turn any catalog on or off.

### Star Catalogs

The Hipparcos-Tycho Catalogs are the primary stellar databases used to display information by *TheSkyX* for stars to about 12<sup>th</sup> magnitude and brighter.

*TheSkyX* also cross-references stars from the following catalogs.

- Bayer/Flamsteed Designations
- Smithsonian Astrophysical Observatory Catalog (SAO)
- Positions and Proper Motion Catalog (PPM)
- Henry Draper Catalog (HD)

| Star Catalog Name                               | Details/Object Count                               |
|---|--|
| <a href="#">Hipparcos/Tycho Stellar Catalog</a> | 1.2 million stars, complete to 12th magnitude      |
| Hubble Guide Star Catalog (GSC) Version 1.2     | 19 million stars, complete to about 14th magnitude |
| General Catalog of Variable Stars (GCVS)        | 40,214 variable stars                              |
| New Suspected Variable Star Catalog (NSV)       | 13,490 suspected variable stars                    |
| Struve Double Star Catalog                      | 4,307 double stars                                 |
| Washington Catalog of Double Stars (WDS)        | 102,139 double stars                               |

### Non-Stellar Catalogs

| Non-stellar Catalog Name  | Details/Object Count      |
|---|---------------------------|
| Historically Corrected New General Catalogue (HCNGC) from the NGC/IC Project* | 7,840 non-stellar objects |
| Index Catalog (IC) from the NGC/IC Project*                                   | 5,382 non-stellar objects |
| Catalog of Principal Galaxies (PGC 2003)                                      | 900,000 galaxies          |

| Non-stellar Catalog Name                 | Details/Object Count      |
|--|---------------------------|
| Catalog of Principal Galaxies (PGC 2011) | 1,670,818 galaxies        |
| PK Planetary Nebula Catalog (PLN)        | 1,455 planetary nebulae   |
| Tomm Lorenzin 2000+ Catalog              | 2,088 non-stellar objects |
| Herschel Catalog                         | 400                       |
| Caldwell Catalog                         | 109                       |
| Messier Catalog (M)                      | 110                       |
| Saguaro Astronomy Club (SAC) Database    | 10,580                    |

\*The HCNGC and IC catalog is used with permission of The [NGC/IC Project LLC](http://www.ngcic.org) - <http://www.ngcic.org> – please contact Bob Erdmann at *hcngc at ngcic dot org* for questions or clarifications regarding this astronomical catalog.

## Additional Sky Databases (SDBs)

TheSkyX includes the following additional astronomical catalogs that can be displayed on the Sky Chart. From the **Input > Database Manager** window, navigate to the **Sky Databases (SDBs) > Optional Databases** node in the **Databases** list to turn them on or off.

| Catalog Name                      | Search Prefix | Object Count | Object Type         |
|-----------------------------------|---------------|--------------|---------------------|
| 1.4 GHz Northern Sky              | 1-4ghz        | 31524        | Reference Point     |
| 6C Survey of Radio Sources        | 6CSRSI        | 1761         | Radio Source        |
| 6C Survey of Radio Sources II     | 6CSRSII       | 8278         | Radio Source        |
| 6C Survey of Radio Sources III    | 6CSRSIII      | 8749         | Radio Source        |
| 6C Survey of Radio Sources IV     | 6CSRS-IV      | 5421         | Radio Source        |
| 6C Survey of Radio Sources V – A  | 6CSRS-VA      | 2229         | Radio Source        |
| 6C Survey of Radio Sources V – B  | 6CSRS-VB      | 1229         | Radio Source        |
| 6C Survey of Radio Sources VI     | 6CSRS-VI      | 6752         | Radio Source        |
| Abell–Zwicky Clusters of Galaxies | AGC           | 2712         | Cluster of Galaxies |

| Catalog Name                                 | Search Prefix | Object Count | Object Type      |
|--|---------------|--------------|------------------|
| Abell Planetary Nebulae                      | APN           | 86           | Nebula           |
| Ackerman Red Stars                           | ARS           | 267          | Reference Point  |
| APM Bright Galaxy Catalogue                  | APM           | 14681        | Galaxy           |
| Arp Globular Clusters                        | Arp-GC        | 43           | Globular Cluster |
| Arp Peculiar Galaxies                        | ARP-PG        | 38           | Galaxy           |
| Barnard's Dark Nebulae                       | Barnard       | 349          | Dark Nebula      |
| Bright Nebulae Drawings (TMB)**              | TMB-BN        | 25743        | Bright Nebula    |
| Catalog of Bright Galaxies                   | CBG           | 4364         | Galaxy           |
| Celestron NexStar Doubles                    | CND           | 55           | Double Star      |
| Cepheids in the Large Magellanic Cloud       | LMC-CV        | 97           | Variable Star    |
| Cluster System of the Large Magellanic Cloud | LMC-CL        | 1762         | Mixed Deep Sky   |
| Cool Galactic Carbon Stars                   | CCS           | 5987         | Reference Point  |
| Cousins Photometric Standards                | CPS           | 670          | Reference Point  |
| Culled Henden CI Labels                      | HC-L          | 0            | Reference Point  |
| Dark Nebulae Isophotes TMB**                 | DND           | 650          | Dark Nebula      |
| Declination Zero                             |               | 51           | Reference Line   |
| Declination Zero Label                       |               | 13           | Reference Point  |
| DeepMap 600                                  |               | 470          | Reference Point  |
| Don Macholtz Messier Marathon                | Macholtz      | 110          | Target Object    |
| Double Stars with common names               |               | 169          | Double Star      |
| Einstein Observatory Ex M-S Survey           | EMSS          | 835          | X-Ray Source     |
| Feitzinger Dark Nebula                       | FZ-DN         | 489          | Dark Nebula      |
| Feitzinger Globules                          | FG            | 331          | Reference Point  |
| Florsch - Small Magellanic Cloud Stars       | SMC-Florsch   | 584          | Reference Point  |
| G2 V Stars from SIMBAD Query                 | G2V           | 688          | Reference Point  |

| Catalog Name  | Search Prefix | Object Count | Object Type         |
|---|---------------|--------------|---------------------|
| Galactic Globular Clusters – Monella                  | GC-Monella    | 160          | Globular Cluster    |
| Galactiglob Galaxies                                  | TJ-GG         | 2495         | Galaxy              |
| Galaxy Isophote M51 Example                           | BSR-GI        | 902          | Galaxy              |
| Hickson Compact Groups of Galaxies                    | Hickson       | 463          | Galaxy              |
| Hickson Compact Groups of Galaxies – Group Identifier | HGG           | 100          | Cluster of Galaxies |
| Hickson Compact Groups of Galaxies – Labels           | <none>        | 463          | Galaxy type         |
| Heinz Nebula Small Magellanic Cloud                   | HN            | 117          | Nebula              |
| Henden 3C   | H3C           | 504          | Reference Point     |
| Herbig-Haro Objects                                   | HH            | 454          | Reference Point     |
| HW Clusters Large Magellanic Cloud                    | HW-SMC        | 87           | Globular Cluster    |
| IRAS 1.2 Jy Redshift                                  | IRAS-1.2      | 9899         | Galaxy              |
| IRAS Small Scale Structure                            | IRASS         | 16740        | Reference Point     |
| Kron Clusters Small Magellanic Cloud                  | SMC-KRON      | 69           | Globular Cluster    |
| Landolt Faint Photometric Standards                   | LFPS          | 526          | Reference Point     |
| Landolt Photometric Standards                         | LPS           | 1154         | Reference Point     |
| Landolt Photometric Standards South                   | LPS-S         | 109          | Reference Point     |
| Lindsay Clusters Small Magellanic Cloud               | SMC-L         | 118          | Globular Cluster    |
| Lynds' Bright Nebulae                                 | LBN           | 1053         | Bright Nebula       |
| Lynds' Dark Nebulae                                   | LDN           | 1791         | Dark Nebula         |
| Meade Alignment Star Labels                           | MAS           | 78           | Reference Point     |

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| <b>Catalog Name</b>                          | <b>Search Prefix</b> | <b>Object Count</b> | <b>Object Type</b>  |
|--|----------------------|---------------------|---------------------|
| Michael Covington Deep Sky Objects           | COV                  | 200                 | Mixed Deep Sky      |
| Milky Way Globular Clusters                  | MW-GC                | 150                 | Globular Cluster    |
| Molonglo Reference - Radio Sources           | Molongo Radio        | 12141               | Radio Source        |
| Navigational Stars                           | NavStar              | 58                  | Reference Point     |
| NB Carbon Stars – Skiff                      | NBC                  | 211                 | Reference Point     |
| Nebulae in the Magellanic Clouds – HII       | LMC-HII              | 358                 | Nebula              |
| NGC and IC objects UNKNOWN magnitudes        |                      | 982                 | Mixed Deep Sky      |
| NGC Max Alignment Stars – JMI                | JMI                  | 30                  | Star                |
| Objects in the Direction of the SMC          | SMC-B                | 965                 | Reference Point     |
| Open Cluster Data Fifth Edition (Lynga 1987) | OC-L                 | 1151                | Open Cluster        |
| Palomar Globular Clusters                    | PAL                  | 15                  | Globular Cluster    |
| Palomar Sky Survey - 102 CD labels           | DSS-102              | 0                   | Reference Point     |
| Palomar Sky Survey Plates Additional Data    | POSS                 | 1037                | Reference Point     |
| Parkes Radio Sources                         | PKS90                | 8264                | Radio Source        |
| Planetary Nebulae in LMC                     | LMC-PLN              | 169                 | Planetary Nebula    |
| Pulsars (Taylor+ 1993)                       | PULSARS              | 558                 | Radio Source        |
| Query Common Non-Stellar                     |                      | 329                 | Mixed Deep Sky      |
| RealSky CD's North Labels                    | RealSky-N            | 765                 | Reference Point     |
| RealSky CD's South Labels                    | RealSky-S            | 800                 | Reference Point     |
| RealSky North & South Labels                 | RealSky-NS           | 658                 | Reference Point     |
| Redshift Galaxies                            | RG                   | 12844               | Galaxy              |
| Rich Clusters of Galaxies (North)            | RC-GN                | 2712                | Cluster of Galaxies |
| Rich Clusters of Galaxies (South)            | RC-GS                | 1364                | Cluster of Galaxies |
| Roslund Red Stars in Scorpius                | RR                   | 69                  | Reference Point     |

| Catalog Name   | Search Prefix | Object Count | Object Type      |
|--|---------------|--------------|------------------|
| Seyfert Galaxies   | Seyfert       | 121          | Galaxy           |
| Shapley-Ames Bright Galaxies                                       | SA-BG         | 1246         | Galaxy           |
| Sharpless H II Regions   | SH2-          | 313          | Nebula           |
| Skiff North Bright Standards                                       | BK-NBS        | 119          | Reference Point  |
| Southern hemisphere H-alpha emission regions (Rogers+ 1960)        | RCW           | 14           | Nebula           |
| Southern hemisphere H-alpha emission regions (Rogers+ 1960) Labels | <none>        | 14           | Label            |
| Star Clusters and Associations                                     | SCA           | 1039         | Open Cluster     |
| Stars in the Double-Double   | DDS           | 2            | Star             |
| Supernova Remnants – Green   | SNR-G         | 231          | Supernova        |
| Terzan Globular Clusters   | Ter           | 11           | Globular Cluster |
| Third Catalogue of Nearby Stars                                    | CNS3          | 3802         | Reference Point  |
| Trapezium Circumstellar disks                                      | TCD           | 149          | Reference Point  |
| Trapezium ROSAT PSPC   | Trap-XRay     | 171          | X-Ray Source     |
| Trapezium Stars – TMB**  |               | 14           | Star             |
| Trapezium Stars Vizier   | Trap-Vzr      | 292          | Reference Point  |
| Trumpler Clusters  | Tr            | 34           | Open Cluster     |
| Trumpler Stars   | Tr-S          | 39           | Reference Point  |
| UV-Excess Galaxies   | UVG           | 8162         | Galaxy           |
| Van Den Berg Reflection Nebulae                                    | Vdb           | 158          | Nebula           |
| Video Calibration Stars  | VCS           | 958          | Target Object    |
| W-G Clusters Small Magellanic Cloud                                | WG            | 18           | Globular Cluster |
| X-ray source   | 1RXSJ         | 108          | Galaxy           |
| Yale Bright Star Catalog First Half                                | YBSC-1        | 4991         | Star             |
| Yale Bright Star Catalog Second Half                               | YBSC-2        | 4105         | Star             |

\*TMB indicates this optional SDB was created or compiled by Thomas M. Bisque.

