2009 Epsilon Aurigae
Eclipse Campaign Newsletter #6
Summer 2008

Campaign Web Site
http://www.hposoft.com/Campaign09.html

Dear Colleagues,

Summer is here and with the hot temperatures (several days a few weeks ago in excess of 121 degrees F at HPO) and onslaught of the monsoon season, observing in Arizona has slowed considerably. In addition, epsilon Aurigae is below or very low on the horizon now. We hope to get some first UBV photometric data of the new season near the end of July. This will mean pre-twilight observations which are fairly nice as that is about the only time the temperature in the observatory is reasonable. The next season is the last pre-eclipse season and will be a last chance to make out-of-eclipse observations prior to the eclipse. While the real excitement starts next summer, there is still much to be learned before first contact. In addition, now is a good time to calibrate equipment and refine observational techniques. Epsilon Aurigae will be rising just before sunrise in the Northeast in early July so any early risers in the higher latitudes can get an early start.

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Standard Stars For Epsilon Aurigae

Brian Skiff of the Lowell Observatory in Flagstaff, Arizona has suggested some stars in the vicinity of epsilon Aurigae that can be used to determine color transformation coefficients:

Names			RA (J2000)	Dec	
ε (Epsilon) Aur	HR 1605	HD 31964	5 01 58	+43 49.4	
58 Per	HR 1454	HD 29094/5	4 36 41	+41 15.9	
59 Per	HR 1494	HD 29722	4 42 54	+43 21.9	
1 Aur	HR 1533	HD 30504	4 49 55	+37 29.3	
2 Aur	HR 1551	HD 30834	4 52 38	+36 42.2	
ω (Omega) 4 Aur	HR 1592	HD 31647	4 59 15	+37 53.4	(cpm pair)
5 Aur	HR 1599	HD 31761	5 00 18	+39 23.7	
6 Aur	HR 1602	HD 31780	5 00 23	+39 39.3	
ζ (Zeta) Aur	HR 1612	HD 32068/9	5 02 29	+41 04.6	

η (Eta) Aur	HR 1641	HD 32630	5 06 31	+41 14.1
μ (Mu) Aur	HR 1689	HD 33641	5 13 26	+38 29.1
λ (Lambda)Aur	HR 1729	HD 34411	5 19 08	+40 05.9
ρ (Rho) Aur	HR 1749	HD 34759	5 21 48	+41 48.3
ξ (Sigma) Aur	HR 1773	HD 35186	5 24 39	+37 23.1

Names	**V**	**B-V**	**U-B**	**V-Rj**	**R-Ij**	**R-Ic**	**V-Ij**	**MK**
eps Aur	2.98	0.54	0.32	0.52	0.45		0.97	F0Ia
58 Per	4.25	1.22	0.79	0.98	0.69		1.67	G7Ib + B9:
59 Per	5.31	0.01	0.02	0.00				A0Vn
1 Aur	4.89	1.45	1.71	1.09	0.787 0.006	0.707 0.006	1.88	K3+ III
2 Aur	4.78	1.41	1.58	1.09	0.78	0.672 0.006	1.87	K3- III Ba0.4
ω 4 Aur	4.94	0.05	0.01	0.05	0.03		0.08	A1V + F9V
5 Aur	5.95	0.41	-0.04					F5V
6 Aur	6.46	1.71	2.01					K4I
ζ Aur	3.75	1.22	0.38	1.13	0.87		2.00	K4II+ + B5.5
η Aur	3.17	-0.18	-0.67	-0.05	-0.17		-0.22	B3V
μ Aur	4.84	0.19	0.10	0.19	0.10		0.29	kA2hA7mA7(IV)
λ Aur	4.70	0.62	0.13	0.53	0.320 0.007	0.319 0.006	0.85	G1.5IV-V Fe-1
ρ Aur	5.22	-0.15	-0.58					B5V
ξ Aur	5.00	1.42	1.76		0.740	0.664		K3III CN+2

Boyd used a different comparison star which is over a magnitude fainter.
HR1644 , HD32655
V= 6.20 B=6.63 U= 6.93.

