



epsilon Aurigae

Update on the 2009-2011 eclipse

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twitter.com/epsilon_Aurigae

CITIZEN SKY workshop 2
Cal. Academy of Sciences
September 3, 2010

<http://www.citizensky.org>

epsilon Aurigae 2008 Michael Carroll
(c) R. Stencel, Denver University

9/3/20

(c) 2010 Univ. Denver



All about epsilon Aurigae



- Developments since Citizen Sky Workshop 1
(2009 Aug, Adler) and prior to mid-eclipse (2010 Aug 1)
- Very recent developments – mid-eclipse & beyond
 - *Light curve evolution; spectral asymmetries?*
- Coming attractions, 2011 & beyond
 - *Will egress start on schedule? Predix: 3/19/2011*
- You came for eps Aur, now stay for the AAVSO feast
- Our goal: helping you report your efforts

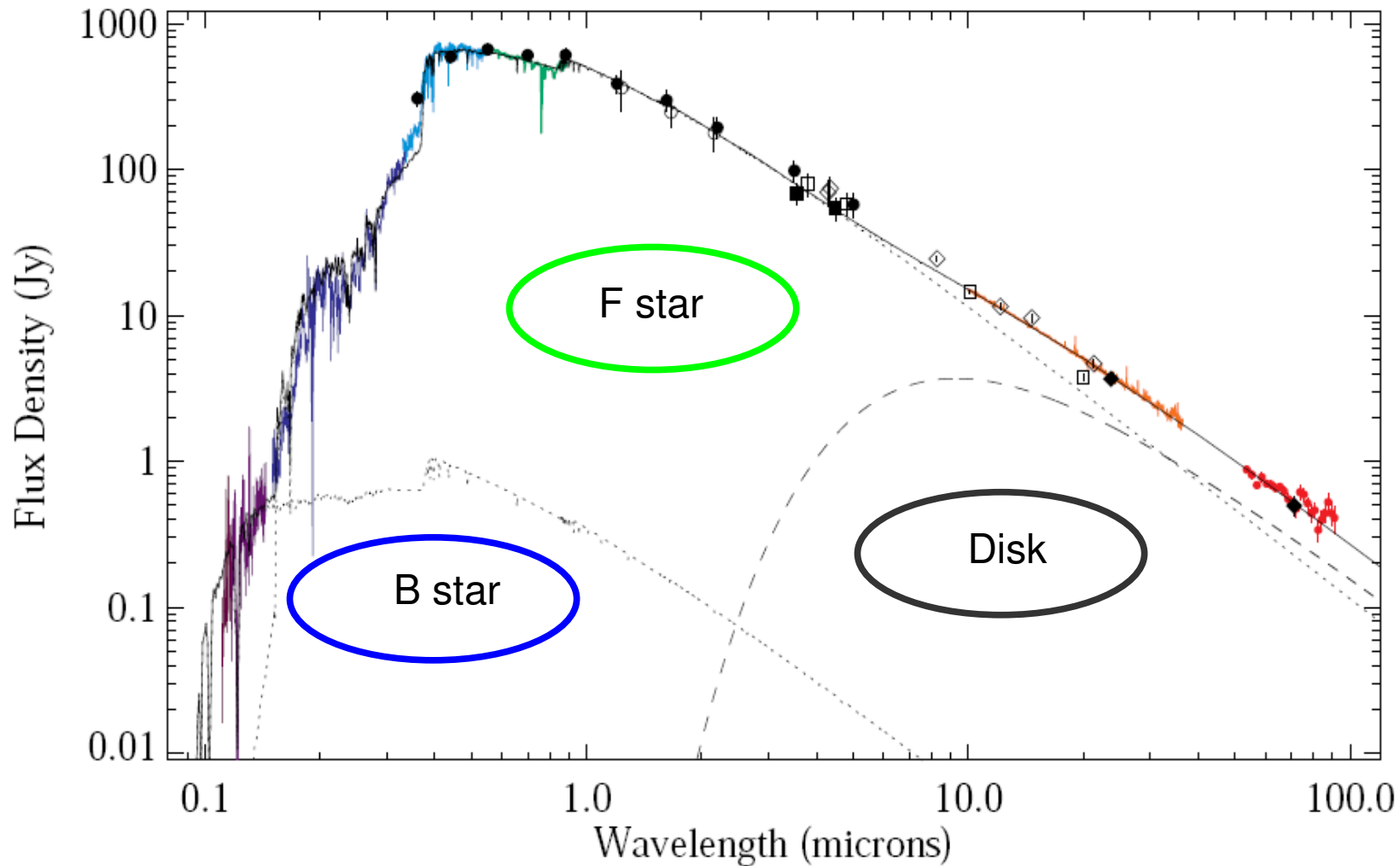
QUICK RECAP of DEVELOPMENTS AT/SINCE ADLER MEETING:

The spectral energy distribution (SED) analysis has provided a detailed system model – HHS: <http://arxiv.org/pdf/1003.3694v1>

ϵ Aurigae from the Far-UV to the Mid-IR

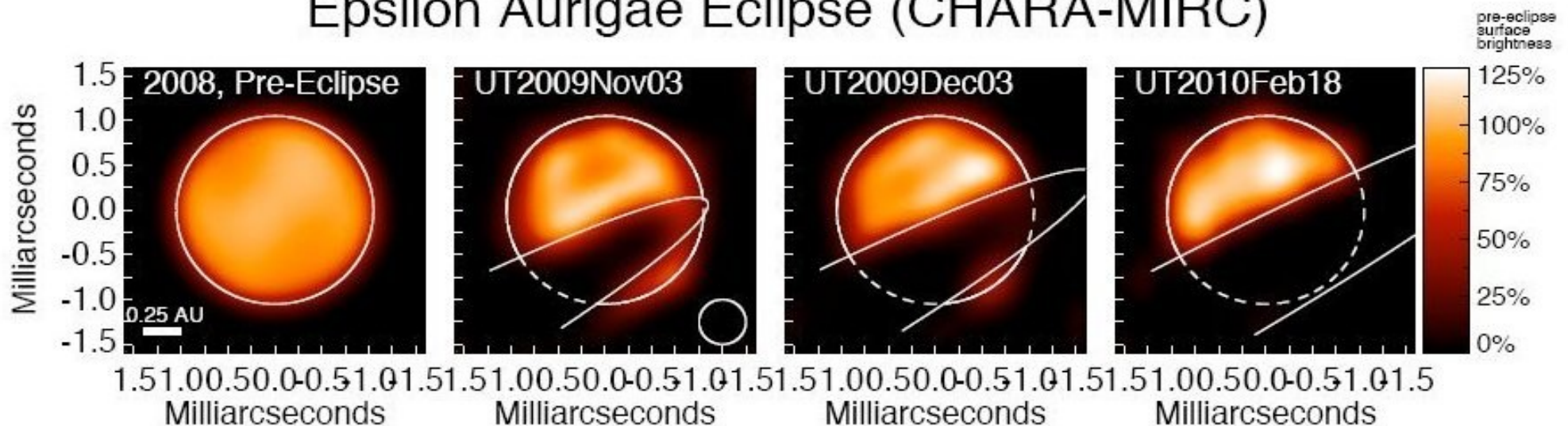
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Hoard, Howell & Stencel 2010 ApJ & <http://arxiv.org/abs/1003.3694> .