## Solar System Objects

| Group                     | Objects in Group  | Number of Objects   |
|---------------------------|---|---|
| Sun, Planets, Moons       | Sun<br>Mercury<br>Venus<br>Earth<br>Earth's Moon<br>Mars<br>Jupiter<br>Io<br>Ganymede<br>Europa<br>Callisto<br>Saturn<br>Enceladus<br>Mimas<br>Tethys<br>Dione<br>Rhea<br>Titan<br>Hyperion<br>Iapetus<br>Uranus<br>Neptune | 22  |
| Small Solar System Bodies | Pluto   | 1   |
|                           | Comets  | Up to 1000 at once.   |
|                           | Asteroids (Minor Planets)   | Every known asteroid (Orbital elements are updated from the web.)   |
| Artificial Satellites     | Updated from the web via the <i>Input &gt; Satellites</i> command.  | Up to 10,000 two-line elements (TLEs) can be imported and updated from the web when <i>TheSkyX</i> is launched. |

## Photographs

| Photos Database                     | Details   |
|-------------------------------------|---|
| Anglo-Australian Observatory Photos | 172 color photos from the David Malin collection of AAO images. |
| Deep-sky Overlays                   | 127 photos that appear on the Sky Chart.                        |
| Hubble Photos                       | 314 color photographs from the Hubble Space Telescope.          |
| Messier Overlays                    | 104 color photographs.  |
| Non-stellar objects                 | 53 color photographs of non-stellar objects.                    |
| Solar System Photos                 | 255 color photographs of the solar system objects.              |
| Digitized Sky Survey thumbnails     | 100,000 grayscale photos from the Digitized Sky Survey.         |

## Catalog Cross References

TheSkyX includes cross references the following catalogs. Use the **Find** command on the **Edit** menu to locate any object in these catalogs.

| Cross-Referenced Catalogs                    | Prefix                | Object Count |
|--|-----------------------|--------------|
| 2MASS Galaxies                               | 2MASXJ                | –            |
| 2MFGC Catalog                                | 2MFGC                 | –            |
| 6dFJ   | 6dFJ                  | –            |
| Abell  | ABELL                 | –            |
| Abell 1644                                   | ABELL_1644            | 145          |
| AGC  | AGC                   | –            |
| AM   | AM                    | –            |
| Antila Group                                 | Antila Group          | –            |
| Arakelian Catalog of Galaxies                | ARK                   | 591          |
| Arp  | ARP                   | –            |
| Bayer/Flamsteed Designations                 | n/a                   | –            |
| Bonner Durchmusterung Number                 | B+nn nnnnn            | –            |
| BTS  | BTS                   | –            |
| Caldwell Catalog                             | Caldwell + Cn         | 109          |
| Cape Durchmusterung Number                   | P-nn nnnn             | –            |
| Catalog of Galaxies and Clusters of Galaxies | CGCG                  | 29,809       |
| Catalog of Galaxy Groups                     | KDG                   | 253          |
| Catalog of Isolated Pairs of Galaxies        | KCPG                  | –            |
| CGMW   | CGMW                  | –            |
| Common Non-Stellar Object Names              | name of object        | –            |
| Common Star Names                            | name of object        | –            |
| Compact Groups of Galaxies                   | 2DFGRSN               | –            |
| Constellations                               | name of constellation | 88           |

| Cross-Referenced Catalogs                        | Prefix       | Object Count |
|--|--------------|--------------|
| Cordoba Durchmusterung                           | C-nn nnnnn   | –            |
| David Dunlap Observatory Catalog of Galaxies     | DDO          | 242          |
| DDO  | DDO          | –            |
| Dorado Group                                     | DORADO_GROUP | –            |
| DRCG   | DRCG         | –            |
| DUKST  | DUKST        | –            |
| EDCC   | EDCC         | –            |
| European Southern Observatory (Southern objects) | ESO          | 16,239       |
| Fairall Catalog of Galaxies                      | FAIR         | 1,185        |
| FCC  | FCC          | –            |
| FCCB   | FCCB         | –            |
| FGC  | FGC          | –            |
| FGCE   | FGCE         | –            |
| FM   | FM           | –            |
| Galaxy Identification Number                     | GIN          | 795          |
| GIN  | GIN          | –            |
| GMP  | GMP          | –            |
| Groups of Galaxies                               | 2DFGRSS      | –            |
| HCG  | HCG          | –            |
| Henry Draper Number                              | HD           | 359,083      |
| Hickson Compact Galaxy Groups                    | HCG          | 450          |
| HIPASSJ  | HIPASSJ      | –            |
| HRG  | HRG          | –            |
| HSTGC  | HSTGC        | –            |
| IC (PGC 2011 Cross Reference)                    | IC           | –            |
| IISZ   | IISZ         | –            |
| Infrared Astronomical Survey                     | IRAS         | 9,347        |

| Cross-Referenced Catalogs           | Prefix    | Object Count |
|-------------------------------------|-----------|--------------|
| ISZ                                 | ISZ       | –            |
| Karachentseva Catalog of Galaxies   | KARA      | 183          |
| Kazaryan UV Galaxies                | KAZ       | 581          |
| KDG                                 | KDG       | –            |
| KIG                                 | KIG       | –            |
| Kiso UV Galaxies                    | KUG       | 5,455        |
| KKH                                 | KKH       | –            |
| KPG                                 | KPG       | –            |
| KUG                                 | KUG       | –            |
| LCRSB                               | LCRSB     | –            |
| Leo Group                           | LEO_GROUP | –            |
| LGG                                 | LGG       | –            |
| MCG                                 | MCG       | –            |
| Messier Catalog                     | M         | 110          |
| MRK                                 | MRK       | –            |
| NFPJ                                | NFPJ      | –            |
| NGC (PGC 2011 Cross Reference)      | NGC       | –            |
| NPM                                 | NPM       | –            |
| NRGb                                | NRGb      | –            |
| NRGs                                | NRGs      | –            |
| PDFJ                                | PDFJ      | –            |
| PGC (PGC 2011 Cross Reference)      | PGC       | –            |
| PKS                                 | PKS       | –            |
| Positions and Proper Motions Number | PPM       | -            |
| POX                                 | POX       | –            |
| RKK                                 | RKK       | –            |

| Cross-Referenced Catalogs                           | Prefix | Object Count |
|---|--------|--------------|
| SBS   | SBS    | –            |
| SDSSJ   | SDSSJ  | –            |
| Second Byurakay Survey                              | SBS    | 259          |
| Smithsonian Astrophysical Observatory Catalog (SAO) | SAO    | 258,997      |
| SRGb  | SRGb   | –            |
| SS  | SS     | –            |
| Struve Catalog                                      | STRUVE | 3,100        |
| Tololo Galaxies                                     | TOL    | 111          |
| UCG   | UCG    | –            |
| UCGA  | UCGA   | –            |
| University of Michigan Catalog of Galaxies          | UM     | 652          |
| LGS   | LGS    | 5            |
| Uppsala General Catalog of Galaxies                 | UGC    | 13,073       |
| VCC   | VCC    | –            |
| Virgo Cluster Catalog of Galaxies                   | VCC    | 2097         |
| VV  | VV     | –            |
| Weinberger Catalog of Galaxies                      | WEIN   | 207          |
| WINGSJ  | WINGSJ | –            |
| WKK   | WKK    | –            |
| WMMA  | WMMA   | –            |
| ZOAG  | ZOAG   | –            |
| Zwicky1   | 1ZW    | 238          |
| Zwicky2   | 2ZW    | 199          |
| Zwicky3   | 3ZW    | 159          |
| Zwicky4   | 4ZW    | 203          |
| Zwicky5   | 5ZW    | 531          |
| Zwicky6   | 6ZW    | 238          |

| Cross-Referenced Catalogs | Prefix | Object Count |
|---------------------------|--------|--------------|
| Zwicky7                   | 7ZW    | 1,145        |
| Zwicky8                   | 8ZW    | 645          |

## Ephemeral Data

TheSkyX can display the positions of comets and minor planets and man-made satellites. The orbital element data required to *accurately* display these objects changes frequently and can be updated from TheSkyX using different sources on the worldwide web.

The table below lists the sites the TheSkyX uses to update this information.

| Object Type                | Object Count        | Web Site Address to Obtain Updated Orbital Element Data   |
|----------------------------|---------------------|---|
| Comets                     | Up to 1000          | <a href="http://www.minorplanetcenter.net/iau/MPEph/MPEph.html">http://www.minorplanetcenter.net/iau/MPEph/MPEph.html</a> |
| Satellites                 | Up to 10,000        | <a href="http://celestrak.com">http://celestrak.com</a>   |
| Asteroids (Large Database) | All known asteroids | <a href="http://asteroid.lowell.edu">http://asteroid.lowell.edu</a>   |

## TheSkyX Professional Edition-Specific Databases

### PROFESSIONAL

TheSkyX Professional Edition includes a subset of the UCAC4 star catalog that contains approximately 30 million stars, more or less evenly distributed across the celestial sphere. This catalog is ideal for determining the astrometric solution of photos with moderate to wide fields of view using Image Link (page 312).

The limiting magnitude of the UCAC4 Subset catalog is *approximately* 14.

### TheSkyX Professional Edition Database Add On



Figure 278: TheSkyX Pro Database Add On hard drive (the physical SSD drive may vary).

Software Bisque offers an optional [TheSkyX Professional Edition Database Add On](#), a set of astronomical catalogs distributed on a 350 GB hard drive. The table below lists each catalog or resource included on the drive.

| Catalog or Resource Name   | Number of Stars or Description | Approximate Size (GB) |
|--|--------------------------------|-----------------------|
| Native <a href="#">NOMAD Catalog</a> and related files             | 1.1 billion                    | 100                   |
| TheSkyX Pro-specific NOMAD plot files                              | 800 million                    | 40                    |
| Native <a href="#">UCAC4 Catalog</a> and related files and folders | 113 million                    | 8                     |
| Small TheSkyX Pro-specific UCAC4 plot file                         | 30 million                     | 1                     |

| Catalog or Resource Name                                     | Number of Stars or Description   | Approximate Size (GB) |
|--|--|-----------------------|
| All Sky Image Link Database installers for macOS and Windows | This database is required to perform All Sky Image Links.  | 2                     |
| AAVSO Photometric All Sky Survey ( <a href="#">APASS</a> )   | Funding for APASS was provided by the Robert Martin Ayers Sciences Fund.   | 2                     |
| Large TheSkyX Pro-specific UCAC4 plot file                   | 113 million  | 3                     |
| Digitized Sky Survey   | “First generation” <a href="#">Digitized Sky Survey</a> from the Space Telescope Science Institute contains photos of the entire celestial sphere at 10x compression. Distributed with permission. | 60                    |
| <b>Total</b>   |  | <b>200</b>            |

These databases can be accessed from *TheSkyX Professional Edition* for Mac or Windows.

## Packing List

*TheSkyX Professional Edition* Database Add On includes the following items:

| Quantity | Description          |
|----------|----------------------|
| 1        | 250 GB USB SSD drive |
| 1        | USB cable            |



Figure 279: TheSkyX Pro Database Add On USB SSD drive cable.

## **Getting Started**

After unpacking the drive and cable from the shipping box, the next step is to plug the USB drive into your computer. The following procedure applies to all operating systems.

