ASTRONOMY 221 LABORATORY: OBSERVING THE NIGHT SKY

First Laboratory: Introduction to Telescopes and Astronomical Observations

Objectives –

The aim of this first laboratory is to give you a variety of experiences in using telescopes and observing different types of astronomical objects – as well as exploring around the "dark night sky" (albeit its not too dark on campus…!) becoming familiar with bright stars and constellations. Most of the observing will be done on campus at our observatory in the North Annex parking lot, but you are encouraged to do some observing outside Houston if you have the opportunity to travel a bit on weekends or holidays. Some extra credit is available for such efforts.

The laboratory is divided into six parts that can be done in any order you wish. At times some parts cannot be done (e.g., no moon up, hazy or cloudy skies preventing deep sky observing, etc.) so keeping abreast of the weather and lunar phase and observing opportunities indicated by the lab web site (http://www.ruf.rice.edu/~rjd/astr221.html) is important for success. You will have until mid- to late-October to complete this lab. Most of the report can consist of just filling out the lab writeup and adding any additional notes or information on the back of the sheets or inserted pages. You do not need to type up all of this stuff!

It is important to prepare for the observing by (a) reviewing the lab writeup and relevant information given in the lectures, (b) coming prepared with a small (hopefully red) flashlight and hard back notebook or similar thing to write your notes on the lab sheets, and (c) wearing long pants and shirts so the mosquitoes won't suck your blood dry! Most importantly, SHOW UP WHEN THE WEATHER IS GOOD ON YOUR ASSIGNED NIGHTS.

Lab Parts and Tasks

The Six Parts of the Lab are as follows: I—The Evening Sky, II—Lunar Observing, III—Planetary Observing, IV—Double Stars and Seeing, V—Deep Sky Observing, VI—Hands-on Using a Telescope, and an extra-credit (optional) Part VII—Dark-sky Observing. Parts I--VI constitute the tasks that make up the first lab and while desirable, you may not be able to accomplish all of these in detail before the due date. My suggestion is to do a good job taking your time with the observing and write detailed notes on each item you do observe or calculate, rather than worry about getting everything done quickly and superficially.

In addition to the tasks and questions, at the end are attached various charts for the different parts of the lab. Both the write up and charts are available at the lab website also.

PART I – THE EVENING SKY (15 points) Name: ___________________________

In the appendix the evening sky maps for September and October 2009 are given, which are to be used in this part. (note: your grade here does not depend on the relative numbers of y's compared to n's!) BUT, you must do all the parts below the same night and time and mid-September or mid-October are the best (moonless) times.

A. Pick a night when the sky conditions are good (clear with little haze or moonlight) and go to the campus observatory area with good surrounding horizon visibility and the moon is absent or not bright (like crescent phase). Turn off the parking lot lights (turn switch clockwise 90 degress and get binoculars available in the hatchbox…combination = 1812). Answer as many of these as possible:

   Date: ___________ Time: __________ Location: _______________________

B. Can you see ("y" or "no"): Vega____? Altair____? Deneb____? Arcturus____? Antares____? Fomalhaut_____? Polaris____? The Summer Triangle____? The "Teapot"____? The Great Square of Pegasus____? The Northern Cross (Cygnus)____? The Little Dipper____? Jupiter____?

C. Locate Polaris and using your hand/fingers, estimate the altitude of Polaris above the horizon: _______________degrees. (this should be close to your latitude)

D. Among the stars above that you see, which is the (a) brightest__________? (b) faintest__________? (c) bluest__________? (d) reddest__________? (e) lowest__________? (f) highest__________? twinkles most __________? (g) nearest the zenith__________? (h) closest to setting__________?

E. Estimate/count the total number of stars you can see in the sky: _________?

F. Using binoculars, can you see (a) the (small) constellation of Lyra around Vega____? (b) the satellites of Jupiter____(how many…____)? (c) the "pigmy constellation" of Delphinus____? (d) resolve Alberio into two stars____?

G. Is the moon out____? If yes, what phase is it_________? Guess how many days since new moon_______? Can you see craters in the binoculars______?

H. Can you discern the constellation of Cassiopeia_____? (looks like a "W" to the east of Polaris). If so, use the binoculars to see the Double Cluster in Perseus (see starmap for location relative to the "W"). How many stars can you see in the field of view__________?

I. How many mosquito bites did you experience doing this lab part_______?!

PART II: LUNAR OBSERVING (15 points)   Name:___________________________

Here you will observe the moon near first quarter through one or more telescopes with different magnifications and draw (as best you can…!) one of the craters or regions near the terminator. In doing the drawing, it is suggested you use "eyepiece projection" (projecting the field of view of an eyepiece onto a sheet of paper and tracing the surface feature). In the appendix are lunar maps. Use them to identify the crater, feature, or region you wish to draw, then center it in the eyepiece, and draw it in the circle below. Make sure you focus the telescope carefully for your own eyes. Remember, the magnification with any eyepiece is the focal length of the telescope divided by the focal length of the eyepiece (usually both are given in millimeters), so calculate this before doing the drawings (you want about 200-300 magnification for best results).

