ASTR 1001.2 Stars and Galaxies

Potential Observing Exercises.

1. The Stonehenge Experiment

2. Star Trail Photography

3. Observing the Surface of the Sun

4. Observing with the 0.4-m Telescope

5. Variable Star Observing

6. Independent Study

1. The Stonehenge Experiment

Purpose

This is a homework exercise intended to introduce you to some observable consequences of the Sun's daily (diurnal) and yearly (annual) motion across the celestial sphere. It requires a few hours of careful observing on your part at the times of local sunset (or sunrise if you prefer). During the exercise you are duplicating a small portion of the observations made by the Bronze Age sky watchers of the British Isles who constructed Stonehenge.

Apparatus

- drawing pad (or overhead transparencies)
- pen or pencil
- protractor (for measuring angles)
- observing site with a clear view of the western (or eastern) horizon)

Procedure

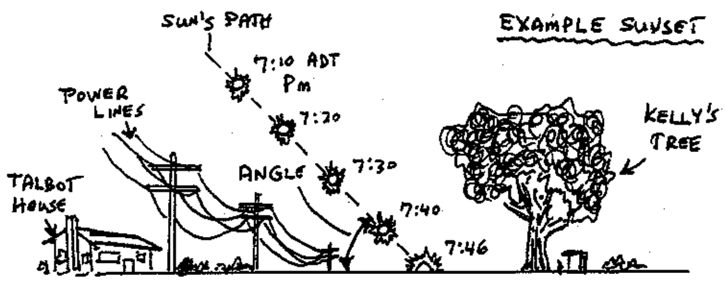
Locate a suitable site from which you have a relatively unobstructed view of the western (or, for sunrise observers, eastern) horizon. Use the site as a **fixed** base for your observations, which entail carefully constructed, neatly labelled drawings to illustrate **clearly** the objects visible along the horizon. Be as accurate as possible in making your observations. Best results are generally obtained by: (i) using a ruler held at arm's length to accurately scale the sizes and separations of objects in the field of view, (ii) using a fixed window site with overhead transparencies and drawing pens to make accurate sketches of the visible horizon, or (iii) taking images with a permanently mounted tripod on different dates.

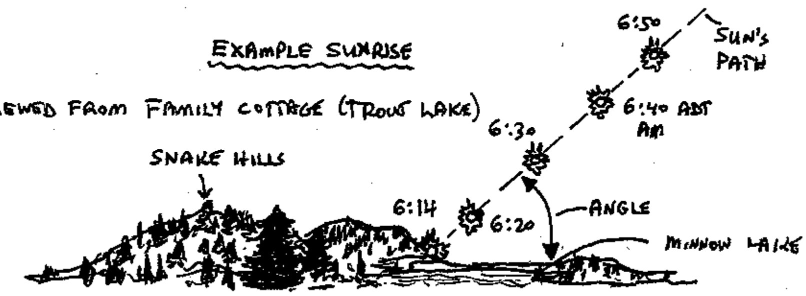
NOTE. DIRECT SUNLIGHT IS VERY HARMFUL TO UNPROTECTED EYES. AVOID STARING AT THE SUN FOR ANY LENGTH OF TIME DURING THE OBSERVATIONS. THE SUN'S LOCATION IN THE SKY CAN BE DETERMINED FAIRLY ACCURATELY FROM BRIEF INDIRECT SIGHTINGS ALONE.

Use the objects visible from your observing site as reference points, and plot the location of the Sun in the sky as it sets, making note of the times for individual observations and the date for each sequence. You should start about 30 to 45 minutes prior to sunset (or at sunrise and for 30 to 45 minutes thereafter) and record the Sun's location at intervals of about 5 or 10 minutes, including the instant of sunset (or sunrise) itself. Each drawing should include the following: date, location of your observing site, correct times for each observation (AST or ADT) including sunset (or sunrise), the Sun's location plotted or shown on your drawings or photographs at those times, a dashed line to connect the individual observations for that day (*i.e.* the Sun's path as it sets or rises), and the identification of specific features on the horizon that served as reference points.

You will need to make sunset (or sunrise) observations on at least two separate dates, preferably separated by about a week in time, in order to detect the effects of annual motion. Observations on only one date are not sufficient to answer all of the questions accompanying this exercise. You may also do the experiment in small groups if you wish, although each individual in the group is required to submit a separate account of the events as well as separate responses to the questions. You may even take along an "observing assistant." Sunset observations for AST 205/206 are an excellent excuse for a date!