1. Plug the non-USB end of the cable into the hard drive port (Figure 280).



**Figure 280: Plug this end of the USB cable on the left into the SSD drive's input port.**

2. Plug the USB connector on the USB cable into a free USB port on your computer (Figure 281).



**Figure 281: Plug the USB connector into the computer's USB port.**

## Troubleshooting

You may have to wait 30 seconds or so for the operating system to recognize the SSD drive after it is plugged in.

### **Windows AutoPlay**

If your computer is configured to run AutoPlay when a USB drive is plugged in, the following AutoPlay window appears:

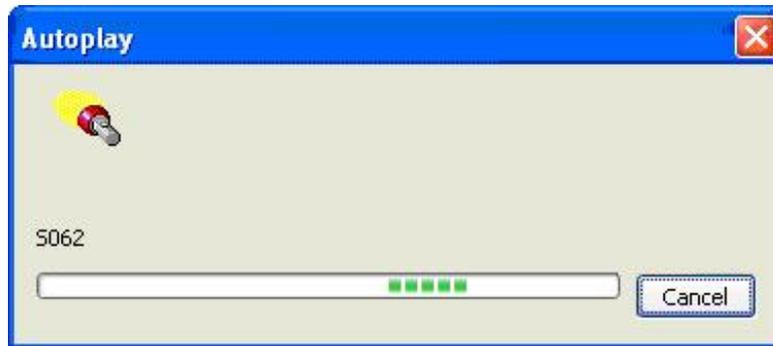


Figure 282: The Windows AutoPlay window.

Click **Cancel** to prevent Windows from scanning the 1.2 million files on the drive.

## Accessing TheSkyX Pro Database Add On Catalogs

Configuring *TheSkyX Professional Edition* to use the *Database Add On* star catalogs and photos from Digitized Sky Survey is straightforward.

1. Launch TheSkyX Professional Edition.
2. From *TheSkyX Pro*, select the **Database Manager** command from the **Input** menu.
3. In the list of databases, expand the **Database Add On**, then highlight **Database Add On**.
4. Click the **Choose Folder** button.
5. Select the volume name (Mac) or drive letter (Windows) for the drive and click the **Choose** button. The **Property** table now shows the location of the files on the Database Add On hard drive.
6. Click **Close**.

The Sky Chart can now show all the stars from the UCAC3, UCAC4 and NOMAD star catalogs at small fields of view.

When the **Disc Or Other Drive** option is turned on from the **Create Photo** tab on the **Digitized Sky Survey** window (**Tools** menu), photos from the Digitized Sky Survey will be retrieved from the hard drive when the **Show Digitized Sky Survey Photo** command is selected from the **Tools** menu.

### **NOMAD Catalog Notes**

- Stars from the NOMAD catalog only appear at one-degree fields of view and smaller.

- Unlike most astronomical catalogs, the NOMAD catalog does not have a unique numerical identifier for each star, so there's no way to search, for example, NOMAD 1000000000. Use the NOMAD star's right ascension and declination coordinates to locate it.
- In order to show stars from the NOMAD catalog, the NOMAD folder with the native NOMAD catalog data must also contain the Software Bisque proprietary 35 GB `nomad.plot` file. If this file is not present, *TheSkyX Professional Edition* will not display NOMAD stars. (Bandwidth limitations prevent Software Bisque from offering this file for download and creating the NOMAD plot file, even on a 12-core machine, requires several days of uninterrupted computer time.)

## **Copying Database Add On to another Drive**

The files and folders on *TheSkyX Professional Edition Database Add On* hard drive are not copy protected, and can be moved to, or copied to a different hard drive (subject to the Copyright Notices below).

If you want to copy the databases to a different drive, make sure to copy the entire contents of *TheSkyX Professional Edition Database Add On* drive to the second drive, then configure *TheSkyX Pro* accordingly (see "Accessing TheSkyX" on page 640).

## **Copyright Notices**

*TheSkyX Professional Edition Database Add On* is a compilation of copyrighted astronomical catalogs from various sources. Please carefully read the copyright information below.

## ***TheSkyX Professional Edition Optimized UCAC and NOMAD Catalogs***

*TheSkyX Professional Edition-specific plot files* that are included on *TheSkyX Pro Database Add On* hard drive are copyright 2016, Software Bisque, Inc. They are licensed to you for private, non-commercial use with *TheSkyX Professional Edition* and cannot be redistributed.

## **Palomar Sky Survey**

The data supplied in the Palomar folder is licensed under agreements between the Association of Universities for research in Astronomy, Inc (AURA), the UK Astronomy Technology Centre, ROE and Software Bisque, Inc.

This dataset is distributed for scientific and educational use, primarily to amateur astronomers and educational institutions. ***Redistribution of this dataset is prohibited without explicit permission from STScI and ROE.***

## ***UCAC and NOMAD Catalog Copyrights***

This catalog contains data from a diverse collection of photographs, reductions, and catalogs. Many different organizations claim copyright and/or intellectual property rights on the various

components. Although the details differ, all permissions for usage of data are contingent on unrestricted access. Distribution and/or other direct costs can be recovered, but re-packaging, re-formatting, or similar activities, especially for commercial purposes, are not permitted except as authorized by the U. S. Naval Observatory in consultation with the other institutions listed below and as appropriate.

- Palomar Observatory, National Geographic Society, and California Institute of Technology own Palomar Observatory Sky Surveys I and II.
- European Southern Observatory.
- The UK Particle Physics and Astronomy Research Council (formerly Science and Engineering Research Council and before that Science Research Council).
- The Anglo-Australian Telescope Board.
- The Hipparcos and Tycho Teams on behalf of the European Space Agency.
- Space Telescope Science Institute on behalf of AURA, Inc. and NASA.
- U.S. Naval Observatory on behalf of the U.S. Government. USNO claims domestic and international copyright protection for the digitized images, the data reduction, catalog compilation, and all other aspects of the derived products.
- Funding for the APASS was provided by the Robert Martin Ayers Sciences Fund.

When using data from this catalog, please acknowledge the source of the data, and if appropriate, please include a specific citation.

### ***Database Add On Hard Drive Warranty Information***

Software Bisque warrants all product media for 30 days from the date of purchase and will replace it free of charge (please return defective media to Software Bisque). Proof of purchase is required for warranty replacements.

### **Backing Up the Databases**

As with all removable media, Software Bisque *strongly recommends* that you make a backup copy of the contents of the Database Add On hard drive.

## Appendix B: Migrating from TheSky6 to TheSkyX

If you are familiar with *TheSky6*, please review the table of changes below to ease the transition to *TheSkyX*.

### Terminology Changes

| This phrase or command in TheSky6...               | Is now this in TheSkyX...                    |
|--|--|
| <b>Chart Mode</b>                                  | Map Like option, Display menu, page 251.     |
| <b>Comets/Minor Planets/Extended Minor Planets</b> | Small Solar System Bodies command, page 244. |
| <b>Data Menu</b>                                   | Input Menu.                                  |
| <b>Data Wizard</b>                                 | Advanced Query, page 289.                    |
| <b>Data Wizard Results</b>                         | Observing List, page 288.                    |
| <b>Daytime Sky Mode</b>                            | Show Daylight, page 57.                      |
| <b>Display Explorer</b>                            | Chart Elements, page 236.                    |
| <b>Display Properties</b>                          | Chart Attributes, page 236.                  |
| <b>Eclipse Finder</b>                              | Solar and Lunar Eclipse Viewer, page 184.    |
| <b>Extended Labels</b>                             | Detailed Labels, page 80.                    |
| <b>Extended Minor Planets</b>                      | Asteroids (Large Database), page 245.        |
| <b>Image Groups</b>                                | Place Photos, page 99.                       |
| <b>Image Link and Sync</b>                         | Synchronize on an Image Link photo, page 379 |
| <b>Image Manager (Data Menu)</b>                   | Place Photo, page 99.                        |
| <b>Images</b>                                      | Photos, page 95.                             |
| <b>Import command</b>                              | Create Sky Database command, page 274.       |

| <b>This phrase or command in TheSky6...</b>               | <b>Is now this in TheSkyX...</b>  |
|---|---|
| <b><i>Mapping/Map Points</i></b>                          | Pointing Calibration/Pointing Samples. See the TPoint Add On User Guide for details about pointing calibration.   |
| <b><i>Minor Planets</i></b>                               | Asteroids, page 245.  |
| <b><i>Mirror Image</i></b>                                | Show Mirror Image, page 49.   |
| <b><i>Moon Phase Calendar</i></b>                         | Calendar, page 135.   |
| <b><i>Moon Viewer</i></b>                                 | Moon Photo Viewer, page 170.  |
| <b><i>N/E Indicator</i></b>                               | Celestial North Arrow (Chart Elements window, page 236).  |
| <b><i>Night Vision Mode</i></b>                           | Show Night Vision Mode.   |
| <b><i>Options command</i></b>                             | Preferences (Tools Menu, Windows) page 201.   |
| <b><i>Pole Up</i></b>                                     | Celestial Sphere, Orientation menu, page 44.  |
| <b><i>Print Preview</i></b>                               | Export Chart, page 164.   |
| <b><i>Real Mode Options</i></b>                           | Horizon & Atmosphere Options, page 259, and Milky Way Options, page 267.  |
| <b><i>Sky Database Manager</i></b>                        | Database Manager, page 269.   |
| <b><i>Sky Display</i></b>                                 | Sky Chart, page 32.   |
| <b><i>Sky Document</i></b>                                | Sky Chart Settings, page 57.  |
| <b><i>Sky View Preferences</i></b>                        | Chart Element Attributes, page 236.   |
| <b><i>Stellar &amp; Solar System Update Frequency</i></b> | Target Frame Rate, page 225 .<br><br>Solar system object updates now occur <i>30 times per second</i> by default, rather than <i>once every 5 minutes</i> as did TheSky6. |
| <b><i>Sun &amp; Moon Report</i></b>                       | Reports, page 149.  |

| This phrase or command in TheSky6... | Is now this in TheSkyX...   |
|--------------------------------------|---|
| <b>Sync command</b>                  | Startup pop-up menu on the Telescope window (Display menu), page 377. |
| <b>Use Computer's Clock</b>          | Computer Clock, page 223.   |
| <b>User-Defined Data</b>             | My Chart Elements, page 283.  |
| <b>User-Defined Object Types</b>     | My Object Types, page 49.   |
| <b>View Menu</b>                     | Display Menu.   |
| <b>Virtual Sky Mode</b>              | Photo Like, page 251.   |
| <b>Zenith Up</b>                     | Terrestrial Sphere Orientation, page 150.                             |

| TheSky6 Feature   | Equivalent TheSkyX Feature  |
|---|---|
| Changing Font Colors  | Edit the Attributes of Chart Elements (page 236).   |
| Defining Telescope Limit Lines                                  | Click the <b>Telescope Limits</b> command from the <b>Telescope</b> menu.   |
| Edit or Draw the Local Horizon                                  | Click the <b>Horizon &amp; Atmosphere</b> command on the <b>Display</b> menu.<br>Click the <b>Horizon</b> tab.<br>Select the <b>Custom Drawn</b> option in the <b>Horizon Type</b> list.  |
| Object Tips (Tool Tips)   | Click the <b>Preferences</b> command from the <b>Tools</b> menu (Windows) or <b>TheSkyX</b> menu (Mac).<br>Click the <b>Report Setup</b> icon.<br>Select <b>Tool Tips</b> from the <b>Report</b> list.<br>Turn on the desired <b>Object Properties</b> to appear in the tool tip. |
| Right-click to drag the screen                                  | <i>Left-click</i> the mouse to drag the Sky Chart.  |
| Setting the Upper and Lower Magnitude Limits                    | Setting the magnitude limit, page 158.  |
| Showing Labels (common labels and extended labels) on Sky Chart | Labels (for <i>common names</i> and <i>detailed labels</i> ) are located on the Labels window.<br>Click <b>Labels</b> command on the <b>Display</b> menu to show this window.   |
| Showing Reference Lines and Reference Photos, including:        | Reference lines can be turned on or off from the <b>Chart Elements</b> window (page 254).   |

| TheSky6 Feature   | Equivalent TheSkyX Feature   |
|---|--|
| Constellation Figures<br>Constellation Drawings<br>Constellation Boundaries<br>Galactic Equator<br>Milky Way<br>Equatorial lines (equatorial grid and North/East Indicator)<br>Horizon<br>Ecliptic<br>Telescope Limit Lines<br>Horizon-based lines, including the local horizon, refracted horizon, meridian and horizon grid<br>Local Horizon Fill Color |  |
| Zoom Box  | Press and hold the SHIFT key while dragging the mouse on the Sky Chart to create a zoom box. |

## TheSky6 and TPoint for Windows Settings

TheSky6 can open and save a variety file formats. The follow section describes each format and how to transition your existing data to TheSkyX.