Brian says looking at the GCPD and Kornilov for this star, I'd suggest:
V = 6.218
B-V = 0.451 (from Kornilov)
U-B = 0.33 (mainly Fernie)
V-Rj = 0.41
R-Ij = 0.30
V-Ij = 0.71 (all Fernie)

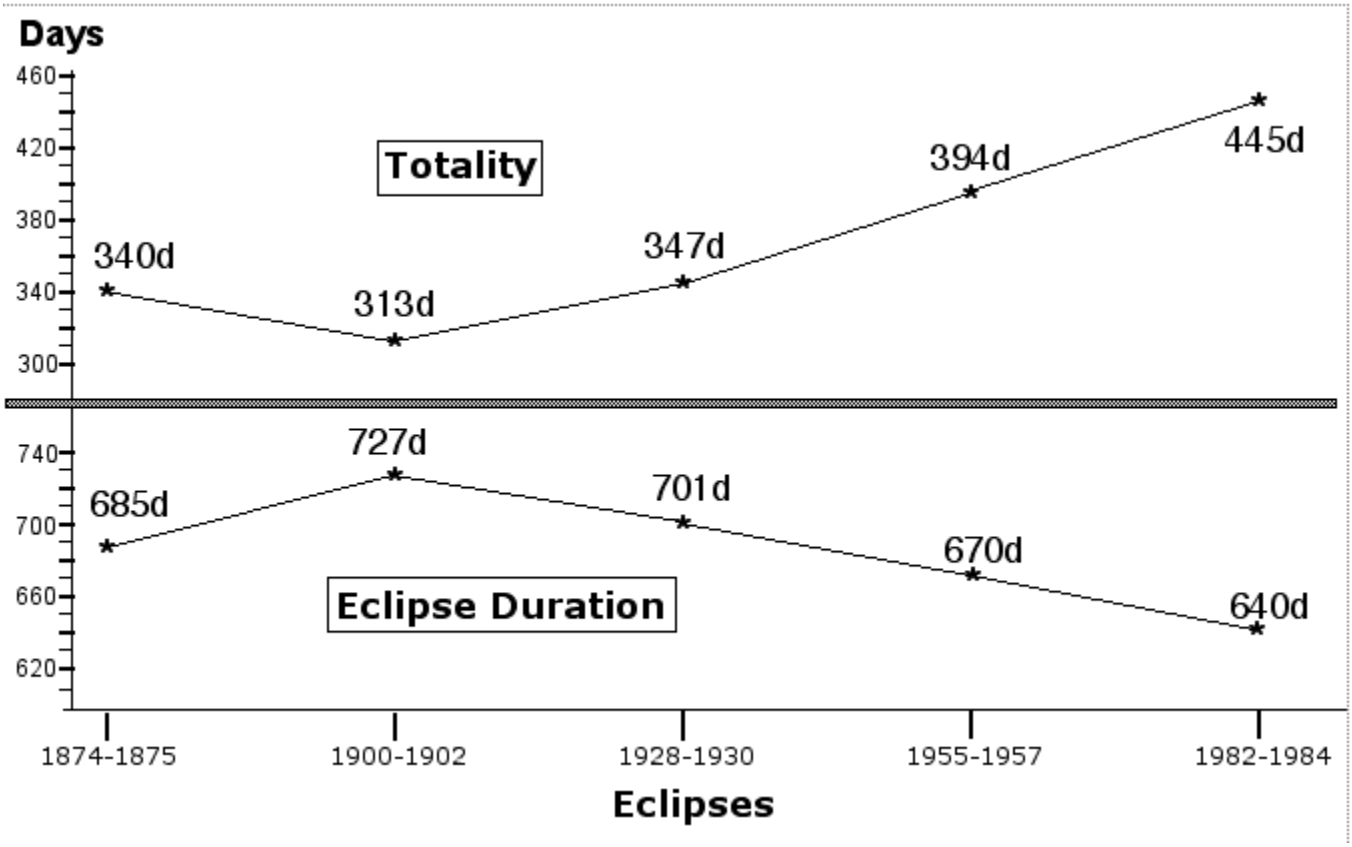
This star is as poorly observed as the others in terms of photometric indices. The MK type suggests it is a fairly evolved star in the Hertzsprung gap (F0IIIa or F2II-III).

