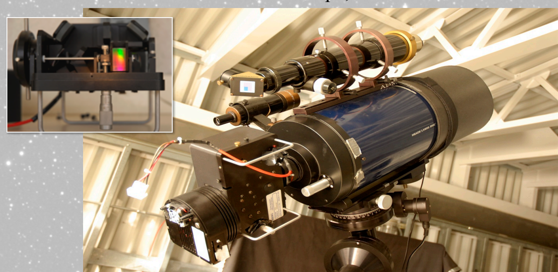
Spectroscopy of Epsilon Aurigae Reveals Ring-Like Structures Surrounding Companion Star

Sally Seebode (San Mateo High School), Steve B. Howell (NOAO), Dean Drumheller (College of San Mateo)
Darryl Stanford (CSM), D. W. Hoard (SSC), Robert Stencel (Denver University),
San Mateo High Students: Larry Chew, Ryan Chew

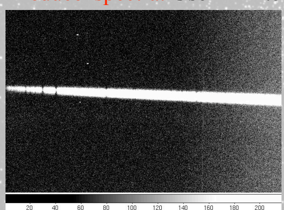
Project Outline:
Students study weekly spectra during the 2 year eclipse of ε Aurigae to learn more about the character of eclipse and the dust disk surrounding the companion B star.

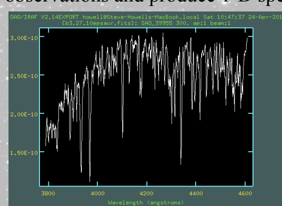
Take Data: CSM Meade 8" Telescope, work with Dean Drumheller.



CSM observatory. Losmandy G11 Mount, Meade 8" SCT @f/6.3, SBIG Self GuidedSpectrograph (SGS), ST7XM camera. Inset: SBIG SGS spectrograph.

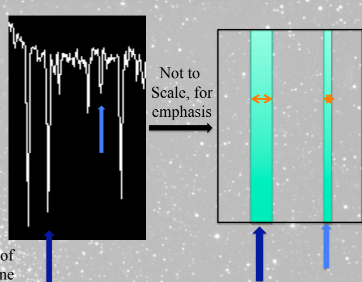
Reduce spectra: Use IRAF to reduce observations and produce 1-D spectra



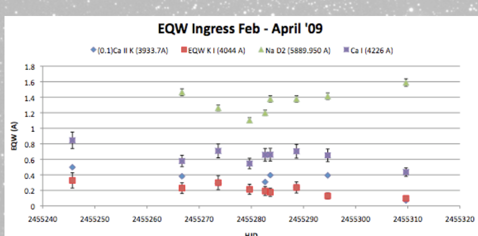


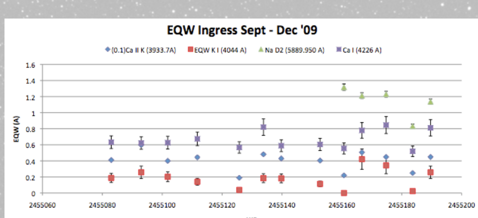
Raw Data compared to Reduced Spectrum: standard methods: 3800 – 4600A; 5800 – 6600A.

Make spectral measurements: wavelength, equivalent widths, FWHM



Equivalent Widths (eqw): the width of standardize rectangle representing the area of the absorption line. Eqw is related to the line flux.





Gather and organize measurements:

Calculations, averages, make graphs

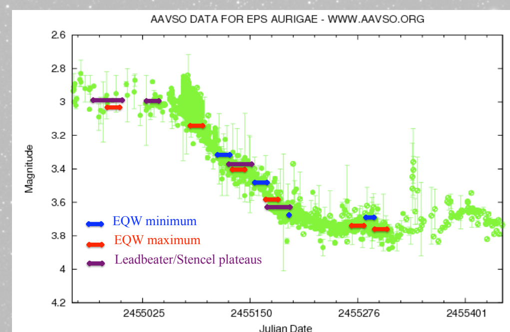
Interpret Results:

Team meetings

"If I knew what I was looking for this would be much easier."

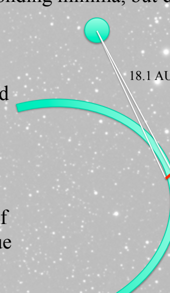
Results:

Plots of equivalent width show increases and decreases in their value that were consistent for many elements present in both our blue and red spectral regions. Equivalent width measurements indicate the amount of absorbance of a particular element. Increased or decreased absorption is related to the amount of element along the line of sight through the dust disk. These changes indicate variations in the density of the dust disk surrounding the companion star. Matching the dates of maxima and minima to the light curve of epsilon Aurigae is illustrated below.



The maxima correspond reasonably well with plateaus seen by Leadbeater and Stencel (astroph/1003.3617). Our data predicts 2 more small plateaus around the Julian date 2455276 during the eclipse maxima. There is an inconsistency between our data and Leadbeater's during the ingress of the eclipse; Leadbeater detects a small plateau on 2455025; we have no corresponding minima, but do see a minima on 2455075.

If we assume the eqw maxima are telling us about local density enhancement of the disk and we take the density enhancements to be in ring like structures, we can construct a toy model and calculate the width of the rings and the gaps. Determining the number of days a variation lasted, we can calculate the fraction of the orbit this time represented and turn the value into an angle (using the small angle approximation) to determine the ring width.



Fraction of orbit
= (20 days) *360
(27.1*365)
= 0.73

Ring Width
= tan 0.73 * 18.1
= 0.23 AU

Min or Max	Start date (HJD)	End date (HJD)	Size (AU)	Species (which elements)
Min	2455111.734	2455133.807	0.253	Ca II K, K I, Ca I
Max	2455125.740	2455139.764	0.161	Ca II K, K I, Ca I
Min	2455152.702	2455166.697	0.161	Ca II K, K I, Ca I, Na D2
Max	2455160.686	2455183.629	0.2644	Ca II K, K I, Na D2, Ca I
Min	2455174.77	2455189.606	0.172	Ca II K, K I, Na D2, Ca I
Max	2455266.706	2455279.633	0.149	Ca II K, Na D2, Si II, H alpha, H gamma
Min (1 data point)	2455273.651	2455282.648	0.103	Ca II K, K I, Na D2, Ca I, Si II, H alpha, H gamma
Max	2455282.648	2455288.659	0.069	Si II, H alpha, H gamma

Ring minima and maxima are roughly 0.2 AU wide. Our results predict an outer ring at a radius of 3.3AU, a wider ring with radius 2.8 AU, and two small closely spaced inner rings with a radius near 1.5 AU. These two inner rings may represent the one inner ring detailed in Ferluga's (1990, A&A, 238, 270) prediction.

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