### Sky Documents

- By default, TheSkyX uses your computer’s IP address to determine your location. TheSkyX also has a **To Google Map** option that can be used verify and refine your location. If you have the GPS coordinates of your observing site, then you can enter them manually, as well as your time zone, from the **Input > Location > Custom** tab (page 36).
- TheSkyX uses the computer’s local time by default. See “Entering the Date and Time (Date & Time Control)” on page 140 for details how to set a specific date and time.

### Field of View Indicators

- TheSky6 stores your custom field of view indicators in a text file named Field of View Indicators.txt in the folder named <My Documents>\Software Bisque\TheSky6\Field of View Indicators.

TheSkyX also stores FOVIs in a text file of the same name, but in the folder named <My Documents>\Software Bisque\TheSkyX Professional Edition\Field of View Indicators. The format of TheSky6's Field of View Indicators.txt text file the same as TheSkyX. So, you can copy TheSky6's Field of View Indicators.txt to TheSkyX's folder to preserve your FOVIs.

## Telescope Configuration

- Telescope-configuration is a manual process. You'll need to manually set the telescope and the telescope settings (telescope type, COM port, limit settings, etc.) from *TheSkyX*.
- Use *TheSky6* to park the telescope. Then connect to the telescope from *TheSkyX* and, without slewing the telescope, on the Telescope window, from the Shut Down pop-up menu, configure *TheSkyX*'s park position by clicking the **Set Park Position** command (page 375).

## TPoint for Windows Settings and Models

Important Note: TPoint for Windows is not compatible with *TheSkyX* Professional Edition. *TheSkyX* Professional Edition instead now offers the integrated TPoint Add On.

- In *TheSky6*, the *TPoint for Windows* model is saved as part of the Sky Document (.SKY) document. *TPoint for Windows* is a separate application. In *TheSkyX*, the can be purchased as an "Add On" but is an integrated component and is accessed by clicking the Telescope > TPoint Add On command at any time (there's a 90-day free trial period to use the TPoint Add On).

### **To transfer an existing TPoint for Windows model to TheSkyX Pro and the TPoint Add On**

1. From *TheSky6*, open the TPoint document by right-clicking on the TPoint icon, and then click *Open*. This launches *TPoint for Windows* and opens the .tpt document with the model.
2. From *TPoint for Windows*, click the **Export** command from the **File** menu, then enter a name for the text file that will hold your exported mapping data. This "pointing data" can be imported into the *TPoint Add On*.
3. From *TheSkyX*, click the *TPoint Add On* command from the **Telescope** menu.
4. From the *TPoint Add On* **Setup** tab, select the **Import** command from the **TPoint Add On Settings** pop-up menu.
5. Select the text file name that holds the TPoint for Windows pointing data and then click **Open**.

The *TPoint Add On* now has your pointing data, and you can turn on the desired terms for your model. A *recalibration* will be required to restore the CH, IH and ID terms (the telescope's "synchronization" information). See the TPoint Add On User Guide for more information about recalibration

## Comets/Asteroids/Satellites

- The latest orbital elements and two-line elements TLEs for these objects will need to be downloaded from *TheSkyX*. See page 183 for details.

## Sky Databases

A folder of *TheSky6* SDBs can be converted to *TheSkyX*-compatible Sky Database format (.SDBX) from the **Advanced** tab of *TheSkyX*'s **Database Manager** (page 272).

## Importing Photographic Horizons

If you have created a photographic horizon for TheSky6 for Windows and want to show it in TheSkyX do the following:

1. Open the tagged image format (.tif) photograph from *TheSky6 for Windows* in your favorite image processing software.
2. Save the photo as a PNG (see “Tips for Creating Panorama Photos” on page 263).
3. Copy the PNG photo to the appropriate folder and select it as the current panoramic horizon (see “Selecting the Panorama Photo” on page 263).

In TheSky6, the orientation of the photographic horizon relative to the local horizon is stored in a file with the extension <Horizon Name>.horizon. If you wish to maintain this position for the same photograph in TheSkyX, do the following:

1. Manually copy *TheSky6's* <Horizon Name>.horizon file for the particular photo into the *Horizons* folder (see “Selecting the Panorama Photo” on page 263).

When the panoramic horizon is selected in *TheSkyX*, the appropriate horizon photo options are set based on the contents of the <Horizon Name>.horizon file, so that the photo is oriented correctly.

## Importing Custom Drawn Horizons

TheSkyX can display custom-drawn horizons that were created in TheSky6. TheSky6's custom drawn horizon data must be saved in a TheSkyX-compatible format first.

Here's how:

1. Launch TheSky6.
2. Choose the **Reference Lines** command from the **View** menu.
3. Click the **Edit Local Horizon** button to show the **Horizon Editor** window.
4. On the **Horizon Editor** window, click the **Copy** button to copy the horizon's azimuth and altitude positions to the Clipboard.
5. Launch Windows Notepad.
6. From Notepad, type the number 360 and press the Enter key.
7. From Notepad, choose the **Paste** command from the **Edit** menu.
8. From Notepad, choose the **Save As** command from the **File** menu.
9. On the **Save As** window, navigate to *TheSkyX's* Application Support Files Folder (see page 26).
10. In the **File Name** text box of the **Save As** window, type the name `custom horizon.hrz` and click the **Save** button.

When TheSkyX is launched, and **Custom Horizon** is selected in the **Horizon Type** pop-up menu on the **Horizon** tab of the **Horizon and Atmosphere Options** window (Display menu), this custom horizon exported from TheSky6 will appear.

## Appendix C: Daylight Saving Time

The following table lists the international Daylight Saving Time (DST) starting and ending dates that *TheSkyX* uses to determine when DST begins and ends.

The Time Zone options are found in the [Daylight Saving Option \(DSO\)](#) pop-up.

| Time Zone       | DST Starts               | DST Ends                   | Adopting Countries   |
|-----------------|--------------------------|----------------------------|--|
| Australia-NSW   | Last Sunday of October   | Last Sunday of March       | Australia (Australian Capital Territory, Lord Howe Island, New South Wales)  |
| Australia-South | Last Sunday of October   | Last Sunday of March       | Australia (Broken Hill NSW, South Australia, Victoria)   |
| Brazil          | Third Sunday of October  | Third Sunday of February   | Brazil   |
| Chile           | Second Sunday of October | Second Sunday of March     | Chile  |
| China           | Third Sunday of April    | Second Sunday of September | China  |
| Cuba            | First Sunday of April    | Second Sunday of October   | Cuba   |
| Egypt           | First Day of May         | First Day of October       | Egypt  |
| Europe          | Last Sunday of March     | Last Sunday of October     | Albania, Andorra, Austria, Belarus, Belgium, Bosnia Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Faroe Islands, Finland, France, Georgia, Germany, Gibraltar, Greece, Greenland (Scoresbysund), Hungary, Italy, Kazakhstan, Latvia, Lebanon, Lithuania, Luxembourg, Macedonia, Malta, Monaco, Mongolia (Ulan Bator), Netherlands, Norway, Poland, |

| Time Zone        | DST Starts                 | DST Ends                   | Adopting Countries  |
|------------------|----------------------------|----------------------------|---|
|                  |                            |                            | Portugal, Romania, Russian Federation, San Marino, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, Yugoslavia                            |
| Falkland Islands | Second Sunday of September | Third Sunday of April      | Falkland Islands  |
| Greenland        | Last Sunday of March       | Fourth Sunday of September | Greenland (except Scoresbysund and Thule)   |
| Iran             | 21st Day of March          | 21st Day September         | Iran  |
| Israel           | Last Friday of March       | Last Sunday of August      | Israel  |
| Jordan           | First Friday of April      | Third Friday of September  | Jordan  |
| Kyrgyzstan       | Second Sunday of April     | Last Sunday of September   | Kyrgyzstan  |
| Moldova          | First Sunday of March      | Last Sunday of September   | Moldova   |
| Namibia          | First Sunday of September  | First Sunday of April      | Namibia   |
| New Zealand      | First Sunday of October    | Third Sunday of March      | New Zealand   |
| U.S. and Canada  | Second Sunday of March     | First Sunday of November   | Begins March 2007<br><br>Bahamas, Bermuda, Canada, Greenland (Thule), Mexico, St. Pierre and Miquelon, Turks and Caicos Islands, United States of America |
| Paraguay         | First Sunday of October    | Last Sunday of February    | Paraguay  |
| Syrian           | First Day of April         | First Day of October       | Iraq, Syria   |

| <b>Time Zone</b> | <b>DST Starts</b>       | <b>DST Ends</b>        | <b>Adopting Countries</b>                      |
|------------------|-------------------------|------------------------|--|
| Tasmania         | First Sunday of October | Last Sunday of March   | Tasmania                                       |
| United Kingdom   | Last Sunday of March    | Last Sunday of October | England, Ireland, Isle of Man, Scotland, Wales |
| Mexico           | First Sunday of April   | Last Sunday of October | Mexico   |



## Appendix D: Macro Commands

The table below lists the macro commands that can run at waypoints in tours.

| Command Name      | Number of Arguments | Argument 1    | Argument 2            | Argument 3 | Argument 4 | Argument 5     |
|-------------------|---------------------|---------------|-----------------------|------------|------------|----------------|
| SetVisible        | 2                   | Object type   | Visible               |            |            |                |
| SetMagFaintest    | 2                   | Object type   | Magnitude             |            |            |                |
| SetMagBrightest   | 2                   | Object type   | Magnitude             |            |            |                |
| SetSizeMin        | 2                   | Object type   | Size (arcmins)        |            |            |                |
| SetSizeMax        | 2                   | Object type   | Size (arcmins)        |            |            |                |
| SetPenStyleWidth  | 3                   | Object type   | Pen style<br>(0=none) | Pen width  |            |                |
| SetPenColor       | 5                   | Object type   | Red                   | Green      | Blue       | Alpha          |
| SetFillRgb        | 5                   | Object type   | Red                   | Green      | Blue       | Alpha          |
| SetFontRgb        | 5                   | Object type   | Red                   | Green      | Blue       | Alpha          |
| SetFontFamilySize | 3                   | Object type   | Family name           | Point size |            |                |
| SetSymbolSVG      | 3                   | Object type   | SVG filename          | Size(mm)   |            |                |
| ToggleVisible     | 1                   | Object type   |                       |            |            |                |
| SetExtendLabel    | 4                   | Dataset/Type  | Database              | Field      | Value      |                |
| AddObject         | 4                   | RA            | Dec                   | Type       | Magnitude  |                |
| AddLabel          | 3                   | RA            | Dec                   | Label      |            |                |
| AddArrow          | 4                   | RA            | Dec                   | Width      | Height     |                |
| AddAreaOfInterest | 3                   | RA            | Dec                   | Size       |            |                |
| AddChartScale     | 2                   | RA            | Dec                   |            |            |                |
| AddTelrad         | 2                   | RA            | Dec                   |            |            |                |
| AddMoveTo         | 2                   | RA            | Dec                   |            |            |                |
| AddLineTo         | 2                   | RA            | Dec                   |            |            |                |
| AddPolyPoint      | 2                   | RA            | Dec                   |            |            |                |
| AddEllipse        | 5                   | RA            | Dec                   | Major axis | Minor axis | Position Angle |
| AddSVG            | 4                   | RA            | Dec                   | File name  | Size       |                |
| ClearUserData     | 0                   |               |                       |            |            |                |
| SetRefFrame       | 1                   | Frame         |                       |            |            |                |
| SetDefaultType    | 1                   | Object type   |                       |            |            |                |
| SetConstLine      | 2                   | Constellation | On/Off                |            |            |                |
| SetConstBoundary  | 2                   | Constellation | On/Off                |            |            |                |
| SetConstDrawing   | 2                   | Constellation | On/Off                |            |            |                |
| SetConstLabel     | 2                   | Constellation | On/Off                |            |            |                |
| ConstLinesUpdate  | 0                   |               |                       |            |            |                |
| LaserPointer      | 3                   | RA            | Dec                   | Duration   |            |                |
| Fade              | 1                   | Seconds       |                       |            |            |                |
| Zoom              | 1                   | Degrees       |                       |            |            |                |
| Center            | 1                   | Object name   |                       |            |            |                |
| Frame             | 1                   | Object name   |                       |            |            |                |
| TourIncrement     | 1                   | Days          |                       |            |            |                |
| TourText          | 3                   | Text          | Height                | Position   |            |                |



