Chapter 15

One-Semester Astronomical Research Seminars

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Introduction

College and high school students are conducting original scientific research through an innovative one-semester seminar offered by Cuesta College. Students present their research at major scientific conferences and their findings are published in scientific journals. Real science is about the unknown; these students, just like working scientists, do not know what they will find—no one knows. They are thrilled by their discoveries.

Being a coauthor of one or more research papers boosts educational careers. Undergraduate college admission offices are impressed with publications. Graduate schools are always in need of students willing to help with research and are often eager to admit those rare undergraduates with published research.

This research seminar at Cuesta College is the direct descendent of an earlier research seminar. Several years ago, while teaching astronomy and mathematics at the Superstition Mountain campus of Central Arizona College, one of us (Genet) organized, with the assistance of Cheryl Genet, a one-semester astronomical research class. Nine students were formed into three teams and asked what research they would like to pursue. A number of possibilities were considered as students talked to various astronomers via conference calls. All three teams chose to observe bright Cepheid stars using a robotic telescope at the Fairborn Observatory on Mt. Hopkins in southern Arizona.

Figure 1: Central Arizona College students pose with seminar instructor Russ Genet (upper right) during a late night data analysis session.

Small Telescopes & Astronomical Research. 2010. Eds. Genet, Johnson, & Wallen.

Astronomer Kenneth Kissell discussed the Cepheid project with the students during several conference calls and assisted them in selecting appropriate Cepheids for observation. Michael Seeds, the Principal Astronomer for the Phoenix-10 robotic telescope at the Fairborn Observatory, also spoke with the students by way of conference calls and helped them formulate their observational requests. Another astronomer, Douglas Hall of Vanderbilt University, aided the students in selecting appropriate comparison and check stars, while Louis Boyd, Director of the Fairborn Observatory, operated the robotic telescope.

The Phoenix-10 robotic telescope obtained the student-requested UBV observations of the selected Cepheids. Results became available toward the end of the semester. In several late-night sessions the students tabulated and plotted differential magnitudes as time series which, of course, appeared quite random. They then produced phase plots and, as if by magic, the Cepheid light curves appeared. They were most impressed!

Figure 2: Students plot Cepheid data points with assistant seminar instructor Cheryl Genet.

Figure 3: Cheryl, Klay, and Russ put up posters at the 200th meeting of the American Astronomical Society in Albuquerque.

One student, Klay Lapa, only 16 years old at the time, presented his results on T Vulpecula (T Vul) at the 200th meeting of the American Astronomical Society (Lapa 2002). Cheryl Genet presented her results on U Aguila (U Aql) (Genet 2002) at the same meeting. Cheryl and Russ Genet described the research course itself (Genet and Genet 2002).

The following year (2002), the Genets moved to California's Central Coast (near San Luis Obispo) so Cheryl could be near her aging parents. Russ established the Orion Observatory and equipped it with a 10-inch Meade LX-200 telescope and an SBIG ST-8 CCD camera. Thomas Smith, at the nearby Dark Ridge Observatory, and Russ collaborated in observations of short-period W Ursa Majoris (W UMa) eclipsing binaries. Russ also began teaching introductory astronomy as an Adjunct Professor of Astronomy at nearby Cuesta College.

Cuesta College seemed to be an appropriate venue for another community college astronomical research course, which offered a physics research seminar in the fall of 2006. Three students—Noll Roberts, Casey Milne, and Neelie Jaggi—observed nine stars tagged as "possibly interesting" by a Global Network of Astronomical Telescopes (GNAT) survey. They took thousands of electronic "pictures" of these nine stars, found two to be variable stars, and determined their pulsation periods. They presented their findings to both the American Astronomical Society and the Society for Astronomical Science.

Figure 4: Left: College students Noll Roberts, Casey Milne, and Neelie Jaggie used the 10" telescope at the Orion Observatory in California to discover two new variable stars. Right:: Neelie Jaggie receives an award for her scientific discovery of variable stars from San Luis Obispo Mayor Dave Romero at the Discovery Institute's Young Scientist Awards Banquet.