0.006 0.006

Recent Translations and Past Eclipse Plots

Roger Mansfield of the Astronomical Data Service in Colorado Springs, Colorado has kindly translated from German into English, two important papers by Ludendorff that discuss the 1874 and 1901 eclipses. The originals and translations can be found on the Campaign web page under Photometry References. These translations have helped us extend the knowledge of changes in the disk during the past century.

The following figure shows the estimated durations of totality only and duration of entire eclipse (including partial phases) for the past five eclipses. Quite obviously, the long term changes suggest the coming eclipse may feature very quick partial phases.



Past Eclipse Photometric Data

Brian Skiff of the Lowell Observatory in Flagstaff, Arizona has researched photometric data for past eclipse and complied the data for us. HPO has plotted the data and created .pdfs of it. These documents are now available on the Campaign web site under Photometry References.

News from our Campaign Members

From Paul Beckmann in Minneapolis, Minnesota USA area (14 May 2008)

Greetings Campaign members.

I've been busy re-engaging in the Eps Auriga BVRI single-channel as the semester winds down. A large part of that work has been focused on what can be done here to make observing more consistent during an always hectic academic year. The challenges faced here at JBO are:

* no shelter structure for the telescope & instruments & no realistic hope of obtaining permission from the city to build one given the building restrictions in place.(Our lot backs up to a wetland.)
* "mitten weather" throughout much of the peak observing season (unlike HPO that enjoys beautiful weather in the winter!)
* harsh teaching schedules with skeptical college students over most of the observing season (placing a limitation on the amount of sleep deprivation allowable).
* bright suburban skies, especially to the NW in the direction of downtown Minneapolis.
* limited actual experience with BVRI photometry.
* age on the close approach to 60.

Central issues have been:

* fumbling around switching the BV / RI sliders back and forth in an SSP-3
* very difficult recording of data with low temps, mittens, frozen pens, etc.
* poor ergonomic access to the SSP-3 eyepiece as the star approaches the horizon
* less than optimal data recording with little journaling of weather and poor time-stamping of data
* haphazard measurement of standard stars for assessment of extinction coefficients
* poor planning of observation sessions that leads to inefficient time at telescope/missed opportunities.

We're addressing these issues as follows:

* conversion of mount from Meade LX3 fork to a Hypertuned LXD55 "GOTO" mount
* acquisition of proper counter weighting systems
* continued control of dew and low temp effects with Kendrick's heaters.
* conversion of SSP-3 to SSP-3A with motorized filter changing
* development of acquisition software that will run on an indoor computer and will control the SSP-3, acquire local weather data from backyard, acquire GPS-generated time for time stamping, generate both printed and comma-delimited text file records of the observations.
* development of a custom pendant for the observing position that will

provide a number of "mitten-compatible" buttons to initiate filter change, gain and integration time control, and star type or sky indication. Pointing of the telescope will initially be under the observer's direct control.

* planting of three deep but small concrete pads for the heavy-duty tripod at a location in the backyard that will give us the best view to the NE and NW horizons. This location is least susceptible to nearby illumination from house lights and headlights of cars driving by.
* attention to better planning techniques to map out EpsAur visibility throughout the season and groups of standard stars to use during any observing interval.
* practice & system debug throughout the summer months possibly on other stars while time is more available than during the academic year.
* investigation of means to provide "temporary" shelter for the telescope during the day and shielding from the harsh winter winds during observation.

Some of these are complete, some are underway. Any thoughts, suggestions, or encouragement are welcome. Stay tuned for future updates from Minnesota!

Best,
--Paul Beckmann
Jim Beckmann Observatory
Mendota Heights, MN
44=B053'16.48"N, 93=B006'52.74"W
941 ft.