## Appendix E: Constellation Abbreviations

|                        |                       |                            |
|------------------------|-----------------------|----------------------------|
| (And) Andromeda        | (Cru) Crux Australis  | (Ori) Orion                |
| (Ant) Antlia           | (Cyg) Cygnus          | (Pav) Pavo                 |
| (Aps) Apus             | (Del) Delphinus       | (Peg) Pegasus              |
| (Aqr) Aquarius         | (Dor) Dorado          | (Per) Perseus              |
| (Aql) Aquila           | (Dra) Draco           | (Phe) Phoenix              |
| (Ara) Ara              | (Equ) Equuleus        | (Pic) Pictor               |
| (Ari) Aries            | (Eri) Eridanus        | (Psc) Pisces               |
| (Aur) Auriga           | (For) Fornax          | (PsA) Pisces Australis     |
| (Boo) Bootes           | (Gem) Gemini          | (Pup) Puppis               |
| (Cae) Caelum           | (Gru) Grus            | (Pyx) Pyxis                |
| (Cam) Camelopardus     | (Her) Hercules        | (Ret) Reticulum            |
| (Cnc) Cancer           | (Hor) Horologium      | (Sge) Sagitta              |
| (CVn) Canes Venatici   | (Hya) Hydra           | (Sgr) Sagittarius          |
| (CMa) Canis Major      | (Hyi) Hydrus          | (Sco) Scorpius             |
| (CMi) Canis Minor      | (Ind) Indus           | (Scl) Sculptor             |
| (Cap) Capricornus      | (Lac) Lacerta         | (Sct) Scutum               |
| (Car) Carina           | (Leo) Leo             | (Ser) Serpens              |
| (Cas) Cassiopeia       | (LMi) Leo Minor       | (Sex) Sextans              |
| (Cen) Centaurus        | (Lep) Lepus           | (Tau) Taurus               |
| (Cep) Cepheus          | (Lib) Libra           | (Tel) Telescopium          |
| (Cet) Cetus            | (Lup) Lupus           | (Tri) Triangulum           |
| (Cha) Chamaeleon       | (Lyn) Lynx            | (TrA) Triangulum Australis |
| (Cir) Circinus         | (Lyr) Lyra            | (Tuc) Tucana               |
| (Col) Columba          | (Men) Mensa Berenices | (UMa) Major Ursa           |
| (Com) Coma Berenices   | (Mic) Microscopium    | (UMi) Ursa Minor           |
| (CrA) Corona Australis | (Mon)                 | (Vel) Vela                 |
| (CrB) Corona Borealis  | (Mus) Musca           | (Vir) Virgo                |
| (Crv) Corvus           | (Nor) Norma           | (Vol) Volans               |
| (Crt) Crater           | (Oct) Octans          | (Vul) Vulpecula            |
|                        | (Oph) Ophiuchus       |                            |



## Appendix F: TheSkyX Pro Automation Model

### PROFESSIONAL

*TheSkyX Professional Edition* can be scripted using *TheSkyX Scriptable Objects*. Documentation is available on the web at <http://www.bisque.com/scripttheskyx>.

For third-party developers using *TheSky6*'s object model, note that *TheSkyX Professional Edition*'s automation model interface, for the most part, mirrors *TheSky6 Professional Edition*. Click on the Modules tab on the above web page for details about *TheSkyX* objects and *TheSky6 Classic Objects*. See *ScriptTheSkyX Documentation and Source Code Examples* at *ScriptTheSkyX Documentation and Source Code Examples* on the Software Bisque Downloads page for scripting documentation and source code examples. The URL to this page is: <http://www.bisque.com/sc/media/p/44090.aspx>.

*TheSkyX Pro* can replace or be exchanged for *TheSky6 Pro* as far as automation is concerned, the only caveat is that controlling programs (clients) need to use *TheSkyX Pro*'s program identifiers (or program ids) in place of *TheSky6 Pro*'s program identifiers.

For example, if your existing script or application source code references *TheSky6 Pro*'s **StarChart** object:

TheSky6.StarChart

To use *TheSkyX Pro*'s StarChart object, replace the above syntax with:

TheSkyXAdaptor.StarChart

Your application will now use *TheSkyX Professional Edition*'s StarChart object instead of *TheSky6 Pro*'s StarChart object.

The table below includes a complete list of *TheSky6 Pro* and *TheSkyX Pro* program ids.

| <b><i>TheSky6 Pro</i> Program ID</b> | <b>Equivalent <i>TheSkyX Pro</i> Program ID</b> |
|--------------------------------------|---|
| TheSky6.DataWizard                   | TheSkyXAdaptor.DataWizard                       |
| TheSky6.MyFOVs                       | TheSkyXAdaptor.MyFOVs                           |
| TheSky6.ObjectInformation            | TheSkyXAdaptor.ObjectInformation                |
| TheSky6.RASCOMTele                   | TheSkyXAdaptor.RASCOMTele                       |
| TheSky6.RASCOMTheSky                 | TheSkyXAdaptor.RASCOMTheSky                     |
| TheSky6.RASServerApp                 | TheSkyXAdaptor.RASServerApp                     |
| TheSky6.Raven                        | TheSkyXAdaptor.Raven                            |
| TheSky6.StarChart                    | TheSkyXAdaptor.StarChart                        |
| TheSky6.Utills                       | TheSkyXAdaptor.Utills                           |

The Windows-specific Visual Basic (VB) code below shows an example how to use the **StarChart** object in either *TheSky6 Pro* or *TheSkyX Pro*. Note that both applications can be installed and run on the same computer, and both object models can be accessed on a single computer, without issue.

Dim StarChart

'Remove the tic mark below to use TheSky6

'Set StarChart = CreateObject("TheSky6.StarChart")

'The following line will use TheSkyX Pro's StarChart object

Set StarChart = CreateObject("TheSkyXAdaptor.StarChart")

## **Automation and User Account Control**

In an effort to minimize the spread of malware, Windows operating systems employ [User Account Control \(UAC\)](#) which attempts to prevent unwanted or unauthorized changes to the operating system.

UAC, unfortunately, may also prevent wanted or *necessary* changes to your computer. For example, when *TheSkyX Professional Edition* is launched, it attempts to "register" COM automation interfaces in the Window Registry.

By default, UAC blocks the registration, so that attempts to access *TheSkyX Professional Edition's* automation interfaces in an external script (or by a third-party observatory automation application) are not possible.

The workaround is to run *TheSkyX Professional Edition* as an Administrator to elevate the account's privileges and allow changes to the Windows Registry.

To run *TheSkyX Professional Edition* as an Administrator:

1. Right-click on ***TheSkyX Professional Edition*** icon.
2. Click the ***Run As Administrator*** command.

## Appendix G: TheSkyX Pro Device Driver Architecture

### PROFESSIONAL

*TheSkyX Professional Edition's X2 Standard* provides a cross-platform, plug in device driver architecture that allows third-party software developers and hardware manufacturers to develop and distribute *TheSkyX Professional Edition*-compatible software drivers for astronomical devices (mounts, cameras, rotators, focusers, and domes).

Documentation and source code examples are available at:

<http://www.bisque.com/x2>.



## Appendix H: TheSkyX Change Log

The list of improvements, changes and bug fixes to *TheSkyX Professional Edition* and *TheSkyX Serious Astronomer Edition* is available at the following URL:

<http://www.bisque.com/sc/pages/TheSkyXChangeLog.aspx>



## Appendix I: Keyboard Shortcuts

The table below lists *TheSkyX*'s main menu commands and the appropriate Mac and Windows keyboard shortcuts. Menu commands without a keyboard shortcuts are left blank.

| Menu                      | Command or Pop-Up Menu           | Keyboard Accelerator   |                                |
|---------------------------|----------------------------------|------------------------|--------------------------------|
|                           |                                  | Mac                    | Windows                        |
| <b>TheSkyX (Mac only)</b> |                                  |                        |                                |
|                           | About TheSkyX                    |                        |                                |
|                           | Preferences                      | COMMAND+, (⌘,)         |                                |
|                           | Hide TheSkyX                     | COMMAND+H, (⌘H)        |                                |
|                           | Hide Others                      | SHIFT+COMMAND+H (⇧⌘H)  |                                |
|                           | Show All                         |                        |                                |
| <b>File</b>               |                                  |                        |                                |
|                           | New                              | COMMAND+N (⌘N)         | CONTROL+N (CTRL+N)             |
|                           | Open                             | COMMAND+O (⌘O)         | CONTROL+O (CTRL+O)             |
|                           | Save                             | COMMAND+S (⌘S)         | CONTROL+S (CTRL+S)             |
|                           | Save As                          | SHIFT+COMMAND+S (⇧⌘S)  | CONTROL+SHIFT+S (CTRL+SHIFT+S) |
|                           | Print                            | COMMAND+P (⌘P)         | CONTROL+P (CTRL+P)             |
|                           | Print Setup                      | SHIFT+COMMAND+P (⇧⌘P)  | CONTROL+SHIFT+P (CTRL+SHIFT+P) |
|                           | Export Chart                     |                        |                                |
|                           | Exit                             | n/a                    | CONTROL+Q (CTRL+Q)             |
| <b>Edit</b>               |                                  |                        |                                |
|                           | Find                             | COMMAND+F (⌘F)         | CONTROL+F (CTRL+F)             |
|                           | Paste Photo                      | COMMAND+V (⌘V)         | CONTROL+V (CTRL+V)             |
|                           | Copy                             | COMMAND+C (⌘C)         | CONTROL+C (CTRL+C)             |
| <b>Display</b>            |                                  |                        |                                |
|                           | Photo Like                       | OPTION+COMMAND+P (⌥⌘P) | CONTROL+ALT+P                  |
|                           | Map Like                         | OPTION+COMMAND+K (⌥⌘K) | CONTROL+ALT+K (CTRL+ALT+K)     |
|                           | Celestial Objects Pop-Up         |                        |                                |
|                           | Show Stars                       |                        |                                |
|                           | Show Variable Stars              |                        |                                |
|                           | Show Double Stars                |                        |                                |
|                           | Show Clusters                    |                        |                                |
|                           | Show Galaxies                    |                        |                                |
|                           | Show Nebulas                     |                        |                                |
|                           | Field of View Indicators         | COMMAND+6 (⌘6)         | CONTROL+6 (CTRL+6)             |
|                           | Show Mirror Image                |                        |                                |
|                           | Full Screen                      | COMMAND+F8 (⌘F8)       | CONTROL+F8 (CTRL+F8)           |
|                           | Show Daylight                    | OPTION+COMMAND+A (⌥⌘A) | CONTROL+ALT+A (CTRL+ALT+A)     |
|                           | Show Night Vision Mode           | OPTION+COMMAND+J (⌥⌘J) | CONTROL+ALT+J                  |
|                           | Constellation & Asterism Options |                        |                                |
|                           | Horizon & Atmosphere Options     |                        |                                |
|                           | Star Options                     |                        |                                |
|                           | Milky Way Options                |                        |                                |