In the fall 2007 research seminar, five Cuesta freshmen and sophomores were joined by five early-enrollment high school seniors, five experienced amateur astronomers, and two educators to form a dynamic class of 17 seminar students. The students worked individually and in teams on a variety of projects, each of which produced a paper for publication. Seven papers were published.

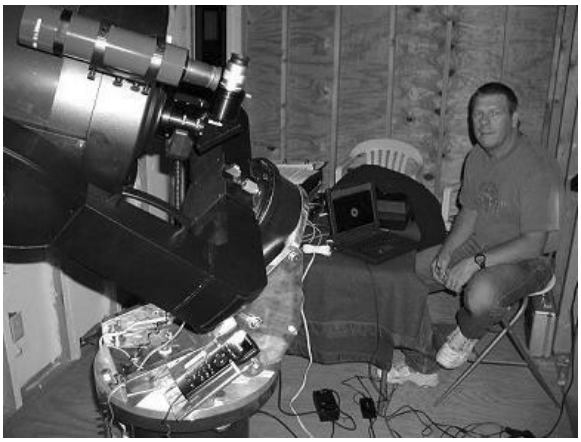

Figure 5: Tom Smith, Director of the Dark Ridge Observatory (now in New Mexico), gathered data of exoplanet transits and double stars for student papers.

Five of the projects used a low cost ($150) laser-etched astrometric eyepiece (a ruler and protractor projected onto a highly magnified view of the sky) to observe the separations between and position angles of double stars that rotate around one another over the course of years, decades, or even centuries. These same observations, published as papers in the *Journal of Double Star Observations (JDSO),* will eventually be used, along with other observations, to determine the orbital periods and masses of these stars.

Figure 6: Seminar instructor and astronomer Russ Genet (middle) works with students Jolyon Johnson (left) and Darrell Grisham (right) to reduce observations of visual double stars. Their results were published in the *JDSO.*

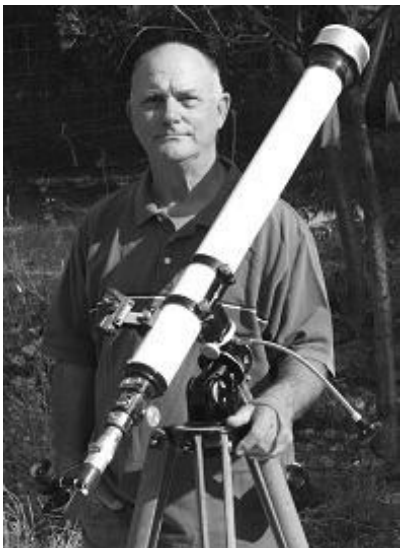

Figure 7: Darrell Grisham used a modified 1960's 3 inch Tasco telescope to make startlingly precise and accurate measurements of double stars.

Three telescopes and CCD cameras—Jim Carlisle's telescope at Hill House Observatory in California, Tom Smith's telescope at the new Dark Ridge Observatory in New Mexico, and Cindy Foote's telescope at the Vermillion Cliffs observatory in Utah—were used to observe the transit of exoplanet WASP-1b across its distant parent star. The planet blocked a small but detectable amount of light as it crossed in front of the star. Interestingly, the transit of WASP-1b occurred approximately twenty minutes earlier than predicted, perhaps due to a second planet.

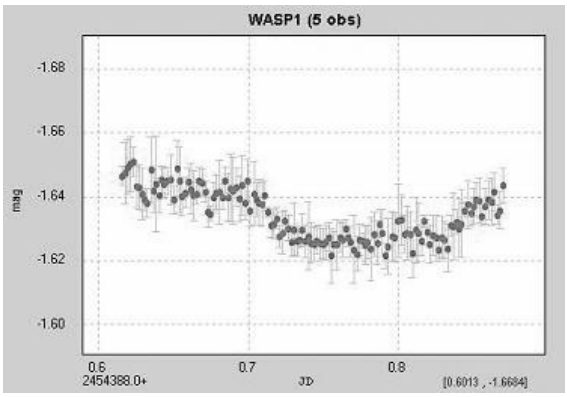

Figure 8: Above is a light curve of WASP-1b generated from data obtained by seminar student Jim Carlisle on his 14 inch telescope in Atascadero, California. The transit occurred several minutes earlier than predicted.