Give the following information:

Date:_________________ Time:__________ Sky Conditions:______________________

Telescope_____________ Eyepiece focal length/magnification:_____________________

Name of feature or region drawn (from the attached lunar map):

____.

PART III (20 points) PLANETARY OBSERVING Name: ____________________

This September we are fortunate that Jupiter is well situated in the evening sky and near it is Neptune and Pluto is near the meridian. Finally Uranus rises around sunset and is available for observing beginning about 10pm. Remember to focus the telescope!

<u>A. Jupiter</u> – Observe Jupiter with the 16inch telescope at low and medium magnification. At low magnification (31mm eyepiece = ~130 magnification) pay attention to the location of the four Galilean satellites and draw them below. At medium magnification (12mm eyepiece = ~340 magnification) pay attention to the surface features like belts and spots, along with nearby satellites and maybe even an eclipse spot if you are lucky. Draw what you see below:

Low magnification High magnification

List the date and time of your observations: ______________________________

Identify the Galilean satellites (Io, Europa, Ganymede, & Callisto) seen on your low magnification drawing (do this when you get back to your room or later by accessing:

http://www.skyandtelescope.com/observing/objects/planets/3307071.html

Also, note any colors for the belts and spots seen on your high magnification view.

<u>B. Neptune</u> – Observe Neptune with the 16inch at medium (340X) magnification. Can you resolve the disk_____? How would you characterize its color_________________?

<u>C. Uranus</u> – Observe Uranus with the 16inch at medium magnification. In the circle below, draw (roughly to the scale of the eyepiece field-of-view) the size of the disk noting its color and any surface features as well as any of its satellites visible (up to five can be seen at times).

As with Jupiter, you can identify them using the javascript routine at:

http://www.skyandtelescope.com/observing/objects/planets/3310476.html#

<u>D. Pluto</u> – Have the telescope operator try to find Pluto and, if successful, note on the back of this sheet if you see any color to it and can tell it to be a planet rather than just another star in the field-of-view (use medium or high magnification).

PART IV: DOUBLE STARS AND SEEING (15 points) Name: ___________________

In this part you will observe two double stars, Alberio and Epsilon Lyrae, and a bright star at high magnification to study the effects of the atmosphere on images (seeing), telescope resolving power (diffraction rings), and comparative stellar colors. Make sure you focus the telescope to your own eyes in each of the tasks.

A. Alberio – Alberio (Beta Cygni in the tail of Cygnus the Swan or Northern Cross) is a 2nd magnitude star that is a double (actually a triple!) that is among the prettiest in the sky due to the color difference between the two stars. It consists of a 3.2 magnitude K3III (giant) star (Alberio A) and a 5.8 mag B0V (main sequence dwarf) star (Alberio B) separated by 35 arc seconds. Its distance is 120 parsecs and the period of revolution of the two stars is about 214 years. Observe Alberio with the 12mm eyepiece (340X) through the 16inch telescope and answer the following:
(a) What is the distance of Alberio in light years____________? (1parsec = 3.26ly)
(b) Characterize the colors of the two stars – A:______________ B:______________.
(c) Which star (A or B) is hotter________ ? (d) larger___________? (e) Estimate the field-of-view of the eyepiece in arcseconds by comparing the FOV circle diameter to the separation of the two stars (35 arc seconds)_____________? What is this FOV in arc minutes______________?

B. Epsilon Lyrae – Epsilon Lyrae is the famous "double-double" star consisting of four stars orbiting in pairs around each other and each pair orbiting the other pair! Its distance is 162 light years and it is located in the constellation of Lyra the harp near Vega. One pair (ε^1) consists of two 4.7 and 6.2 magnitude stars separated by 2.6 arc seconds (1200 year period) and the other pair (ε^2) consists of two 5.1 and 5.5 magnitude stars separated by 2.3 arc seconds (585 year period). The two pairs are separated by 208 arc seconds and revolve around a barycenter with a period of several hundred thousands of years.
(a) Can you separate the two pairs in the 16inch finders____________?
(b) With the low magnification (31mm eyepiece = 130X) identify e1 and e1 and noting that there separation is 208 arc seconds, estimate the FOV of the 31mm eyepiece in arc seconds_____________? …in arc minutes______________? With that eyepiece can you just tell that the "two" stars are each double (elongated images)________?
(c) Center the ε^2 pair in a high magnification eyepiece (12mm + 2X Barlow lens = 480X) and estimate the apparent diameter of each star's image compared to their separation (2.3 arc sec). This is the "seeing disk" of a star…your estimate: __________arc seconds.