| Menu        | Command or Pop-Up Menu      | Keyboard Accelerator     |                                       |
|-------------|-----------------------------|--------------------------|---------------------------------------|
|             |                             | Mac                      | Windows                               |
|             | Find                        |                          |                                       |
|             | Date And Time               |                          |                                       |
|             | Labels                      |                          |                                       |
|             | Photos                      |                          |                                       |
|             | Chart Elements              |                          |                                       |
|             | Tours                       |                          |                                       |
|             | Observing List              |                          |                                       |
|             | Chart Status                |                          |                                       |
|             | Telescope-Specific Commands |                          |                                       |
|             | Nexstar                     |                          |                                       |
|             | Meade                       |                          |                                       |
|             | Astro-Physics               |                          |                                       |
|             | iOptron                     |                          |                                       |
|             | Gemini                      |                          |                                       |
| Orientation |                             |                          |                                       |
|             | Look Pop-Up                 |                          |                                       |
|             | Look North                  | OPTION+COMMAND+N         | CONTROL+ALT+N                         |
|             | Look South                  | OPTION+COMMAND+S         | CONTROL+ALT+S                         |
|             | Look East                   | OPTION+COMMAND+E         | CONTROL+ALT+E                         |
|             | Look West                   | OPTION+COMMAND+W         | CONTROL+ALT+W                         |
|             | Look Up                     | OPTION+COMMAND+Z         | CONTROL+ALT+Z                         |
|             | Zoom To Pop-Up              |                          |                                       |
|             | Minimum 30'                 | OPTION+COMMAND+END (⌘↵)  | CONTROL+ALT+END                       |
|             | Telescope 1°                | OPTION+COMMAND+T (⌘T)    | CONTROL+ALT+T (CTRL+ALT+T)            |
|             | Finder 10°                  | OPTION+COMMAND+F (⌘F)    | CONTROL+ALT+F (CTRL+ALT+T)            |
|             | Binocular 50°               | OPTION+COMMAND+B (⌘B)    | CONTROL+ALT+B (CTRL+ALT+B)            |
|             | Naked Eye 100°              | OPTION+COMMAND+Y (⌘Y)    | CONTROL+ALT+Y (CTRL+ALT+Y)            |
|             | Wide Field 180°             | OPTION+COMMAND+I (⌘I)    | CONTROL+ALT+I (CTRL+ALT+I)            |
|             | Maximum                     | OPTION+COMMAND+HOME (⌘↵) | CONTROL+ALT+HOME (CTRL+ALT+HOME)      |
|             | Move Pop-Up                 |                          |                                       |
|             | Move Up                     | SHIFT+↑ (⇧↑)             | SHIFT+UP ARROW (SHIFT+UP)             |
|             | Move Down                   | SHIFT+↓ (⇧↓)             | SHIFT+DOWN ARROW (SHIFT+DOWN)         |
|             | Move Left                   | SHIFT+← (⇧←)             | SHIFT+LEFT ARROW (SHIFT+LEFT ARROW)   |
|             | Move Right                  | SHIFT+→ (⇧→)             | SHIFT+RIGHT ARROW (SHIFT+RIGHT ARROW) |
|             | Navigate Pop-Up             |                          |                                       |
|             | Zoom In                     | SHIFT+PAGE DOWN (⇧⌘↓)    | SHIFT+PAGE DOWN (SHIFT+PGDOWN)        |
|             | Zoom Out                    | SHIFT+PAGE UP (⇧⌘↑)      | SHIFT+PAGE UP (SHIFT+PGUP)            |
|             | Terrestrial Sphere          | OPTION+1 (⇧1)            | ALT+1                                 |
|             | Celestial Sphere            | OPTION+2 (⇧2)            | ALT+2                                 |
|             | Free Rotation               |                          |                                       |
|             | Rotate Clockwise            | OPTION++ (⇧+)            | ALT++                                 |
|             | Rotate Counterclockwise     | OPTION+- (⇧-)            | ALT+-                                 |
| Input       |                             |                          |                                       |
|             | Location                    | COMMAND+L (⌘L)           | CONTROL+L (CTRL+L)                    |

| Menu      | Command or Pop-Up Menu              | Keyboard Accelerator  |                                |
|-----------|-------------------------------------|-----------------------|--------------------------------|
|           |                                     | Mac                   | Windows                        |
|           | Date and Time                       | COMMAND+T (⌘T)        | CONTROL+T (CTRL+T)             |
|           | Small Solar System Bodies           | COMMAND+1 (⌘1)        | CONTROL+1 (CTRL+1)             |
|           | Satellites                          | COMMAND+2 (⌘2)        | CONTROL+2 (CTRL+2)             |
|           | Database Manager                    | COMMAND+3 (⌘3)        | CONTROL+3 (CTRL+3)             |
|           | Create Sky Database                 | COMMAND+4 (⌘4)        | CONTROL+4 (CTRL+4)             |
|           | My Chart Elements                   | COMMAND+5 (⌘5)        | CONTROL+5 (CTRL+5)             |
| Tools     |                                     |                       |                                |
|           | Manage Observing List               | COMMAND+M (⌘M)        | CONTROL+M (CTRL+M)             |
|           | Rotate Tool                         | COMMAND+R (⌘R)        | CONTROL+R (CTRL+R)             |
|           | Angular Separation & Position Angle | SHIFT+COMMAND+R (⇧⌘R) | CONTROL+SHIFT+R (CTRL+SHIFT+R) |
|           | Tours                               |                       |                                |
|           | Create Tour                         |                       |                                |
|           | Conjunction Finder                  |                       |                                |
|           | Solar and Lunar Eclipse Viewer      |                       |                                |
|           | Calendar                            |                       |                                |
|           | Moon Photo Viewer                   |                       |                                |
|           | Reports                             |                       |                                |
|           | Iridium Flares                      |                       |                                |
|           | Object Paths                        |                       |                                |
|           | Solar System                        |                       |                                |
|           | 3D Stars                            |                       |                                |
|           | Satellites from Above Earth         |                       |                                |
|           | Image Link                          | SHIFT+COMMAND+I (⇧⌘I) | CONTROL+SHIFT+I (CTRL+SHIFT+I) |
|           | Mosaic Grid                         |                       |                                |
|           | Place Photo                         |                       |                                |
|           | Time Skip Pop-Up                    |                       |                                |
|           | Computer Clock                      | OPTION+N (⌥N)         | ALT+N                          |
|           | Go Forward                          | OPTION+> (⌥>)         | ALT+>                          |
|           | Step Forward                        | OPTION+] (⌥])         | ALT+]                          |
|           | Stop                                |                       |                                |
|           | Step Backward                       | OPTION+[ (⌥[)         | ALT+[                          |
|           | Go Backward                         | OPTION+< (⌥<)         | ALT+<                          |
|           | Object Paths                        |                       |                                |
|           | Verify TheSkyX Time                 |                       |                                |
|           | Open FITS                           | SHIFT+COMMAND+O (⇧⌘O) | CONTROL+SHIFT+O (CTRL+SHIFT+O) |
|           | Digitized Sky Survey                |                       |                                |
|           | Preferences (Windows Only)          |                       | CONTROL+, (CTRL+,)             |
| Telescope |                                     |                       |                                |
|           | Telescope Setup                     |                       |                                |
|           | Connect                             |                       |                                |
|           | TPoint Add On                       |                       |                                |
|           | Telescope Limits                    |                       |                                |
|           | Digital Setting Circles             |                       |                                |
| Help      |                                     |                       |                                |

| Menu               | Command or Pop-Up Menu       | Keyboard Accelerator   |                            |
|--------------------|------------------------------|------------------------|----------------------------|
|                    |                              | Mac                    | Windows                    |
|                    | Search (Mac only)            |                        |                            |
|                    | TheSkyX Help                 |                        |                            |
|                    | TheSkyX User Guide           |                        |                            |
|                    | About TheSkyX (Windows only) |                        |                            |
| FITS Viewer Window |                              |                        |                            |
|                    | Photo Pop-Up                 |                        |                            |
|                    | Open                         |                        |                            |
|                    | Save                         |                        |                            |
|                    | Save As                      |                        |                            |
|                    | Print                        |                        |                            |
|                    | File Information             |                        |                            |
|                    | Zoom In                      | COMMAND+= (⌘=)         | CONTROL+= (CTRL+=)         |
|                    | Zoom Out                     | COMMAND+- (⌘-)         | CONTROL+- (CTRL+-)         |
|                    | Zoom Normal                  |                        |                            |
|                    | Actual Pixels                | OPTION+COMMAND+0 (⇧⌘0) | CONTROL+ALT+0 (CTRL+ALT+0) |
|                    | Clear                        |                        |                            |
|                    | To Image Link                |                        |                            |
|                    | Close                        |                        |                            |

### Mac Keyboard Key Accelerator Symbols

| Symbol | Equivalent Keyboard Key |
|--------|-------------------------|
| ⌘      | Command key             |
| ⇧      | Option/Alt key          |
| ⇧      | Shift key               |
| ⇩      | Page down               |
| ⇧      | Page up                 |
| ↶      | Home                    |
| ↷      | End                     |

## Appendix J: Object Properties

*TheSkyX* includes a myriad of standard astronomical catalogs with a wide-range of information on each object. It provides the ability to create observing lists using open-ended database queries, as well as customize the information displayed for each object.

The table below lists the breakdown of database parameters that can appear in observing list reports, on tool tips and on the Object Information Report.

| Object Property                          | Description   |
|--|---|
| <b>Active</b>                            | Specifies whether the <i>object type</i> (satellites and asteroids only) is visible on the Sky Chart.<br><br>0 = Not active<br>1 = Active |
| <b>Air Mass</b>                          | Estimate of air mass at the current position.   |
| <b>Alt Rate (arcsecs/sec)</b>            | Rate at which the object is moving, in altitude.  |
| <b>Altitude</b>                          | The angular distance from horizontal.   |
| <b>Altitude w/Refraction</b>             | The angular distance from horizontal, including refraction.   |
| <b>Angular Separation (Prior Object)</b> | The angular separation from the previous target object.   |
| <b>Apparent Angular Diameter</b>         | The apparent angular diameter of the object.  |
| <b>Apparent Magnitude</b>                | The object's apparent magnitude.  |
| <b>Astronomical Twilight End</b>         | The time of day when the sun is 18° below the horizon after sunset (evening).   |
| <b>Astronomical Twilight Start</b>       | The time of day when the sun is 18° below the horizon before sunrise (morning).   |
| <b>Axis Position Angle</b>               | The position angle, in degrees, of the extended object, measured counterclockwise from north.   |
| <b>Az Rate (arcsecs/sec)</b>             | The rate, in arcseconds per second, at which the current target is moving.  |
| <b>Az Rise</b>                           | The azimuth of the target object when it rises.   |
| <b>Az Set</b>                            | The azimuth of the target object when it sets.  |
| <b>Azimuth</b>                           | The azimuth of the target object.   |
| <b>Catalog</b>                           | The name of the astronomical catalog that is used to display information about the target object.   |