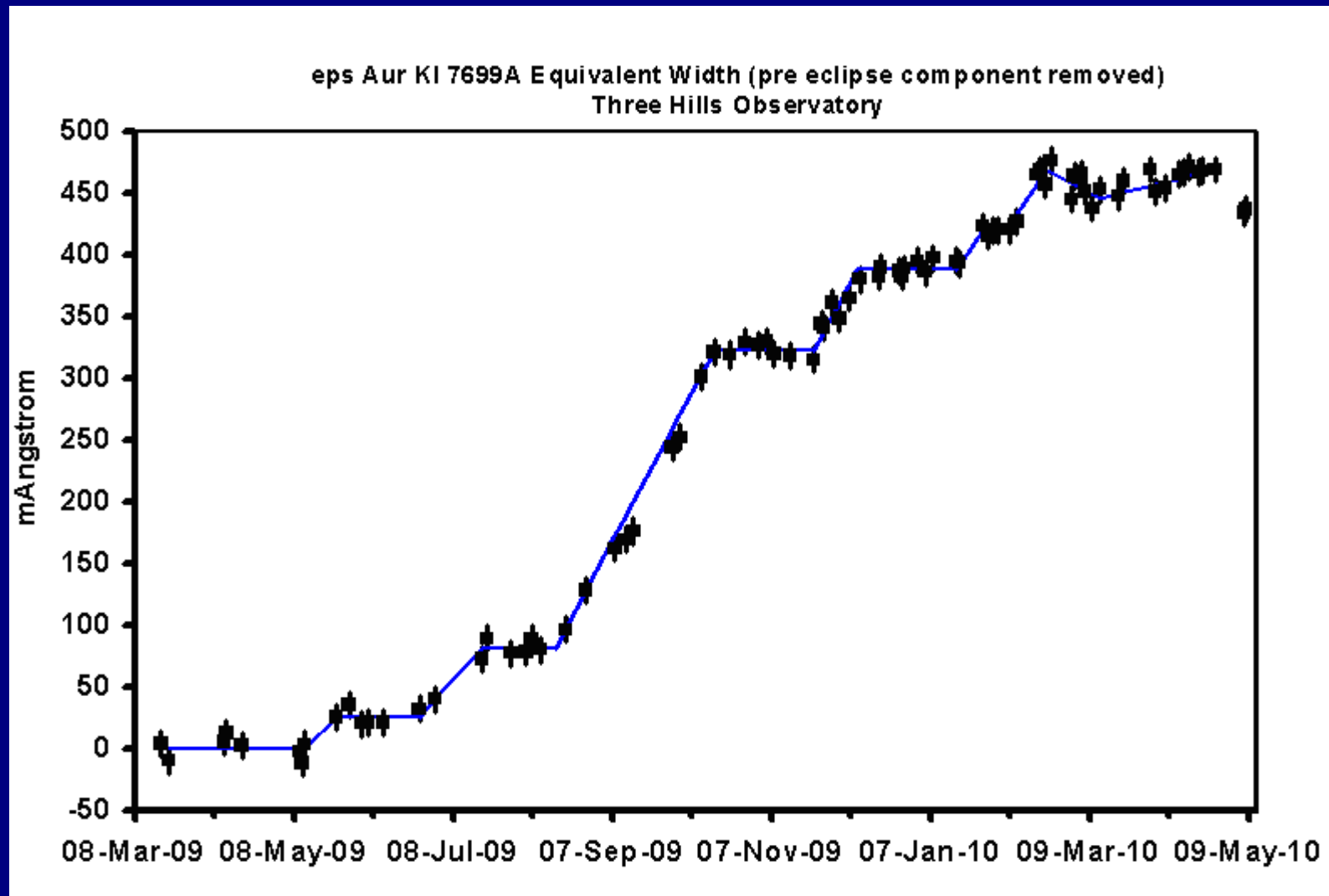


Interferometric imaging clearly showed the silhouette of a dark, elliptical object advancing across the face of the F star, fully consistent with the disk hypothesis and constraining the mass ratio to be $\sim 2:1$ in favor of the disk's central B star - see *Kloppenborg et al. 2010 Nature* & <http://arxiv.org/pdf/1004.2464> for details.