From Dr. Bob

As noted in the SAS 2008 meeting paper by Hopkins, Schanne and Stencel, Table 7, the eclipse timings are changing. To help bring attention to the coming eclipse, I prepared the following press release for the St. Louis meeting of the American Astronomical Society, to share the information with science reporters. Several reporters did include notice of the story in their meeting reports - search the web with keywords: stellar fireworks epsilon Aurigae

Press Release Tuesday June 3, 2008

FOR RELEASE: 9:40 AM Central Daylight Time, June 3, 2008

Contact information:
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ASTRONOMERS PREDICT NEARBY STELLAR FIREWORKS BY MID-CENTURY

Astronomers are announcing today the prediction that the bright northern star called epsilon Aurigae is headed for a "doomsday event" within a few decades. The report is being presented by Dr. Robert Stencel of the University of Denver Observatories in a press conference at the American Astronomical Society meeting in St. Louis, Missouri. Observations over the coming three years, when the mysterious star undergoes a once-per-generation eclipse event, may hold the secret to the extreme changes detected during the past few decades.

THE DETAILS:

Science case:

What could be simpler than an eclipsing binary star? As they orbit each other, it is relatively easy to measure brightness change and the duration of change, and, from simple geometric arguments, to obtain size and temperatures for each star in the binary. With the addition of Doppler spectroscopy, which measures orbital velocities, one can solve for mass of each star, using Kepler's third law.

The classic example of this is the so-called Demon Star, Algol, which exhibits 2 hour eclipses every 2.87 days. With such eclipsing binary stars, astronomers can calibrate important parameters that describe a star's structure. The Vogt-Russell theorem says the mass, composition and age uniquely determine the stellar structure, when normal laws of physics are applied. This theorem appears largely true, except for epsilon Aurigae - the real "Demon star". It's behavior has "bedeviled" astronomers for centuries.

The spectrum of epsilon Aurigae looks like a normal F supergiant star, estimated at about 12 to 15 times the mass of the Sun. The orbit data implies that the mass ratio in the binary is close to one, implying that the companion is about 12 to 14 solar masses as well. Epsilon Aurigae exhibits Algol-like eclipses every 27 years, which last

for nearly 2 years. The next one starts in August 2009, and should run through May 2011.

The problem? The 12 to 14 solar mass second "star" is largely INVISIBLE! The best model (Huang, 1965) says the secondary is a huge dark disk, not a sphere. Such a shape needs a massive central object(s) to stabilize it.

Normal eclipsing binary star analysis suggests that the secondary is about 10 A.U. across (10 times the distance from the Earth to the Sun, or 930 million miles). It does not emit anywhere near the amount of light expected from a star of its size. Scientists are confident that it is not a black hole, because it hasn't been detected with X-ray observations (Einstein, Swift).

Epsilon Aurigae shows low amplitude quasi-periodic light variations, similar to Cepheid variable stars. Cepheid variable stars are close relatives of epsilon Aurigae, being high mass yellow stars prone to pulsation - a useful property in terms of their Period-Luminosity relationship. Currently the light variations in epsilon Aurigae are on a 67 day cycle, but -KEY POINT- these were nearer to 100 days during the last two decades. Something is accelerating in this system! At this rate, variations will become very rapid within six decades, perhaps cataclysmically so. Much of the relevant photometric data has been obtained by Jeff Hopkins of Phoenix Observatory, Arizona (http://www.hposoft.com/EAur09/EAur0307Plots.html), Il-Seong Nha of the Yonsei University Observatory, Korea (http://adsabs.harvard.edu/abs/1993ASPC...38..291N) and other observers.

But wait---there's more. Observations made during the last eclipse suggest that the F supergiant star may be shrinking by about 1/2 percent per year (noted in 1986 by Mamuro Saito and Masatoshi Kitamura at Tokyo Astronomical Observatory - http://adsabs.harvard.edu/abs/1986Ap%26SS.122..387S). The duration of total eclipse (during which the F star is partially covered by the disk shaped companion) has increased by about 25 percent between the 1956 and 1983 eclipses. Despite this, the overall length of the total plus partial phases of eclipse - especially the time where the F star moves out from the cover of its partner - has gotten shorter!

If these trends continue, the F star will come out of eclipse (from totality) in only 1 or 2 weeks during 2011. BUT, it will still take 140 days or so to move from the beginning of the eclipse to totality next year, autumn.