| <b>Object Property</b>                      | <b>Description</b>   |
|---|--|
| <b><i>Catalog Identifier</i></b>            | The astronomical catalog's name or abbreviation that can be used by the Find command to locate objects. For example, M is the designation for objects from the Messier catalog. Enter M1 in the Find text box locates Messier object number 1. |
| <b><i>Catalog Number</i></b>                | A number or set of characters that uniquely identifies the target object in an astronomical database. For example, M42 is the forty second object in the Messier catalog.  |
| <b><i>Celestial Type</i></b>                | Displays the celestial object's type, for example, planet, satellite, galaxy, spiral cluster, double star, etc.  |
| <b><i>Civil Twilight End</i></b>            | The time of day when the sun is 6° below the horizon after sunset.   |
| <b><i>Civil Twilight Start</i></b>          | The time of day when the sun is 6° below the horizon before sunrise.   |
| <b><i>Click Distance</i></b>                | The number of screen pixels between successive mouse clicks.   |
| <b><i>Comet Eccentricity</i></b>            | The measure of an ellipse's distortion from a circle. This defines the shape of the comet's orbit.   |
| <b><i>Comet Ecliptic</i></b>                | The standard year (1950 or 2000) to which the orbital elements refer.  |
| <b><i>Comet Inclination</i></b>             | The tilt of the comet's orbital plane relative to the plane of the ecliptic.   |
| <b><i>Comet Long. of the Asc. Node</i></b>  | The angle, as viewed from the Sun, between the comet and the first point of Aries, when the comet passes through the plane of the ecliptic from below.   |
| <b><i>Comet Longitude of Perihelion</i></b> | The comet's longitude at the perihelion point.   |
| <b><i>Comet Magnitude 1</i></b>             | The brightness of the comet as seen by a viewer at a standard distance.  |
| <b><i>Comet Magnitude 2</i></b>             | A value which represents the change in the comet's brightness during its orbit.  |
| <b><i>Comet Perihelion Day</i></b>          | The day at which the object is closest to the Sun. This date should be in Universal Time (UT).   |
| <b><i>Comet Perihelion Distance</i></b>     | The distance, in astronomical units, of the comet's closest approach to the Sun.   |

| <b>Object Property</b>                | <b>Description</b>   |
|---------------------------------------|--|
|                                       |  |
| <b><i>Comet Perihelion Month</i></b>  | The month at which the object is closest to the Sun. This date should be in Universal Time (UT). |
| <b><i>Comet Perihelion Year</i></b>   | The year at which the object is closest to the Sun. This date should be in Universal Time (UT).  |
| <b><i>Constellation</i></b>           | The name of the constellation in which the target object resides.                                |
| <b><i>Constellation (Abbrev.)</i></b> | The abbreviation of the constellation in which the target object resides.                        |
| <b><i>Constellation Number</i></b>    | The constellation number (11-88) in which the target object resides.                             |
| <b><i>Date</i></b>                    | The current date.  |
| <b><i>DB Field 1</i></b>              | The contents of the custom Sky Database field number 1.  |
| <b><i>DB Field 10</i></b>             | The contents of the custom Sky Database field number 10.   |
| <b><i>DB Field 11</i></b>             | The contents of the custom Sky Database field number 11.   |
| <b><i>DB Field 12</i></b>             | The contents of the custom Sky Database field number 12.   |
| <b><i>DB Field 13</i></b>             | The contents of the custom Sky Database field number 13.   |
| <b><i>DB Field 14</i></b>             | The contents of the custom Sky Database field number 14.   |
| <b><i>DB Field 15</i></b>             | The contents of the custom Sky Database field number 15.   |
| <b><i>DB Field 16</i></b>             | The contents of the custom Sky Database field number 16.   |
| <b><i>DB Field 2</i></b>              | The contents of the custom Sky Database field number 2.  |
| <b><i>DB Field 3</i></b>              | The contents of the custom Sky Database field number 3.  |
| <b><i>DB Field 4</i></b>              | The contents of the custom Sky Database field number 4.  |
| <b><i>DB Field 5</i></b>              | The contents of the custom Sky Database field number 5.  |

| <b>Object Property</b>                 | <b>Description</b>  |
|--|---|
| <b><i>DB Field 6</i></b>               | The contents of the custom Sky Database field number 6.                               |
| <b><i>DB Field 7</i></b>               | The contents of the custom Sky Database field number 7.                               |
| <b><i>DB Field 8</i></b>               | The contents of the custom Sky Database field number 8.                               |
| <b><i>DB Field 9</i></b>               | The contents of the custom Sky Database field number 9.                               |
| <b><i>Dec (2000.0)</i></b>             | The target object's declination at equinox 2000.0.                                    |
| <b><i>Dec (Topocentric)</i></b>        | The target object's topocentric declination.  |
| <b><i>Dec Rate (arcsecs/sec)</i></b>   | The arcseconds per seconds rate of motion in declination for the target object.       |
| <b><i>Declination of Earth</i></b>     | The current declination of Earth.   |
| <b><i>Declination of Sun</i></b>       | The current declination of the Sun.   |
| <b><i>Defect of Illumination</i></b>   | A measure of the widest non-illuminated portion of a celestial object, in arcseconds. |
| <b><i>Depth of Eclipse</i></b>         |   |
| <b><i>Earth Altitude</i></b>           |   |
| <b><i>Earth Distance (au)</i></b>      | Target object's distance from Earth, in astronomical units.                           |
| <b><i>Eccentricity</i></b>             | A measure of an orbit's distortion from circular.                                     |
| <b><i>Ecliptic</i></b>                 | Asteroid's ecliptic epoch.  |
| <b><i>Epoch Day</i></b>                | Day of the epoch (asteroid).  |
| <b><i>Epoch Month</i></b>              | Month of the epoch (asteroid).  |
| <b><i>Epoch Year</i></b>               | Year of the epoch (asteroid).   |
| <b><i>Flamsteed-Bayer</i></b>          | Target object's Flamsteed and Bayer designation (when available).                     |
| <b><i>Frame Size (arcmins)</i></b>     | Minimum angular size, in arcminutes, of the field of view that can frame the object.  |
| <b><i>Geocentric Latitude</i></b>      | Target object's Earth-centered latitude.  |
| <b><i>Geocentric Longitude</i></b>     | Target object's Earth-centered longitude.   |
| <b><i>Geocentric Mean Latitude</i></b> | Target object's Earth-centered mean latitude.   |

| <b>Object Property</b>                               | <b>Description</b>  |
|--|---|
|  |   |
| <b><i>Geocentric Mean Longitude</i></b>              | Target object's Earth-centered mean longitude.  |
| <b><i>Geocentric Mean Radius</i></b>                 | Target object's Earth-centered mean radius.   |
| <b><i>Geocentric Radius</i></b>                      | Target object's Earth-centered radius.  |
| <b><i>GSC Block</i></b>                              | <p>Stars in the GSC are separated into 9537 blocks that represent a small region of the sky.</p> <p>This value is the target object's Guide Star Catalog block offset number.</p> |
| <b><i>GSC Num</i></b>                                | Target object's Guide Star Catalog identifier, for example, GSC 9520:526  |
| <b><i>Height</i></b>                                 | The height, in pixels, of the target object (photos only).  |
| <b><i>Heliocentric Latitude</i></b>                  | The target object's heliocentric latitude.  |
| <b><i>Heliocentric Radius</i></b>                    | The target object's radius when observed from the center of the Sun.  |
| <b><i>Hour Angle</i></b>                             | The target object's hour angle.   |
| <b><i>Inclination</i></b>                            | The target object's inclination.  |
| <b><i>Index</i></b>                                  | The target object's catalog index number.   |
| <b><i>Julian Date</i></b>                            | The current Julian date.  |
| <b><i>Latitude</i></b>                               | The target satellite's longitude.   |
| <b><i>Light Years</i></b>                            | The distance, in light years, of the target object from Earth.  |
| <b><i>Long. of the Ascending Node</i></b>            | The target asteroid's longitude of the ascending node parameter.  |
| <b><i>Longitude</i></b>                              | The target satellite's longitude.   |
| <b><i>Longitude of the Central Meridian</i></b>      | The longitude of the target object's central meridian.  |
| <b><i>Longitude of the Central Meridian (II)</i></b> | The longitude of the target object's central meridian (system II).  |
| <b><i>Longitude Perihelion</i></b>                   | The target asteroid's longitude of perihelion.  |
| <b><i>Mag. 1st Component</i></b>                     | The magnitude of the first component of a binary system.  |

| <b>Object Property</b>                | <b>Description</b>  |
|---------------------------------------|---|
| <b>Mag. 2nd Component</b>             | The magnitude of the second component of a binary system. |
| <b>Magnitude</b>                      | The target object's apparent magnitude.                   |
| <b>Magnitude 1</b>                    | The target asteroid's absolute magnitude (g).             |
| <b>Magnitude 2</b>                    | The target asteroid's magnitude constant (k).             |
| <b>Magnitude B</b>                    | The target object's apparent blue magnitude.              |
| <b>Magnitude R</b>                    | The target object's apparent red magnitude.               |
| <b>Magnitude V</b>                    | The target object's apparent violet magnitude.            |
| <b>Major Axis</b>                     | The target object's major axis, in arcseconds.            |
| <b>Maximum Mag.</b>                   | The target variable star's maximum magnitude.             |
| <b>Mean Anomaly</b>                   | The target asteroid's mean anomaly parameter.             |
| <b>Minimum Mag.</b>                   | The target variable star's minimum magnitude.             |
| <b>Minor Axis</b>                     | The target object's minor axis, in arcseconds.            |
| <b>Moon Alt w/Refraction</b>          | The Moon's altitude including refraction.                 |
| <b>Moon Angular Diameter</b>          | The Moon's angular diameter.                              |
| <b>Moon Distance (km)</b>             | The Moon's distance from Earth, in km.                    |
| <b>Moon Ecliptic Latitude</b>         | The Moon's ecliptic latitude.                             |
| <b>Moon Ecliptic Longitude</b>        | The Moon's ecliptic longitude.                            |
| <b>Moon Ecliptic Radius</b>           | The Moon's ecliptic radius.                               |
| <b>Moon Optical Libration b</b>       | The Moon's optical libration (b).                         |
| <b>Moon Optical Libration l</b>       | The Moon's optical libration (l).                         |
| <b>Moon Parallax</b>                  | The Moon's parallax.                                      |
| <b>Moon Phase Angle</b>               | The Moon's phase angle.                                   |
| <b>Moon Physical Libration b</b>      | The Moon's physical libration (b).                        |
| <b>Moon Physical Libration l</b>      | The Moon's physical libration (l).                        |
| <b>Moon Pos. Angle of Bright Limb</b> | The position angle of the Moon's bright limb.             |
| <b>Moon Position Angle</b>            | The Moon's position angle.                                |

| <b>Object Property</b>                       | <b>Description</b>  |
|--|---|
| <b><i>Moon Topocentric Ang. Diameter</i></b> | The Moon's topocentric angular diameter, in arcseconds.               |
| <b><i>Moon Total Libration b</i></b>         | The Moon's total libration (b).                                       |
| <b><i>Moon Total Libration l</i></b>         | The Moon's total libration (l).                                       |
| <b><i>Moon True Dec</i></b>                  | The Moon's true right declination.                                    |
| <b><i>Moon True RA</i></b>                   | The Moon's true right ascension.                                      |
| <b><i>Moon's Age (Days Past New)</i></b>     | The age of the Moon's phase, in days past the new Moon.               |
| <b><i>Name 10</i></b>                        | One of up to ten different aliases for the target object.             |
| <b><i>Name 2</i></b>                         | One of up to ten different aliases for the target object.             |
| <b><i>Name 3</i></b>                         | One of up to ten different aliases for the target object.             |
| <b><i>Name 4</i></b>                         | One of up to ten different aliases for the target object.             |
| <b><i>Name 5</i></b>                         | One of up to ten different aliases for the target object.             |
| <b><i>Name 6</i></b>                         | One of up to ten different aliases for the target object.             |
| <b><i>Name 7</i></b>                         | One of up to ten different aliases for the target object.             |
| <b><i>Name 8</i></b>                         | One of up to ten different aliases for the target object.             |
| <b><i>Name 9</i></b>                         | One of up to ten different aliases for the target object.             |
| <b><i>Nautical Twilight End</i></b>          | The time of day when the sun is 12° below the horizon after sunset.   |
| <b><i>Nautical Twilight Start</i></b>        | The time of day when the sun is 12° below the horizon before sunrise. |
| <b><i>NGC/IC</i></b>                         | This parameter is reserved for future use.                            |
| <b><i>Non-stellar Fields</i></b>             | This parameter is reserved for future use.                            |
| <b><i>Object Name</i></b>                    | The target object's common name.                                      |
| <b><i>Object Type</i></b>                    | The target o  |
| <b><i>Observing Notes</i></b>                | This parameter holds observing notes for the target object.           |
| <b><i>Parallax</i></b>                       |   |
| <b><i>Parsecs</i></b>                        | The distance to the target object, in parsecs.                        |
| <b><i>Penumbra Diameter</i></b>              | The diameter of the Earth's penumbra.                                 |