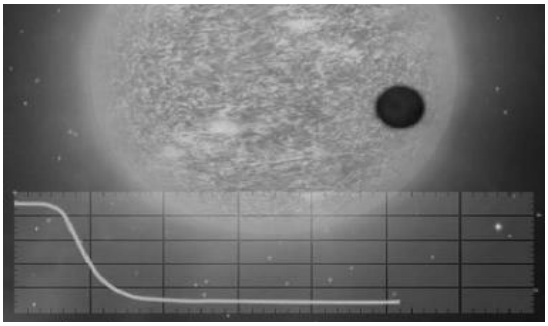

Figure 9 This illustration (courtesy of Google Images) shows how an exoplanet blocks light coming from its parent star as it "transits" across the disk of the star.

Figure 10: Jolyon Johnson and Jim Carlisle observe the asteroid Pallas for Cal Poly astronomer John Keller. The observations were coordinated with Hubble Space Telescope observations of Pallas.

Figure 11: Five students at Arroyo Grande High School made astrometric observations of the bright double star 3 Pegasi. Their paper was published in the *JDSO*. Also shown are Cuesta College President Ed Maduli (right), physics instructor John Baxter (behind), seminar student Vera Wallen (left), Arroyo Grande High School Principal Ryan Pinkerton (behind), and seminar instructor Russ Genet.

Closer to home, three seminar students, in conjunction with astronomy Professor John Keller at California Polytechnic State University in San Luis Obispo (Cal Poly), observed the asteroid 2 Pallas with the university's telescope and CCD camera. The observations were made in conjunction with observations made by a team using the Hubble Space Telescope. Finally, three students used a control system made by Sidereal Technology to computerize a normally manual telescope.

Figure 12: Aubrey Schachter (right) watches Vega drift across the field of view of a 6 inch Newtonian telescope, while Molly Summers (center) times the drift with a stopwatch, and Cheyne Kight (left) records the time. Their paper is the second from Arroyo Grande High School students in a Cuesta College research seminar published by the *JDSO*.

Figure 15: Seminar members from Coast Union High School presented their obs3rvations of the neglected double star ARY 54 AC at a meeting of the Central Coast Astronomical Society. Their subsequent analysis indicated that this double star is optical (not physically bound by gravity). Their paper was published in the *JDSO*.

In the third Cuesta College astronomical research seminar in 2008, the focus turned from undergraduate to high school students taking their fist college course. A dozen students from Arroyo Grande High School met weekly to plan and carry out their research comparing the astrometric precision and accuracy of two different-sized telescopes based on double star observations. Their results were published in the *JDSO*. Several students from Coast Union High School made observations of the double star ARY 54 AC, classified as "neglected" in the Washington Double Star Catalog. Their analysis was also published in the *JDSO* and helped to classify the double as optical rather than gravitationally bound in a binary system.

As a result of these seminars at two community college over a number of years, the instructor and advisors have isolated several factors that contribute to the success of student research:

- Students can and should complete scientific research projects in a single semester. Once the semester is over, students rarely complete projects.
- Some research projects are more amenable to this short time frame than others.
- Requiring the publication of research is vital, as are outside reviews prior to publication. To count as science, research must be published.
- It helps to have a mix of younger and older students as well as experienced and inexperienced observers.
- Student research teams can exercise their diverse talents and experience by allocating their skills to the various aspects of scientific research.
- A mixture of local hands-on-the-telescope and remote CCD observations works well.
- A mixture of quick projects to assure prompt during-the-semester publication and advanced, somewhat riskier projects, also works well.
- Including distant observers and experts as team members and coauthors promotes learning, improves quality, and is standard practice in scientific research.
- Students as young as high school freshmen can complete publishable research projects as community college students and present them to the science community at symposiums.

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