Examples of sketches made of a typical sunset and a typical sunrise are provided below to give you some idea of what is wanted. See also http://www.ap.smu.ca/~turner/skyviews.html. Your own drawings will be for your own observing site.





Exercise Write-Up

When you have completed your observations, submit them — in the form described below and with each point in the checklist noted — along with a brief account of your findings and short answers to the following questions:

1. At sunset the Sun is located in the western sky with north to the right and south to the left as you view the horizon (the directions are reversed for sunrise observers facing east). In which direction (north or south) has the sunset (sunrise) point moved (if at all) between the dates of your observations?

2. The celestial equator intersects the horizon at two fixed points that correspond to due west and due east (the west and east points on the celestial sphere), which coincide with the sunset and sunrise points for September 23rd. Any change in the location of the sunset (sunrise) point must therefore correspond to a change in the location of the Sun relative to the celestial equator. Determine the direction (north or south) in which the Sun is moving relative to the celestial equator between the dates for your observations.

3. Any change in the location of the Sun relative to the celestial equator should also be reflected in a change in the Sun's mid-day altitude. Describe any such changes that you would expect to observe as a consequence of such a prediction, and provide any observational evidence that supports your expectations.

4. The Sun's path at sunset (sunrise) makes a specific angle with respect to the horizon (see example sketches). Does the angle appear to change with time? Use a protractor to determine the approximate size of the angle in degrees.

Observing Exercise Check List

- date for each set of observations
- location of your observing site
- correct times for individual observations including sunset (or sunrise)
- the Sun's location plotted at those times
- a dashed line to connect the individual observations for each date
- the identification of reference points on the horizon

2. Star Trail Photography

Purpose

The object of this exercise is to image star fields using a 35-mm or digital camera, and to make use of the resulting images to identify specific constellations and bright stars, as well as to correlate star colours with spectral types. Examples are available. A 35-mm camera can be used with a tripod and bulb setting to take time exposure images. Similar results are possible with a digital camera, with its special settings.

Apparatus

- a 35-mm camera with a standard 50-mm lens or a digital camera
- a sturdy tripod that will mate with the camera
- a cable release to lock open the shutter of the camera for time exposures
- 35-mm film (for black and white shots, Kodak T–MAX 400 film or the equivalent is recommended — for colour shots any 400 ASA film should suffice)

Procedure

Set up your camera on a tripod at your chosen observing site, and use clear nights to photograph two or three constellations using short exposures. Good star trails can be obtained with exposures of 10–30 minutes. Keep an accurate record of the date and times for your exposures, as well as of your observing location. You should then be able to identify a few stars on the prints by making use of desktop planetarium software to correlate where the camera was pointing with an image of the sky at the same instant. You can record short star trails for just about any constellation, but you will need longer star trails when the camera is pointed towards the north celestial pole. Try to identify a range of stellar colour on your images. Can you correlate the observed colours with the known spectral types of stars? Reference to the *Observer's Handbook* will help answer that question.

General Guidelines for Success

- Avoid areas near the centre of cities if possible. The darker the site the better.
- Avoid times when the Moon is up and relatively bright (First Quarter to Last Quarter).
- Be sure you know how to use the camera properly.
- Your results will be more interesting if you know what the camera was pointing at when the image was taken.

Suggested Exposure Times

Be sure the lens is wide open during the exposure, which means that the *f*-stop should be adjusted to its lowest value. Of course, the focus should always be set for infinity. Under such conditions exposures around 30 seconds are good for making recognizable photos of star patterns. Longer exposures of up to 30 minutes will record the arc-like paths caused by the Earth's rotation.

Write-Up

Submit your best images along with information on the exposure times and other camera settings. Indicate the dates and times of your observations and the location of the observing site. Summarize weather information, and briefly discuss the procedure you followed. Identify the constellations and the brightest stars on your prints.

3. Observing the Surface of the Sun

Purpose

The object of this exercise is to observe the solar photosphere and to generate regular records of active regions in the photosphere. From such records it is possible to learn a lot about the properties of features on the Sun, as well as about the Sun's rotation.

Apparatus

- a telescope equipped with either a solar filter or a means of solar projection (the department has special telescopes that can be set up in the Atrium on clear days for this purpose)
- recording paper pre-drawn with a circle representing the Sun's disk
- pen and pencil

Procedure

Before attempting this project you should read the section of your textbook that discusses the Sun's surface features. You will then be prepared to record intelligently the view through the telescope. You should not expect to see immediately all of the features described in the textbook. Prominences and sunspots are transitory — none may be visible when you are observing. That is one reason why you are expected to observe on several occasions. Some features, such as granulation, are not easy to observe visually. The solar photographs in your textbook were made with large special-purpose telescopes, and are therefore somewhat misleading as examples of what you can expect to observe.