| <b>Object Property</b>               | <b>Description</b>  |
|--------------------------------------|---|
| <i>Period</i>                        | The target object's orbital period.   |
| <i>Phase (%)</i>                     | The current phase of the target object.                                       |
| <i>Phase Correction</i>              | The target object's phase correction.   |
| <i>Point 3D X</i>                    | The target object's x-axis position.  |
| <i>Point 3D Y</i>                    | The target object's y-axis position.  |
| <i>Point 3D Z</i>                    | The target object's z-axis position.  |
| <i>Polar Diameter</i>                | The target object's polar diameter.   |
| <i>Position Angle (Prior Object)</i> | The position angle measured between successive mouse clicks on the Sky Chart. |
| <i>Position Error Dec</i>            | The target object's position error in declination.                            |
| <i>Position Error Parallax</i>       | The target object's parallax error.   |
| <i>Position Error RA</i>             | The target object's position error in right ascension.                        |
| <i>Proper Motion Dec</i>             | The target object's proper motion in declination.                             |
| <i>Proper Motion Error Dec</i>       | The target object's proper motion error in declination.                       |
| <i>Proper Motion Error RA</i>        | The target object's proper motion error in right ascension.                   |
| <i>Proper Motion RA</i>              | The target object's proper motion in right ascension.                         |
| <i>RA (2000.0)</i>                   | The target object's equinox 2000.0 right ascension.                           |
| <i>RA (Topocentric)</i>              | The target object's topocentric right ascension.                              |
| <i>RA Rate (arcsecs/sec)</i>         | The target object's rate, in arcseconds per second, in right ascension.       |
| <i>Radius</i>                        | The target object's radius.   |
| <i>Range</i>                         | The target satellite's range, in meters.                                      |
| <i>Range Rate</i>                    | The target satellite's range rate.  |
| <i>Ring Axis (a)</i>                 | Saturn's A ring axis.   |
| <i>Ring Axis (b)</i>                 | Saturn's B ring axis.   |
| <i>Rise Time</i>                     | The target object's rise time.  |

| <b>Object Property</b>       | <b>Description</b>  |
|------------------------------|---|
| <b>Rise/Set Notes</b>        | Notes indicating whether or not Daylight Saving Time is in effect.          |
| <b>Satellite Eclipse</b>     | This value is set to true when the satellite is eclipsed by the Earth.      |
| <b>Satellite Extended</b>    | This value is set to true when the satellite is extended.                   |
| <b>Satellite Julian Date</b> | The Julian Date used to compute the satellite's position.                   |
| <b>Satellite Name</b>        | The name of the satellite.  |
| <b>Satellite TLE1</b>        | The satellite's two line element parameter (line 1).                        |
| <b>Satellite TLE2</b>        | The satellite's two line element parameter (line 2).                        |
| <b>Satellite Visible</b>     | This value is true when the satellite is visible from the current location. |
| <b>Scale</b>                 | Photo's image scale, in arcseconds per pixel.                               |
| <b>Screen X</b>              | The x position of the mouse click, in screen coordinates.                   |
| <b>Screen Y</b>              | The y position of the mouse click, in screen coordinates.                   |
| <b>Semi-Major Axis</b>       | The target object's semi-major axis.  |
| <b>Set Time</b>              | The time at which the target object sets (below the horizon).               |
| <b>Sidereal Time</b>         | The current sidereal time.  |
| <b>Skip Index</b>            | The zero-based index for the object in the object path.                     |
| <b>Source Catalog</b>        | The source catalog used to display information about the target object.     |
| <b>Spectral</b>              | The target object's spectral class.   |
| <b>Spectral Type</b>         | The target object's spectral type.  |
| <b>Star Identifier</b>       | The target star's catalog identifier.                                       |
| <b>Sun Distance (au)</b>     | The target object's distance from the Sun, in astronomical units.           |
| <b>Sun Position Angle</b>    | The Sun's position angle.   |
| <b>Text Record</b>           | Text-based information about the target object.                             |
| <b>Text Record Start</b>     | The starting position of the text record.                                   |
| <b>Time</b>                  | The current time.   |

| <b>Object Property</b>         | <b>Description</b>  |
|--------------------------------|---|
| <b><i>Transit Time</i></b>     | The time at which the target object transits.             |
| <b><i>True Dec</i></b>         | The target object's true declination.                     |
| <b><i>True RA</i></b>          | The target object's true right ascension.                 |
| <b><i>Type of Variable</i></b> | The variable star's classification.                       |
| <b><i>Umbra Diameter</i></b>   | The diameter of the Earth's umbra.                        |
| <b><i>Width</i></b>            | The width, in pixels, of the target object (photos only). |

## Appendix K: User Guide Revision History

| Revision Number | Publish Date    | Changes   |
|-----------------|-----------------|---|
| 6.0             | May, 2018       | <ul style="list-style-type: none"> <li>Updated dome screen capture and documented the dome slit preferences.</li> <li>Updated the Database Add On documentation.</li> <li>Added SBIG macOS disclaimer information.</li> <li>Added missing description for the the SBIG AO relay bump size setting.</li> </ul> |
| 5.9             | November, 2017  | <ul style="list-style-type: none"> <li>Clarify the Default Calibration option on the Take Series tab of the Camera window.</li> <li>Corrected miscellaneous typographical errors.</li> </ul>  |
| 5.8             | October, 2017   | <ul style="list-style-type: none"> <li>Corrected misspelled word.</li> </ul>  |
| 5.7             | September, 2017 | <ul style="list-style-type: none"> <li>Clarified the uses of the Subframe tool.</li> <li>Updated the description of the Cursor Information tool.</li> <li>Added documentation about how to take AutoDarkS using a camera without a mechanical shutter.</li> </ul>   |
| 5.6             | May, 2017       | <ul style="list-style-type: none"> <li>Added @Focus parameter documentation.</li> </ul>   |
| 5.5             | April, 2017     | <ul style="list-style-type: none"> <li>Added references to newly developed X2 Plug Ins.</li> <li>Corrected links to download Dome Add On X2 Plugs.</li> </ul>   |
| 5.4             | March, 2017     | <ul style="list-style-type: none"> <li>Revised the description of the stars' motion in the eyepiece using the drift method to polar alignment a telescope mount.</li> <li>Clarified how the Camera Parameters are used.</li> <li>Corrected the location of the Closed Loop Slew Setup.</li> </ul>             |
| 5.3             | December, 2016  | <ul style="list-style-type: none"> <li>Added missing checkmarks in table of supported focusers.</li> </ul>  |
| 5.2             | December 2016   | <ul style="list-style-type: none"> <li>Added missing camera-specific preference settings.</li> </ul>  |
| 5.1             | November 2016   | <ul style="list-style-type: none"> <li>Updated list of supported cameras and domes.</li> <li>Corrected rotator reference text.</li> </ul>   |
| 5.0             | August 2016     | <ul style="list-style-type: none"> <li>Text and graphics updated for version 10.5.</li> </ul>   |

| <b>Revision Number</b> | <b>Publish Date</b> | <b>Changes</b>   |
|------------------------|---------------------|--|
| 4.2                    | January 2016        | <ul style="list-style-type: none"> <li>• Removed Windows XP installation instructions.</li> <li>• Added Windows 10 to installation instructions.</li> <li>• Miscellaneous OS-specific changes.</li> <li>• Clarified TPoint's pressure requirement.</li> </ul>  |
| 4.1                    | November 2015       | <ul style="list-style-type: none"> <li>• Corrected a misplaced arrow on the dome geometry diagram.</li> <li>• Refined dome geometry diagrams.</li> <li>• Updated dome geometry notes.</li> <li>• Corrected three missing bookmark references.</li> </ul>   |
| 4.0                    | August 2015         | <ul style="list-style-type: none"> <li>• Added notes about the NOMAD catalog.</li> <li>• Removed dated Canon plug in documentation.</li> </ul>   |
| 3.9                    | April 2015          | <ul style="list-style-type: none"> <li>• Clarified the explanation of the time zone setting on the Locations window.</li> <li>• Added Moonlite/FTDI USB Driver troubleshooting on Mac OS X.</li> <li>• Removed incorrect TOC entry.</li> <li>• Added additional Image Link troubleshooting tips and examples.</li> </ul> |
| 3.8                    | April 2015          | <ul style="list-style-type: none"> <li>• The Camera Add On controls SBIG AO with STT model cameras. Removed documentation stating otherwise.</li> </ul>  |
| 3.7                    | March 2015          | <ul style="list-style-type: none"> <li>• Corrected cross references.</li> <li>• Formatted photos for HTML and App-based help.</li> <li>• Update FOVI Options documentation.</li> </ul>   |
| 3.6                    | March 2015          | <ul style="list-style-type: none"> <li>• Added instructions for using the MicroTouch focuser (Windows).</li> <li>• Updated dome geometry graphics and documentation.</li> </ul>  |
| 3.5                    | December 2014       | <ul style="list-style-type: none"> <li>• Documentation changes related to TheSkyX version 10.3.0.</li> </ul>   |
| 2.9                    | February 2013       | <ul style="list-style-type: none"> <li>• Updated Dome Add On documentation.</li> <li>• Updated Take Series documentation.</li> </ul>   |
| 2.7                    | November 2013       | <ul style="list-style-type: none"> <li>• Clarified Closed Loop Slew documentation.</li> </ul>  |

| Revision Number | Publish Date | Changes  |
|-----------------|--------------|--|
| 2.6             |              | <ul style="list-style-type: none"> <li>Added Closed Loop Slew documentation.</li> </ul>  |
| 2.4             |              | <ul style="list-style-type: none"> <li>Description of the X2 Plug In driver model.</li> <li>SSAG release notes.</li> <li>Corrected object reference in Figure 24.</li> <li>Miscellaneous changes and corrections</li> </ul>  |
| 2.0             |              | <ul style="list-style-type: none"> <li>Documentation changes related to version 10.2.0. (Note that the file name of this document has been abbreviated from <i>TheSkyX Professional and Serious Astronomer Edition User Guide.pdf</i> to <i>TheSkyX Pro User Guide.pdf</i> in order to accommodate the 27-character maximum length of file names on hybrid media; it still contains documentation for both Editions).</li> </ul> |
| 1.7             |              | <ul style="list-style-type: none"> <li>Camera Add On documentation including Autoguiding, AO Autoguiding, Image Reduction and Histogram.</li> <li>Changes and updates related to TheSkyX version 10.2.0.</li> </ul>  |
| 1.4.8           |              | <ul style="list-style-type: none"> <li>Updated Application Support Files documentation.</li> </ul>   |
| 1.4.6           |              | <ul style="list-style-type: none"> <li>PDF document includes table of bookmarks for Adobe Reader.</li> <li>Updated location input documentation.</li> <li>Update NexStar telescope minimum requirements.</li> </ul>  |
| 1.4.5           |              | <ul style="list-style-type: none"> <li>Clarified telescope synchronization.</li> </ul>   |
| 1.4.4           |              | <ul style="list-style-type: none"> <li>Clarify photo size limitations to All Sky Image Link.</li> </ul>  |
| 1.4.3           |              | <ul style="list-style-type: none"> <li>Added documentation for the Camera Add On's Canon Plug In (Mac).</li> <li>Added documentation for the FOVI window's <b>Update Equipment Databases From Web</b> button.</li> </ul>   |
| 1.4.1           |              | <ul style="list-style-type: none"> <li>Describe all Application Support files and folders.</li> <li>Added step by step procedure for importing TheSky6 horizon lines into TheSkyX.</li> </ul>  |
| 1.4.0           |              | <ul style="list-style-type: none"> <li>Updated documentation for iOptron telescopes.</li> </ul>  |

| Revision Number | Publish Date | Changes  |
|-----------------|--------------|--|
| 1.3.7           |              | <ul style="list-style-type: none"><li>• Dome Add On completely replaces AutomaDome for Windows, making AutomaDome for Windows setup instructions unnecessary.</li></ul> |

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