C. Super High Magnification and Seeing – To illustrate that magnifications of ground-based telescopes beyond ~500X is usually useless for seeing things better, observe a bright star (Altair or Arcturus) far from the zenith with the 5mm (= 813X) eyepiece and describe its shape, colors, and variations on the back of this page. Also note if you can see the telescope diffraction rings in the image (rather stationary circular black rings in the image looking like an archery target in the moving-shaking-vibrating star image). Again, focusing the eyepiece carefully to your eyes is important here.

PART V: DEEP SKY OBJECTS (15 points) Name:_________________________

In this part you will "stretch" you observing skills to observe four types of "deep sky" objects with the 16inch telescope. This is a bit difficult due to the Houston lights and requires rather clear and moonless skies (and low humidity) for good results. Nonetheless, we must try… All of the observations will be done with the low (31mm = 130X and/or medium (12mm = 340X) eyepieces.

Date of Observations: _________________. Sky Conditions: _____________________.

A. Globular Star Cluster – Messier 13, or M22, or M15 – Globular star clusters consist of roughly 100,000 stars that formed early in the history of our galaxy (~11 billion years ago) and are located in the halo (typically tens of thousands of light years away). The telescope operator will pick one to observe (depends on sky conditions) and you will observe it through the 31mm and 12mm eyepieces. Fill out the following:
(a) Which eyepiece gives you the best view___________________?
(b) Can you resolve the cluster into stars, what eyepiece________________?
(c) Later use a search engine (or The Sky software) with your computer and search "Messier xx" and list: (i) coordinates of the cluster: (RA=) and (Dec =) and the constellation it is located in _____________; (ii) distance of the cluster in light years ____________; and size in light years _______________.

B. Open or Galactic Star Cluster – Observe Messier 11 or the Double Cluster in Perseus with the 16inch finders and low magnification eyepieces. Answer the following:
(i) Can you see the "entire" cluster better in the finder than in the 31mm eyepiece _________? (ii) How many stars can you see in the 31mm eyepiece (approximately) _________? (iii) Can you see any colors to the brighter stars in the cluster (y, n, and what colors – ask the TO about this!) ____?
(iv) Later find information on the cluster you observed using a search engine or The Sky program and fill in the following: What is the constellation it is located in ___________; (ii) distance of the cluster in light years _________; and (iii) size in light years________.

C. Planetary Nebula – Planetary nebulae are the gas shells of dying stars that were once like the sun (but are much older, ~10 billion years old). Observe the Ring Nebula (Messier 57) or the Dumbbell Nebula (Messier 27) with the 16inch at low or medium magnification and answer the following:
(i) Which magnification give better view_____________? (ii) Can you see the nebula better looking directly at it or away from it___________________? (iii) Can you discern a shape to it (describe)_________________? Now have the TO attach a "nebular filter" to the eyepiece and look at the nebula again. (iv) Does the nebula look better through the filter____________? (v) If so, explain why _____________________________________. Using a search engine, what is its distance___________ and size_____________ (in ly)?

D. Galaxies – Galaxies are always a disappointment through telescopes because they are blurry and of low surface brightness. Observe the brightest galaxy in the sky – the Andromeda Galaxy, Messier 31, and describe what it looks like on the back of this sheet.

PART VI: USING A TELESCOPE (20 points) Name: _______________________

In this last part of the first lab you will get to actually set up and use one of our "old style" (i.e., non-computerized) telescopes, the 11inch Celestron (C11 – the big black one) or the 8inch Celestron (C8 – the orange one). Both telescopes are stored on tripods inside the campus observatory dome and are taken out during the 16inch observing sessions. Have the labbie or Dr. Dufour help you get oriented to how to set up and move the telescope you pick to use here. On the next page are questions to answer following the instructions and tasks below.

<u>A. Setting Up</u> – Both telescopes have German equatorial mounts with an electric motor "clock drive" to track stars. BUT, the polar (horizontal) axis of the mount has to be pointed towards Polaris and the electrical system plugged in. Basically, the altitude of the polar axis is already approximately set so you just need to adjust the azimuth of the axis (swinging the tube to the side of the mount and pointing it towards Polaris by rotating the tripod). Don't power it up yet, for you need to check the finder center. To do that, put in a long focal length eyepiece (say, ~30-40mm focal length) and center some light atop a medical center building in the eyepiece and check where it is in the finder (hopefully close to center of the crosshairs). If it is far from the center, have the labbie show you how to adjust it. Now plug in the power to the clock drive and put your ear to the motor to see if its on (or lights turn on). Answer question "A" on the next page.