What is changing, and what do the variations mean? Is this binary system preparing for an energetic event?

Is the light variation due to changes in the F supergiant star's radius or temperature? Using the well-known correlation among stellar luminosity, radius and temperature, a ten percent change in Luminosity can result from a 5 percent change in Radius, or a 2.5 percent change in Temperature. At an estimated distance of 625 pc, and assuming the F supergiant star is close to the nominal 100 solar diameters appropriate for its type, then the implied angular diameter is 3 milli-arcseconds. Modern interferometers, like the Palomar Testbed Interferometer (PTI, San Diego

County, CA), are capable of measuring down to fractions of one milli-arcsecond, close to that 5 percent change anticipated, and these measurements are underway. These measurements would help confirm that the F star could be causing the accelerating light changes.

What's a milli-arcsecond? Astronomers use angular measures much finer than degrees on a protractor. The arc-second is 1/3600 part of one degree, and a milli-arcsecond is 1000 times finer. A 25 cent US coin seen at a distance of 6,500 miles (10,000 km) subtends about one milli-arcsecond.

The best model for the eclipsing object makes a clear, testable prediction that is suitable for interferometry: the F supergiant star should be BIFURCATED (cut in half) by the eclipse-causing disk, if indeed it is a disk. Next generation imaging interferometers like CHARA at Mt. Wilson and MROI at Socorro, should be easily able to monitor this set of changes. If the disk is causing the changes in the system, that should be seen with these measurements.

Bonus points: Public participation!

The epsilon Aurigae eclipse event is being promoted as one facet of the International Year of Astronomy, IYA2009: http://astronomy2009.us/citizen_science/ . It is a bright star that can be seen despite light pollution, monitored both visually and with the simplest of digital camera equipment. One goal is to better define the eclipse duration and catch the mysterious central eclipse brightening. The observing activity is intended to promote citizen science in honor of the 400th anniversary of the telescope and Galileo's applications of it. JOIN US FOR THE 2PM SESSION #68 TODAY, ROOM 232: Citizen Science & IYA - Your role, and poster #35.02, Price et al.

In summary, the bright northern star, epsilon Aurigae, is exhibiting rapid changes suggestive of dramatic events within one or two eclipse cycles, later this century. "These changes offer a chance to examine the dynamics of rapidly changing stellar disks on a human time scale, and an opportunity for the public to see for themselves that stars change."

==end of text==

Lots of additional material available at web page:
http://www.du.edu/~rstencel/epsaur.htm

Artwork and illustrations, at web page:
http://www.du.edu/~rstencel/epsaurnews.htm

Forthcoming publication: Epsilon Aurigae - the Book (Hopkins and Stencel, 2008 summer).

References:

Disk Model, S.S. Huang 1965, Astrophysical Journal, vol. 141, p.976
Epsilon Aurigae Star System Model, Sean Carroll, et al. 1991 Ap.J. 367: 278 [invited speaker, cosmology session,Wed. #94.01]
Photometry, Jeff Hopkins, Phoenix AZ: phxjeff@hposoft.com

Artwork inspired by epsilon Aurigae: M.Carroll, D. Weeks, D. Egge.
Contact info for artists:
Michael Carroll - cosmicart@stock-space-images.com
Daniel Weeks - ouiques@comcast.net - 717 264 8570
D. Egge - not available.

Interferometer web sites:
PTI - http://pti.jpl.nasa.gov/index.html
CHARA - http://www.chara.gsu.edu/CHARA/array.html
MROI - http://www.mro.nmt.edu/

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CALENDAR OF ECLIPSE EVENTS:
2009 Aug 6th - predicted start of eclipse (partial phase)
2009 Dec 21st - predicted start of totality
2010 Aug 1st - predicted, mid-eclipse
2011 March 12th - predicted end of totality
2011 May 15th - predicted end of eclipse
...
2036 - next eclipse starts in autumn 2036.

