Epsilon Aurigae - Two Year Totality Transpiring

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Abstract

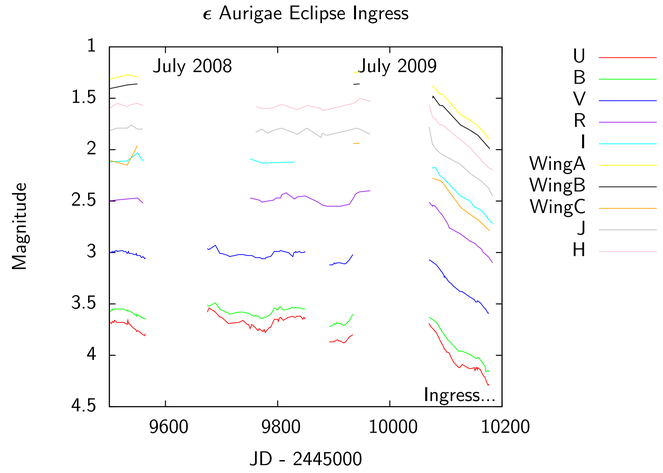
The 27 year period eclipsing binary, epsilon Aurigae, exhibits the hallmarks of a classical Algol system, except that the companion to the F supergiant primary star is surprisingly under-luminous for its mass. Eclipse ingress appears to have begun shortly after the predicted time in August 2009, near JD 2,455,065. At the University of Denver, we have focused on near-infrared interferometry, spectroscopy, and photometry with the superior instrumentation available today, compared to that of the 1983 eclipse. Previously obtained interferometry indicates that the source is asymmetric (Stencel, et. al. 2009 APLJ) and initial CHARA+MIRC closure-phase imaging shows hints of resolved structures. In parallel, we have pursued SPEX near-IR spectra at NASA IRTF in order to confirm whether CO molecules only seen during the second half of the 1983 eclipse will reappear on schedule. Additionally, we have obtained J and H band photometry using an Optec SSP-4 photometer with a newly written control and analysis suite. Our goal is to refine daytime photometric methods in order to provide coverage of the anticipated mid-eclipse brightening during summer 2010, from our high-altitude observatory atop Mt. Evans, Colorado. Also, many parallel observations are ongoing as part of the epsilon Aurigae international campaign. In this report, we describe the progress of the eclipse and ongoing observations. We invite interested parties to get involved with the campaign for coverage of the 2009-2011 eclipse via the campaign websites.

ϵ Aurigae Campaign

The international campaign on epsilon Aurigae consists of more than 50 professional and amateur astronomers. The individuals in this collaboration are conducting photometry in a wide array of filters, high and low resolution spectroscopy, polarimetry, and interferometry all with the goal of solving the mystery of ϵ Aurigae. Below we highlight the photometric and spectroscopic data products to-date from the campaign.

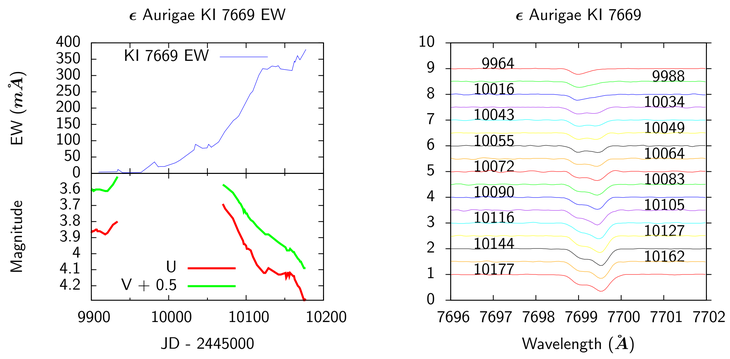
Photometry

One of the primary efforts of the campaign has resulted in coverage of the eclipse in 10 photometric bands. The data below were provided by Jeffrey Hopkins (UBV) and Brian McCandless (RIJH plus WingABC) and are representative of the extensive photometric coverage during this eclipse cycle.



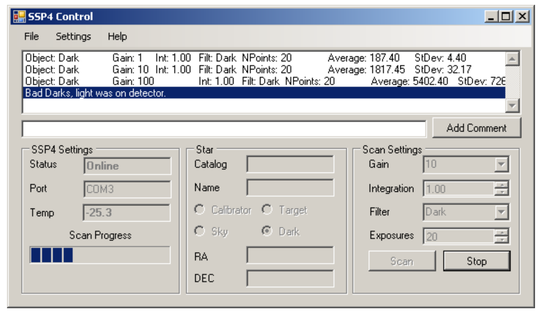
Spectroscopy

Several observers are pursuing spectroscopic observations of ϵ Aur in order to create a longitudinal map of the eclipsing disk. The spectra and equivalent widths, provided by Robin Leadbeater, show the first hints of the eclipsing body having regions of differing composition. The photometry by Jeffrey Hopkins shows an interesting detailed anti-correlation with the KI 7669 EW variation. The individual line profile observations are shown (right) with Julian date labels.