Epsilon Aurigae Eclipse (CHARA-MIRC)

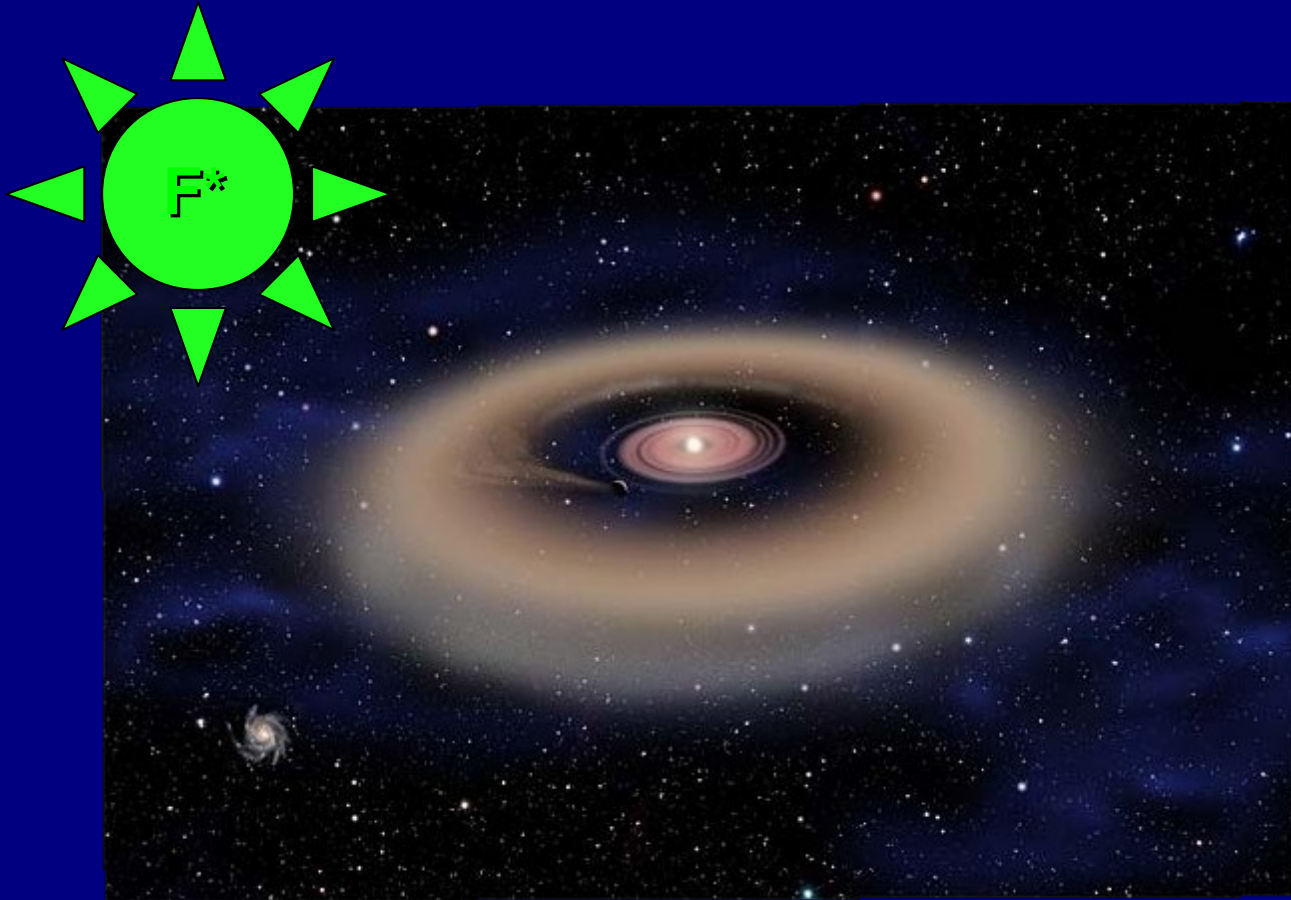


SPECTROSCOPIC DEVELOPMENTS: Many, including: Robin Leadbeater's remarkable monitoring of the neutral potassium line strength (7699A) showed plateaus during ingress, the nature of which deserves further study - details: L&S <http://arxiv.org/pdf/1003.3617> . Correlated with OOE?