Make careful sketches of the view through the eyepiece. Standard observing sheets can be used, or you may prefer to use your own sketchpad, pre-drawn with a circle representing the Sun's disk. Use a soft lead pencil and try to shade your sketch to illustrate the different brightness levels in the image. If the telescope is equipped with a Hydrogen-alpha filter (Hα), you will be observing in deep red light, so everything will appear the same shade of red.

Your sketches should be accompanied by various items of supplementary information. Report the dates and times of your observations. Mention which telescope was used (there are various possibilities for solar observing), and which filter was used. Try to identify the types of features you observed. Use the known diameter of the Sun's disk (32 arcminutes — 32′, or 1,392,000 km) as a yardstick to estimate the actual sizes of some of the features in kilometres. Sunspots sometimes last for a month or more, so you may observe the same ones on different dates, although in different locations since spots take only two weeks to traverse the visible hemisphere of the Sun.

Questions to Answer

1. Did you detect the photospheric limb-darkening during your viewing sessions? What physical process is responsible for the phenomenon?

2. How large (in kilometres) are the various features — *i.e.* sunspots — you observed in the solar photosphere? How do they compare in size to the dimensions of the Earth?

3. How active was the Sun during your period of observation? How will that change with time?

4. Observing with the 0.4-m Telescope

Purpose

The goal of evening observing sessions with the 0.4-m reflecting telescope of the Burke-Gaffney Observatory is to obtain images of at least two different types of objects that can be viewed through the telescope, something that may require more than one observing session. You are expected to relate your observations to the knowledge of such objects gained in class. Telescopic views and images do not always record the same information that is provided in some textbook images, so the project is in part a learning exercise as to what exactly can be detected with a small telescope

Apparatus

- 0.4-m reflecting telescope equipped with CCD camera
- recording paper pre-drawn for telescope observing
- pen and pencil
- warm clothing

Procedure

The Telescope Operator will set the telescope on selected objects that can be imaged with the CCD camera, unless you have a good alternative object in mind (if so, you are expected to provide co-ordinates and other information to the Telescope Operator). Images obtained with the CCD camera will be made available to you later. For extended objects that cannot be imaged with the camera, be prepared to sketch the field of view through the telescope eyepiece. When sketching, try to shade the sketch to indicate different brightness levels in the object. If you are looking at a star cluster, indicate brighter stars using larger dots (the custom for astronomical sketching). Try to produce a realistic impression of what you saw. Indicate the orientation of your sketch by locating the directions north (N) and east (E) at the appropriate points on the edge of the drawing, and note the time and date of each observation.

Write-Up

You should provide supplementary information about each object on a separate sheet along with each sketch. Describe some of the general properties of the type of object you observed, and compare your image with any existing photographs that are available of the object, either in your textbook or in library sources. Explain what useful scientific function could be gained from imaging the two (or more) objects you studied. Be specific. A long, drawn-out description of the specific type of object observed, as can be found in any textbook for example, is *not* what is wanted. Rather, your description should address the nature of the *individual* object of observation, and what purpose is served, or can be served, by imaging that object. What can be learned about the object through imaging, and how is such information of use to astronomers?

5.Variable Star Observing

Purpose

The object of this exercise is to make observations of a bright variable star in order to examine its light curve. Such observations are done by thousands of variable star enthusiasts — both professional and amateur — every clear night. The observations are also useful for tackling a variety of unanswered questions about the nature of light variability in such stars. Although a variety of bright objects could be chosen for such a study, the easiest to observe are δ Cephei, the name star for the Cepheid variables, and Algol (Beta Persei), an eclipsing binary system. Cepheids are stars that are used as the standard candles for determining distances to other galaxies, as well as to establish the distance scale and expansion rate for the universe.

Apparatus

- finder chart, complete with reference star magnitudes (obtain from instructor)
- access to a computer running *Microsoft Excel*
- warm clothing and clear evenings

Procedure

Locate a suitable site from which you have ready access to the night sky. It is not necessary for the site to be completely free from light pollution, although a relatively dark site is of some advantage. The project is also completed most easily if the observing site is adjacent to your living quarters. That way, you can obtain the necessary observations relatively efficiently by stepping outside to your observing site for a brief period — no longer than 5–10 minutes a night.