SSP-4: Near Infrared Photometry

A new control and analysis suite for Optec's SSP-4 J and H-band photometer has been programmed by B.K. for the purpose of reliably observing ϵ Aurigae during the daytime of summer 2010 from our high altitude observatory atop Mt. Evans. The software and database are available from the website listed in the bottom-right corner of this poster.

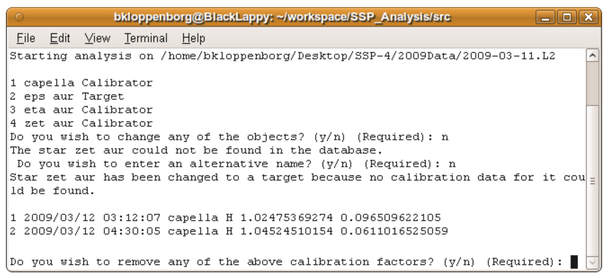


The new control software unleashes the full capabilities of the photometer featuring:

- Integration times between 0.01 to 65.53 seconds in 0.01 sec. increments
- A virtually unlimited number of exposures per scan set
- The Average and Standard Deviation are displayed on screen after each scan
- The ability to add lengthy comments in the data file
- Logging of the detector's temperature
- Programming that is resilient to losing the connection with the camera (lose wires, etc.)
- Cross-platform compatibility (Windows, Mac, Linux)

New Analysis Software

The new control software and daytime observations precipitated the development of new reduction software. This software, written in Python, will eventually be ported to Java and integrated with AAVSO's new VStar application.



The new reduction software features:

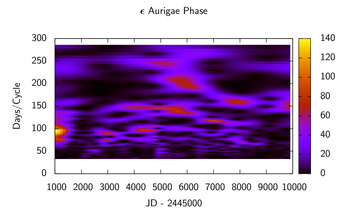
- Conversion routines from Optec's format to the new data format
- Automatic dark and sky subtraction using linear regression (for daytime observations)
- Full uncertainty analysis
- Integration with the new JHK calibration database, nearly automatic lookups for calibration stars

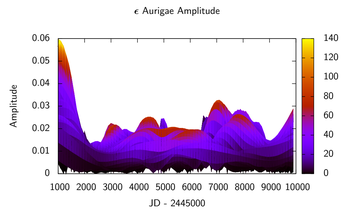
JHK Calibration Database

Full uncertainty analysis requires well-characterized calibrators, therefore B.K. transformed the UKIRT bright star catalog into the MKO-NIR filter set, which closely resembles the SSP-4's filter profiles. The database consists of 322 stars with magnitude ranges of -3.11 to 6.8 in H and -2.33 to 6.91 in J.

ϵ Aur Long Term Photometry

ϵ Aur has been monitored nearly continuously by Louis Boyd and Jeffrey Hopkins since the 1983 eclipse in the U, B, and V photometric bands. Their data is plotted at the bottom of this poster. Gaps are due to sun avoidance periods in the summer. We using this data to constrain the periodicity of the out-of-eclipse variations. The plots below are weighted wavelet transforms of their data showing that ϵ Aur has no dominant period. The changing of periodicity is being investigated further.





Citizen Sky: citizensky.org

R.S. and B.K. are science advisers to the Citizen Sky project, funded under the informal science education program of the NSF. This project welcomes everyone to become a citizen scientist and equips our members with the skills and knowledge to conduct variable star observations, analyze the data, and publish the results in a scientific journal. At present over 1,000 participants have signed up. We encourage you to get involved and check out the Citizen Sky posters at AAS:

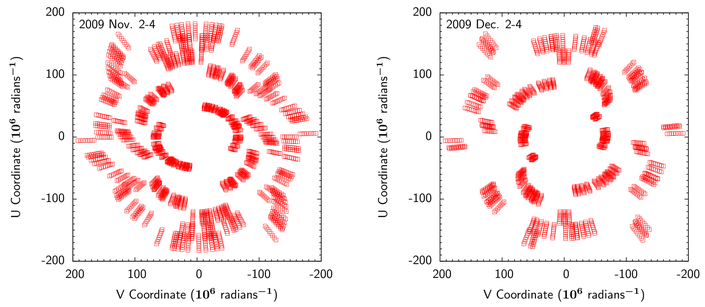
Tuesday 215.03 - Citizen Sky, IYA 2009 and Whats To Come

