Chapter 7: Observing Variable Stars in the Real Sky

Summary

This chapter is the heart and soul of the *Hands-On Astrophysics* curriculum. Those instructors who have access to the real sky can make their students a part of the scientific process of variable star research. As long as your sky is not excessively bright, you will be able to systematically observe bright variables such as delta Cephei and W Cygni.

Terminology

AAVSO	GMAT	period-luminosity relationship
Cepheid variable	HIPPARCHOS	recessional velocity
cosmology	Hubble's constant	
finder charts	Hubble's law	

Common Misconceptions

1. *Stars do not change.*
2. *Only the data collected by professional astronomers are useful to science.*
3. *Telescopes are necessary to make serious measurements of the sky.*

SUGGESTIONS FOR THE POSTER PAGES, INVESTIGATIONS, AND ACTIVITIES

Poster Page: Starlight in Your Eyes

RESOURCE

Your students may be interested in determining their pupil size. An inexpensive pupil gauge can be obtained from the ***Sky Publishing Corporation***. (See Resource List.) Research on diseases of the eye, and how they change vision and affect skywatching, is an area full of possibilities for discussion. Have the types of vision problems changed over time? Did ancient peoples have different diseases and problems? What did they do about visual deficiencies? When were glasses developed? How well did they work? When were filters first used? Were they effective? When was glass developed, and how was it used when first discovered? Does radiation affect eyesight? If so, what precautions should be taken? Did any famous astronomers have vision problems? How do we know this? What about seeing colors and color blindness? The human eye has three types of color cones. Blue, green, and red cones respond to light across the visible spectrum. Their coverage overlaps quite a bit. The green cones, for instance, respond somewhat to red and blue light.

Every color in the spectrum produces a different ratio of red, green, and blue response in the eye. The brain interprets each mix of responses as a different color. How are "true" colors affected by atmospheric conditions? Does aging seriously change the reliability of amateur variable star observers? (In other words, do younger observers see the stars better than older observers?) Can this aging factor be detected and accounted for? Can it be considered a systematic error?

Poster Page: Occupational Hazards of Variable Star Observing

Sometimes funny things happen to amateur variable star observers! If you have internet access, you can find the complete archive of messages for the AAVSO's on-line discussion group. The address is

http://mailman.mcmaster.ca/mailman/listinfo/aavso-discussion

Core Activity 7.1: Observing Your First Variable Star—Delta Cephei

Delta Cephei is recommended as a first observational activity for several reasons. It is circumpolar in the Northern Hemisphere. It is visible from most northern latitudes, at least for a large portion of the year. It is outside the distracting clutter of the Milky Way stars and in a relatively dark part of the sky. Its comparison stars are close by and have magnitudes which approximate the range of delta Cephei. The star is bright enough for unaided eye observation, even at minimum. Also, its period is short enough that a month's observations will yield excellent results.

The student pages do not reveal the range in magnitude or the period. This information is to be given out at your discretion, depending on your group of students. The period for delta Cephei is 5.36 days, and it ranges from a maximum magnitude of 3.5 to a minimum magnitude of 4.3. The students will need the finder charts and the Julian Day numbers provided in this manual, as well as their planispheres, and if available, a *Sky Gazer's Almanac.*

Depending upon your location and the time of year, you may choose one of the other recommended variable stars listed below for which the AAVSO has provided slides and a set of finder charts. They make good independent study or science fair projects as well as long-term class projects.

R and RT Aur
Chi, W, X, and U Cyg
R, S, and Z UMa
T, S, and U Cep
R and V Cas

Students are given the tools to convert their time and date of observation to the Julian Date (JD). Depending on your students, you may elect to have them perform the calculations, or simply use the Julian Day without converting their observation time into the fraction of the day. This would suffice for the classroom. If some of your students would like to have

their observations added to the American Association of Variable Star Observers International Database, however, the complete JD will have to be calculated.

Depending upon your location, or because it will add more validity to the observational data, you may decide to involve another group of students in observing delta Cephei. Then your students can compare their data with others. Compiling all the data will further reduce random error, or perhaps bring to light a previously undetected systematic error. An additional advantage of having data from another class is that they may be able to fill in gaps in your data. For example, you may lose several viewing days due to adverse weather conditions at your site that the other class may not. If you have an internet connection, students could exchange information on a regular basis, or they could correspond by fax or regular mail.

Observing with Binoculars

Delta Cephei can be seen with the unaided eye if you have dark skies, and binoculars are not necessary. Some of the variables on the list *will* require binoculars. Binoculars are extremely underutilized astronomical tools. Most people have the impression that telescopes are necessary to view objects in the sky, and do not consider binoculars—even though many people own a pair. There is no reason or need to purchase a telescope if a pair of 7x35 or 7x50 binoculars is available. They are portable and require no setup time. Binoculars have wide fields of view that are oriented right side up, making it much easier to find celestial objects than with a telescope (which gives an inverted image). In fact, there are a large number of objects for which binoculars provide *better* views than popular telescopes. This is because telescopes have a very small field of view and many objects do not "fit" in the scope. The Pleiades, Hyades, Milky Way star clouds, Rosette and North American nebulae, and the face-on spirals M33 in Triangulum and M101 in Ursa Major are examples. 7x35 binoculars are sufficient; however, the best binoculars for astronomical use are the 10x50 wide angle instruments. Larger binoculars are expensive and so heavy that a tripod is required.