You should observe your target variable star as frequently as possible, since it is possible to notice differences in brightness from one night to the next. It is even possible to observe the variable on partly clear evenings by taking advantage of breaks in the clouds. Estimate the brightness of the star by comparing the variable with reference stars in its vicinity. A reference chart for the variable can be obtained from the instructor.

Data Compilation

You should enter each night's observation into an *Excel* spreadsheet. For that you need to record the date and time of your observation (to the nearest minute). That information can be converted to a Julian date (a sequential running number beginning on January 1, 4713 BC) by a standard procedure (see instructor), or through an Internet site at http://www.phy.vill.edu/astro/links/jd.htm.

Keep track of your observations in a format that consists of: date and time of observation, estimated magnitude (brightness), calculated Julian Date (see above), calculated number of elapsed cycles (E) for periodic variables, and phase of variability (see instructor). Once you have a fairly complete data set, you can make use of the features of Excel to graph the variable's light curve.

Questions to Answer

1. Examine your resulting light curve for your star, the plot of magnitude as a function of phase or Julian Date. How would you describe the shape of the light curve, *i.e.* sinusoidal, asymmetric, *etc.*?
2. Determine as best you can where the star went through light maximum or light minimum.
3. What have you learned about the nature of stars of the type you chose to observe for variability?

6. Independent Study

Purpose

The goal of this exercise is to give individual students the freedom to create their own observing projects, within the constraints of rigour associated with a standard scientific exercise. Although some potential projects are identified below, the intent is for individual students to fashion their own projects based upon some field of astronomy that captures their interest. Projects can be done individually or in small groups, but it is expected that completed projects will be written up by individual students rather than as group reports.

Potential Projects

- Measuring the altitude of the North Star as a means of estimating the local latitude on Earth's surface
- Messier Object Survey (with the goal of using a telescope to make images or sketches of all Messier objects visible from the latitude of Halifax during winter months)
- Aurora Search (with the aim of searching for displays of the aurora borealis on clear nights, and searching for links with solar activity)
- Double Star Observing (with the aim of observing a variety of different double stars having different angular separations for their components, and using the systems to infer the angular resolution of different observing instruments on different nights)

Procedure

Create your own observing project in consultation with the course instructor. Do your own background research on the project using available library resources, and then carry out the project with available facilities. Your project should have specific scientific goals that will enable you to learn something from the study. Those goals must be indicated to the course instructor beforehand.

Write-Up

Write up the results of your observing exercise much as you would any other observing exercise. Be certain to include the educational and observational goals of the exercise, a description of how it was carried out, and the results you obtained. Tie the results to the specific educational goals originally envisaged.

Questions to Answer

1. Were you successful or not?
2. How would you redesign the exercise to make it more successful?

Visual Observing Sketch Form

Burke-Gaffney Observatory, Department of Astronomy and Physics
Web: www.ap.stmarys.ca/bgo E-mail: bgo@ap.stmarys.ca Phone: 902-496-8257

Observer:	Sky Conditions:
Object Sketched:	Right Ascension (2000.0):
Magnitude:	Declination (2000.0):
Date: Time: Time Zone:	Notes:

(Revision 1.1 – September 12, 2001)

Telescope:	Eyepiece:
Filter:	Magnification:
Notes:	True Field Diameter:

Useful Information about the Burke-Gaffney Observatory

Telescope Facts
(Cassegrain Focus)

Aperture:	40.7cm (16-inch)	Latitude:	44° 37' 50" N
Focal Length:	4780mm	Longitude:	63° 34' 52" W
Focal Ratio:	11.75	Altitude:	91 metres
Theoretical Resolution:	~0.3 arc-seconds		
Max. Theoretical Magnification:	~814x	Light Grasp:	~2000 x human eye
Max. Practical Magnification:	400x	Limiting Mag:	~15.7 (no light pollution)

Eyepiece Parameters

Eyepiece	Focal Length	Apparent Field of View	Magnification
Meade 40mm Super Wide	40mm	65°	120x
Tele Vue 13mm Naglar	13mm	82°	368x
Tele Vue 40mm Plössl	40mm	43°	120x
Tele Vue 26mm Plössl	26mm	50°	184x
Tele Vue 13mm Plössl	13mm	50°	368x

Barlows	Nominal Magnification Factor
Tele Vue 1.8x	1.8
Tele Vue "Big-Barlow"	2.0

Useful Formulae

Magnification (M):

M = F/f

where: F is the focal length of the telescope
f is the focal length of the eyepiece
both must be in the same units (eg. mm)

True Field Diameter (TF):

TF = AF / M

where: TF is the true field of view (in degrees)
AF is the eyepiece apparent field of view (in degrees)
M is the magnification