<u>B. Optics</u> – These telescopes are called Schmidt-Cassegrains with a concave primary mirror in the back and a smaller convex mirror on the front attached to a glass "corrector" plate. Check out the optical path on the telescope visually looking down the tube and its description the handout given in class and answer question "B" on the next page.

<u>C. Pointing the Telescope and Focusing</u> – Pick a bright star in the south, I suggest Altair. Unlock the mount clutches and move the telescope along its two axes being careful not to move the tripod towards Altair and center it in the finder. Then look through the eyepiece and focus the star to a "point" through the eyepiece. Answer question "C" on the next page.

<u>D. Comparing Eyepieces</u> – Now you will learn a bit about eyepieces, magnification, and "FOV" (field of view). Remember that the magnification (power) of a telescope is variable, and depends on the focal length of the main objective (usually written in mm in the front ring) divided by the focal length of the eyepiece (written in mm on the side). Pick three eyepieces of focal lengths ~40, 20, and 10mm and focus Altair in each.

<u>E. Field of View</u> – Now with the 20mm eyepiece, move Altair to the center, then to the east (usually left) edge of the eyepiece and measure the time it takes the star to cross the eyepiece field in seconds of time with the power turned off. Given that stars near the celestial equator move at a rate of 15 arc seconds per time second, answer question "E."

<u>F. Observe Something!</u> – Pick something interesting in the sky to observe and center it in telescope and tell me about it by answering question "F."

PART VI QUESTIONS -- Answer the questions below in as much detail as you can using extra pages, if necessary (or back of the lab sheets). Be neat please!

Date & time of observations ______________. Sky conditions ___________________.

A: Describe any difficulties you had setting up the telescope.

B: Draw a diagram of the telescope's optical components and light path in the box to the right.

C: In the two circles below, draw the structure of Altair's image when it is in focus and when it is out of focus (by about ½ turn of the focus knob).

D: Calculate the magnification of the three eyepieces you used:

(1) Eyepiece 1: _____ mm = ______ magnification
(2) Eyepiece 2: _____ mm = ______ magnification
(3) Eyepiece 3: _____ mm = ______ magnification
(4) Which eyepiece was hardest to focus ___________?
(5) Why? ____?

E: (1)Time it took in seconds for star to cross the field of view (FOV):______________.
(2) Estimated FOV in arc seconds: ______________. In degrees ________________.
(3) Would the moon (1/2 degree in size) fit inside the FOV (y or n) _______?

F: Describe your observations of the object you picked.

(a) Name of object and reason picked:

(b) Any problems finding it? If yes, describe:

(c) What eyepiece & magnification gave the best view?

(d) Rate your proficiency now in using a telescope (circle one):
Expert Good Fair Poor Hopeless

PART VII: OPTIONAL DARK-SKY OBSERVING (up to 5pts extra credit)

<u>This optional "extra-credit" part requires driving outside the Houston</u> (or any other city) "light dome" such that you can see at least 5th magnitude stars in part of the sky. It also requires a moonless sky (or at least no brighter than a crescent moon). It can be done on the George Observatory field trip on a Sunday night, or you can go to Brazos Bend State Park on another night on your own (but they lock the gate at 10pm, beware!). October 7-21st is the suggested time period to do this (moon gets too bright afterwards).

<u>It is essential to take the binoculars in the observatory hatchbox</u> with you and for safety you should go with others. Make sure you have a flashlight and mosquito repellant too!

Once you become dark adapted , do the following observations. You should not start until at least an hour after sunset. On a separate page or notebook, record the following and turn it in separate from the first lab writeup, if practical.

A. Write down the date, time period, location, and sky conditions when you did this.

B. Estimate the limiting magnitude using the star chart attached to the end of this lab.

C. Using the star chart(s) given in class and attached to the first lab list the constellations that you can see five or more stars of.

D. Can you see the Milky Way? How well? Can you see the star clouds apart from the dark clouds and dust lanes?

E. Using the binoculars, try to locate some of the Messier objects above Sagittarius, the "teapot" on your star chart and list any you think you see. This is towards the center of the Milky Way Galaxy, FYI, and is the area called "Baade's Window" and the Great Sagittarius Star Cloud (can you see it?).

F. Again with the binoculars, try to find (and write down their description): (a) Jupiter and its satellites; (b) star clusters, such as M11, M13, and the Double Cluster in Perseus; (c) double stars like Alberio and Epsilon Lyrae; (d) galaxies like M31 (Andromeda) and M33 (Triangulum spiral…hard!); and a "big" planetary nebula like M27 (the Dumbell) in Cygnus (hard…need to keep the binoculars real steady!).

<u>Your report:</u> While you can type it up, decently readable notes taken during the trip will do as long as they address each of the items above. Make sure you put your name on the report and turn it into Dr. Dufour no later than the due date for lab 1. It can be turned in separately from the six parts of the Lab 1 write up.