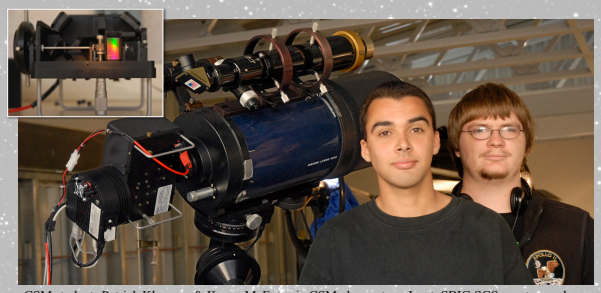
Epsilon Aurigae – A Spectroscopic Investigation

Sally Seebode (San Mateo High School) Darryl Stanford, Dean Drumheller (College of San Mateo)
Steve Howell (NOAO), D. W. Hoard (SSC), Robert Stencel (Denver University), Tim Spuck, (Oil City High, PA)
CSM and San Mateo High Students: Ryan Gray CSM, Patrick Khosraw CSM, Dave Faleschini CSM, Andrada English CSM, Kevan McEntee CSM, Grant Hardy CSM, Michael Johnson CSM, Larry Chew SMHS, Sarah Shtargot SMHS

Introduction

After 175 years of study, astronomers still debate the identity of the companion that eclipses ε Aurigae every 27.1 years. By obtaining and analyzing observations from College of San Mateo's 8" telescope, Spitzer Space Telescope, and Kitt Peak National Observatory, our team hopes to shed light on this mystery.

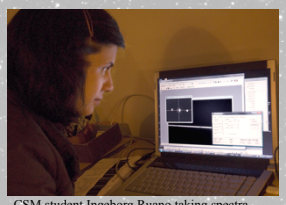
Using spectra from CSM and Kitt Peak, students make EW, radial velocity, and FWHM measurements of prominent absorption lines. Comparisons of these measurements combined with photometric data from the ground and the Spitzer Space Telescope, should illuminate more details of the ε Aurigae companion. Data collection began Feb. '09 (pre-eclipse) and will continue through the two-year event.



CSM students Patrick Khosraw & Kevan McEntee in CSM observatory. Inset: SBIG SGS spectrograph.

Spectroscopy at College of San Mateo

Off-the-shelf imaging equipment in our observatory includes: Losmandy G11 Mount, Meade 8" SCT @f/6.3, SBIG Self Guided Spectrograph (SGS), and ST7XME camera. The SGS resolution is 2.4 Angstroms using a 600 lines/mm grating, and a slit width of 18 microns. The image scale is 1.06Å/pixel. Software includes: TheSky6 for mount control, CCDSoft for image acquisition, and IRAF for data reduction and line measurement.

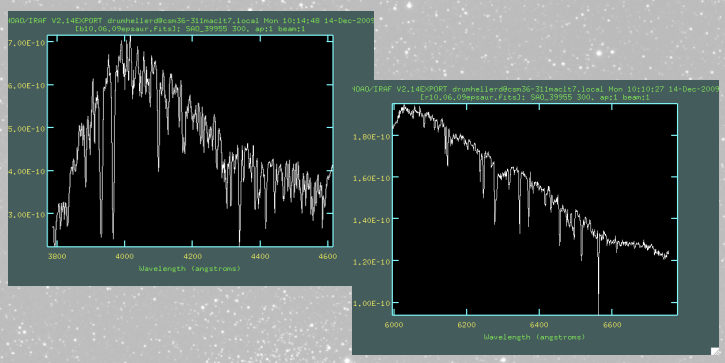


CSM student Ingeborg Ruano taking spectra.

SM High teacher Sally Seebode with student.

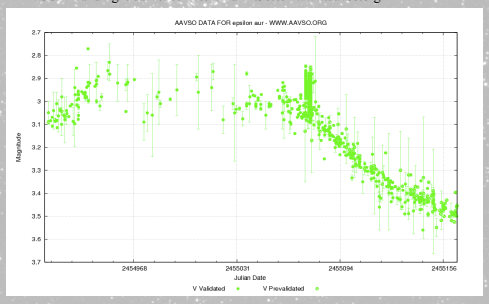
Procedure

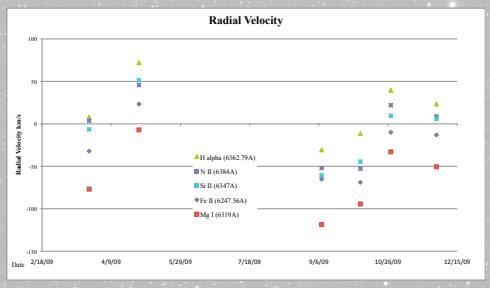
CSM takes weekly data of ε Aurigae. HR1544 (A1V) was chosen as our spectrophotometric standard star. It lies close to ε Aurigae in the sky and is of comparable magnitude at V=4.4. Both stars are imaged at blue and red ends of the spectrum, centered around 4200Å and 6300Å respectively. We are concentrating on strong absorption lines such as hydrogen and singly ionized calcium, as well as low excitation metals such as potassium. Data reduction and line analysis are on-going. All our spectra will be made publicly available through the CSM website: www.collegeofsanmateo.edu/astronomy, and the Citizen Sky website: www.citizensky.org.

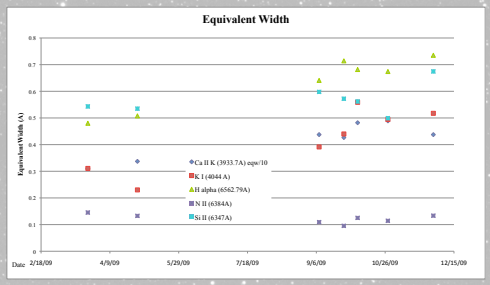


Epsilon Aurigae (in blue and red) at early ingress (6 Oct. 2009). The y-axis gives values in Relative Flux.

AAVSO V band light curve: 3.24.09 thru 11.30.09 www.aavso.org







Preliminary Results

We note that the velocities of the lines have shifted from red to blue by about 38 km/sec from the pre-eclipse to the ingress measurements. This change may be caused by line shape modulation or a true line center change. In either case, this is probably caused by the dark, dusty disc obscuring the F star's light. Continued study through eclipse will provide detailed information about the disk itself, its dust density, and/or opacity. No velocities for the blue spectral lines are shown because our wavelengths are inaccurate due to our Hg calibration lamp having only 2 emission lines.

Changes in equivalent widths (EW) of the absorption lines (related to changes in line flux) are observed. Various elements are responding differently during eclipse ingress. EW of the low excitation lines such as HI, KI, and others appear to be increasing, while the higher excitation ion NII remains constant. These differences are likely due to the locations of the line forming regions in the atmosphere of ε Aurigae, in gas associated with the eclipsing body, or some combination. A given spectral line's excitation potential associates its formation site with a specific temperature range, gas density, and the element's location in the binary star system. A detailed look at the EW values over time, as we are planning, should shed light on the location, temperature distribution, and material density within the ε Aurigae binary.

Organizing this diverse group is somewhat challenging. CSM is regularly taking spectra, but streamlining spectral reduction, peak measurements, and data organization has taken time. We're working toward a regular schedule, as students come and go with new semesters and new interests. We hope to add to our investigation, a study of Vspec capabilities (a PC based reduction program), since it appears more user friendly than IRAF. That said, our group is excited with our progress and preliminary results, and feels this study will contribute to the resolution of this astronomical enigma.

In association with: Spitzer Science Center ◆ National Optical Astronomy Observatory ◆ NASA/NITARP