Footnote regarding Cepheids:
Recent paper on long-period galactic Cepheid RS Puppis by Kervella et al.
http://adsabs.harvard.edu/abs/2008A%26A...480..167K
"The bright southern Cepheid RS Pup (P=41.4 d) is surrounded by a circumstellar nebula reflecting the light from the central star. The propagation of the light variations from the Cepheid inside the dusty nebula creates spectacular light echoes that can be observed up to large distances from the star itself. This phenomenon is currently unique in this class of stars..."

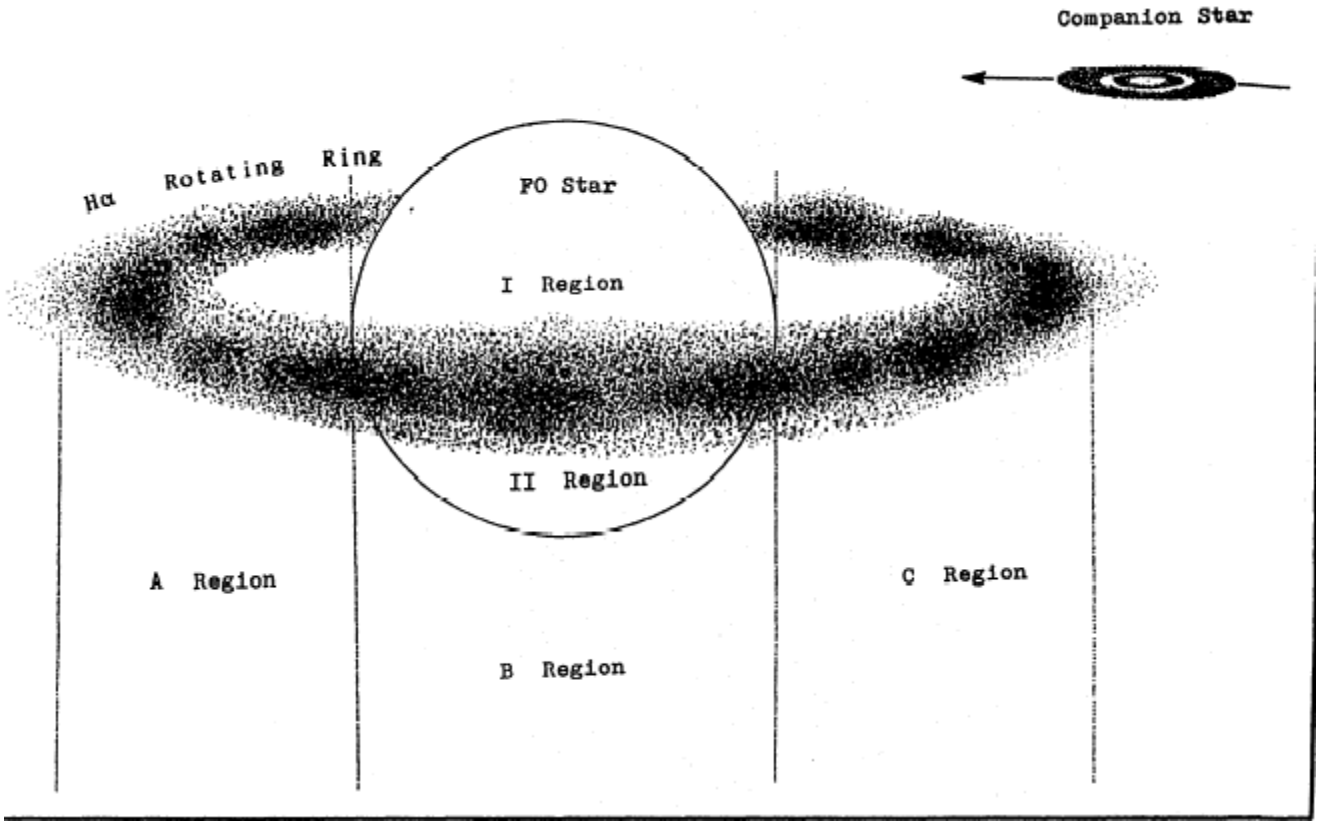
[end]

Interesting Paper

Robin Leadbeater pointed out a very interesting 1994 paper by Cha et al.