Poster Page: She Discovered How to Calculate the Distances to Galaxies (Henrietta Leavitt)

Women have always made significant contributions to astronomy, including variable star astronomy. History is filled with brilliant women astronomers who worked as assistants to husbands, family members, or professors and made many discoveries for which they received little or no credit. With the advent of the application of photography to astronomy, thousands of star fields, spectra, and charts needed to be examined. During this time (the 1880's) women were hired as "computers." It was believed that men would be too bored with the incredible amount of routine work and tedious calculations that such examination required. Women were not only patient, they were also cheap labor. They were allowed the drudgery of cataloging, recording, and classifying. Independent research and theoretical work was attended to by men, since women were thought to be incapable of higher levels of thinking. The women who became accomplished astronomers did so under adverse circumstances and few received recognition.

Some famous women astronomers are listed below. Their lives make interesting research topics. There are still many disadvantages for women in any field of science, including astronomy. How much has changed in the past 200 years? Has the percentage of women astronomers increased? Decreased? Is it different from other fields? Find a woman astronomer to interview (there are many besides the pioneers listed below).

You may elect to compare the status of women astronomers and scientists with that of women in other countries. In which cultures is it easier for women to enter scientific fields?

PAST ASTRONOMERS

Catherina Elizabetha Hevelius (1646–1693)
Wife and assistant to the Polish astronomer Johannes Hevelius. After his death she published two catalogues, one of which contained 1,564 stars. This was the last and largest star catalogue compiled without a telescope.

Nicole-Reine Lepaute (1723–1788)
An extraordinary mathematician who worked with the French astronomers Clairaut and Lalande to predict the path of Halley's Comet, successfully predicting its 1757 return. She also predicted the annular eclipse of 1764.

Caroline Lucretia Herschel (1750–1848)
Assistant to her brother, William Herschel, who discovered Uranus. She discovered 8 comets, and reduced and published William's observational data on nebulae.

Maria Mitchell (1818–1889)
First woman astronomer and first professor of astronomy in America. She discovered a comet in 1847, for which she received a gold medal from the King of Denmark. She became the Director of Vassar College Observatory in 1865.

Williamina P. Fleming (1857–1911)
Discovered over 300 variable stars and 10 novae (one of which was later identified as a supernova) by looking at their spectra.

Winnifred Edgerton (1862–1951)
The first American woman to receive a Ph.D. in astronomy. Her husband insisted that she give up her career and stay home to fulfill her family responsibilities.

Annie Jump Cannon (1863–1941)
Classified the spectra of many thousands of stars, using the stellar classification system (OBAFGKM) of decreasing stellar surface temperature, which utilizes the strength of all spectral lines.

Dorrit Hoffleit (1907–2007)
Spent the first half of her astronomy career at Harvard, and second half at Yale, until she retired as Senior Research Astronomer Emeritus. Made a pioneering study of the light curves of meteor trails, and discovered 1270 variable stars.

Antonia C. Maury (1866–1952)
Developed her own classification system for stars; although awkward to use, it led to the recognition of luminosity classes and the existence of giant stars.

Henrietta Swan Leavitt (1868–1921)
Discovered the period-luminosity relationship in Cepheid variable stars, which led to Cepheids being used to measure distances to other galaxies.

Cecilia Payne-Gaposchkin (1900–1979)
Her doctoral thesis, *Stellar Atmospheres,* has been called the most brilliant Ph.D. thesis ever written in astronomy. She determined that stars were composed mostly of hydrogen and helium.

Henrietta Hill Swope (1902–1980)
Discovered 2000 variable stars and used variables on photographic plates to establish the distance to the Andromeda Galaxy.

SOME CURRENT ASTRONOMERS

Vera Rubin
She was the first woman to have official permission to use the Mount Palomar telescopes. Her work established the presence of "dark matter" in the universe.

Jocelyn Bell Burnell
She was the Chair of the Department of Physics at the Open University in Great Britain. Discovered pulsars in the late 1960's.

Lucy McFadden
A recognized authority on the nature and interrelationships of asteroids, meteorites, and comets.

Carolyn Porco
The head of the Voyager team that studied planetary rings and discovered the faint rings of Neptune.

Margaret Geller
Responsible for the discovery of the large-scale structure of the universe, and that galaxies are clustered around the edges of great voids shaped like bubbles.

Sandra Faber
Determined the existence of the "Great Attractor" 150 million light years away in the direction of Centaurus, a huge mass pulling neighboring galaxies toward it, including the Milky Way.

Heidi Hammel
Principal Research Scientist at Massachusetts Institute of Technology. Team leader for the Hubble Space Telescope imaging of Jupiter during the impact of Comet Shoemaker-Levy.

Activity 7.2: Observing the Variable Stars W Cyg and Chi Cyg

W Cygni is the variable star used in the slide set which taught students how to estimate magnitude variation. It would therefore be an excellent follow-up project after delta Cep. It could also be used as a first project. W Cyg and chi Cyg are not listed first in this chapter because Cygnus is part of the Summer Triangle, and if you do not get to this part of the curriculum before early autumn, Cygnus leaves the sky. These stars are ideal variables for observing from late spring through summer, and even into early fall if the horizon is unobstructed. However, chi Cyg is only visible (with the unaided eye or with binoculars) when it is near maximum; if it is closer to minimum you will need a small to moderate-size telescope. Furthermore, both chi Cyg and W Cyg are embedded within the background clutter of Milky Way stars, and so it may take some practice to locate them against this starry background. Students can practice locating these stars with the provided slides.