Wednesday 467.06 - Citizen Sky, Solving the Mystery of epsilon Aurigae

Wednesday 467.07 - Statistical Software Development as an Example of a Citizen Sky Participant Team

CHARA - Interferometric Imaging

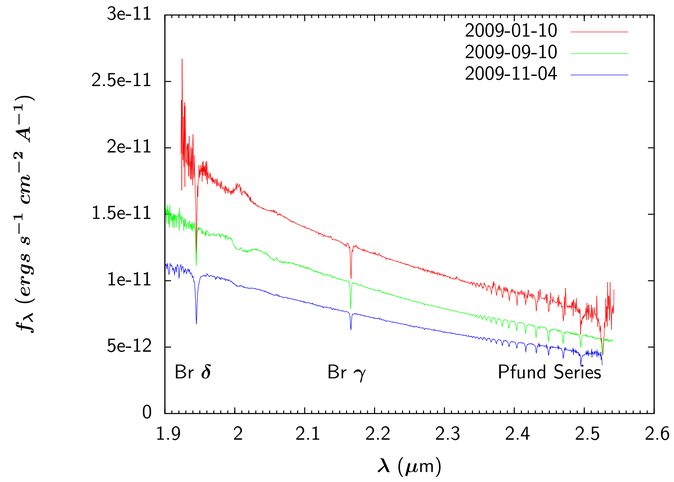
The ϵ Aur Interferometry Team used the MIRC four-telescope beam combiner at the CHARA array to obtain high-resolution (0.5 milliarcsecond) images of epislon Aurigae during autumn 2009. These images and a model for the eclipsing body will be discussed in an upcoming paper. The UV plane coverage for (UT) Nov. 2-4 and Dec. 2-4 are plotted below.



The eps Aur Interferometry Team consists of Kloppenborg, B.[1], Stencel, R.[1], Monnier, J.[2], Schaefer, G.[3], Zhao, M.[4], Baron, F.[2], McAlister, H.[3], ten Brummelaar, T.[3], Farrington, C.[3], Pedretti, E.[5], Sallave-Goldfinger, P.[3], Sturman, J.[3], Sturman, L.[3], Thureau, N.[5], Turner, N.[3], Che X.[2], and Carroll, S.[6] from [1]The University of Denver, [2]The University of Michigan, [3]CHARA/Georgia State University, [4]JPL, [5]The University of St. Andrews, Scotland, UK, and [6]The California Institute of Technology.

IRTF - IR Spectroscopy

In order to better characterize the eclipsing body in the ϵ Aur system, two of us (B.K. and R.S.) have pursued infrared spectroscopy at NASA IRTF. Our observations span 0.5 μm to 5.0 μm at R=2500.

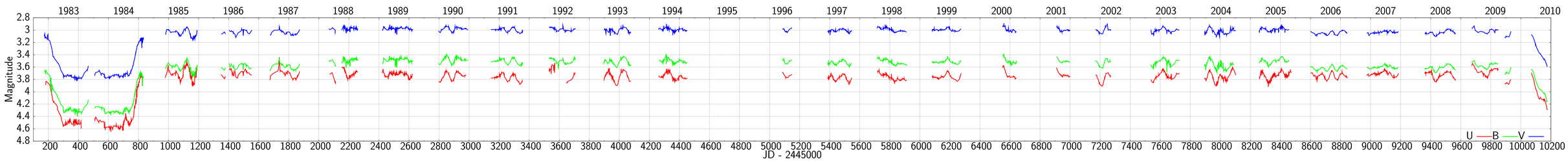


The continuum has been left in the spectra in order to show the clear decrease since the onset of the eclipse. The 2009 Jan. 01 observation was conducted eight months before ingress was detected photometrically. These observations are being used to create a longitudinal map of the disk's structure. Related observational monitoring is underway with BASS and MIRSI by Michael Sitko, with MIRAC by Joseph Hora, and with 2SPEC by William Ketzebak and collaborators.

Acknowledgements

The University of Denver participants are grateful for the bequest of William Hershel Womble in support of astronomy at the University of Denver. The authors are grateful to Robin Leadbeater and Brian McCandless for permitting their data to be displayed on this poster.

Please see the ϵ Aur campaign websites at: http://www.hposoft.com/Campaign09.html and http://www.du.edu/∼rstencel/epsaur.htm



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