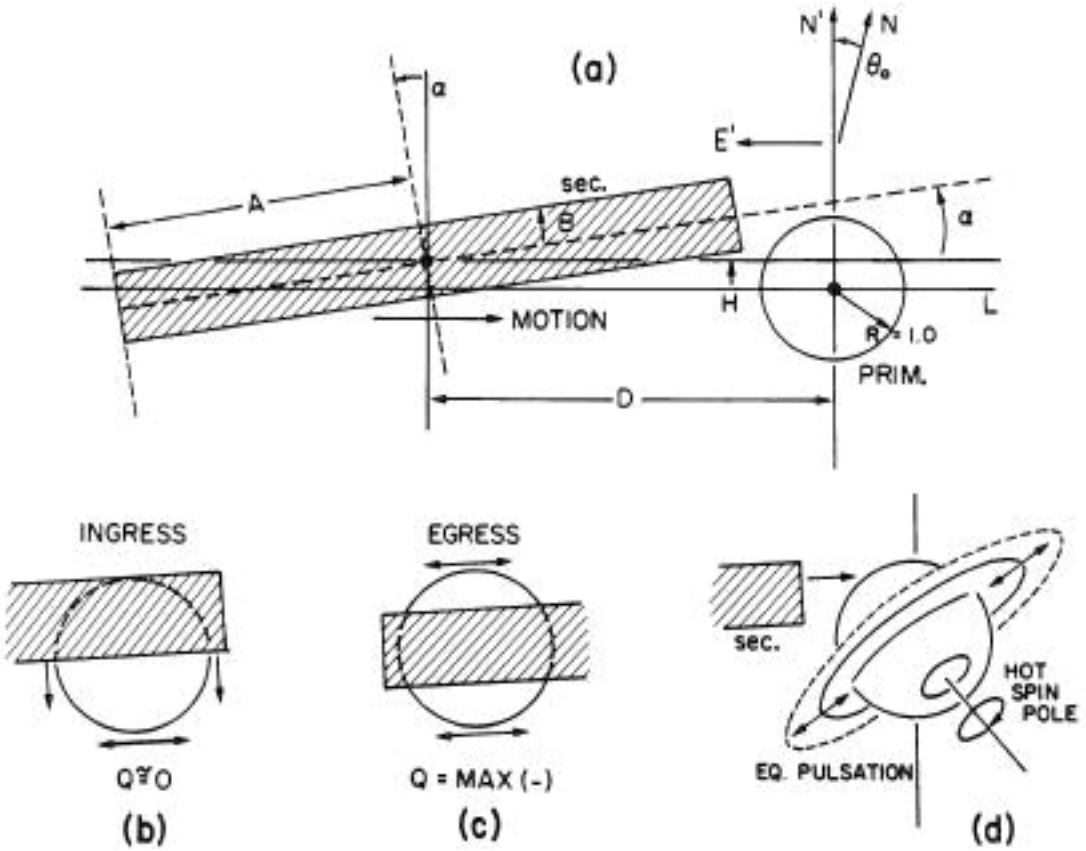
High-dispersion Ha spectroscopy of E Aurigae
CHA G.; TAN H.; XU J. LI Y.
Astron. Astrophys., 284, 874-882 (1994)

Here the authors explore the significance of the hydrogen α profile changes and propose that here is a hydrogen gas disk surrounding the primary star. A .pdf of the paper can be downloaded from the Campaign web site under Spectroscopic References. Below is a diagram of the F star in the system, featuring a lumpy equatorial ring to explain the H-alpha variations.



From Cha's Paper

Kemp et al. 1986 Ap.J. included a similar ring as a feature in the binary system as well.



Model geometry of the eclipse, showing in Figure a the model parameters. Figure d is a hypothetical geometry for future modeling involving a titled, rotating primary star with nonspherical pulsations possibly correlated with the spin axis.
J. Kemp et al. 1986 Astrophys. J. 300, L11.

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Anyone wishing to contribute to the Newsletter, is most welcome. Please send contributions to me at phxjeff@hposoft.com.

Anyone desiring not to receive the Newsletter announcements, please e-mail me and I will remove your name from the mailing list.

Clear Skies!
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