The open questions include:

- the nature of material in the dark disk, and
- the evolutionary status of the system overall.



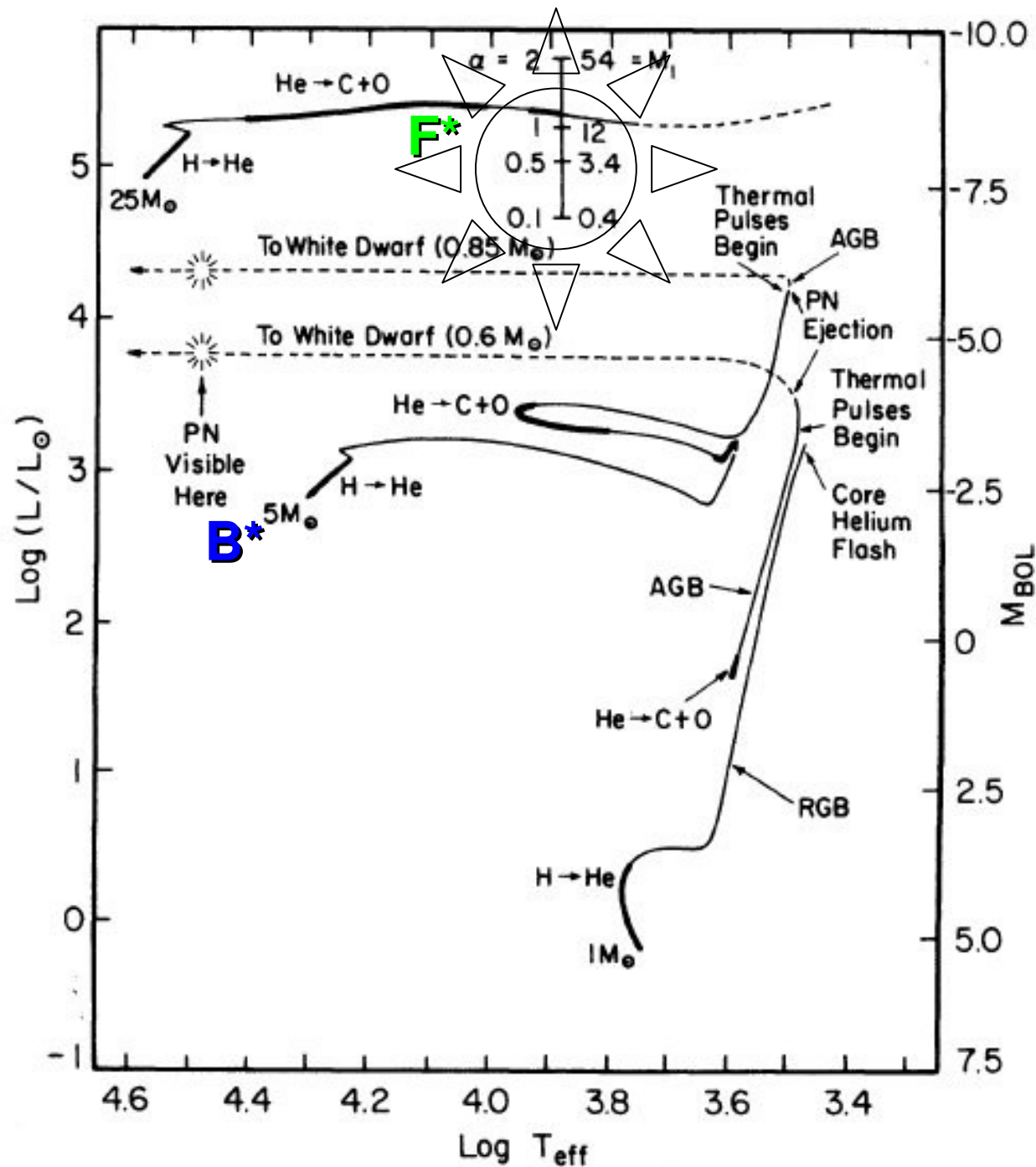
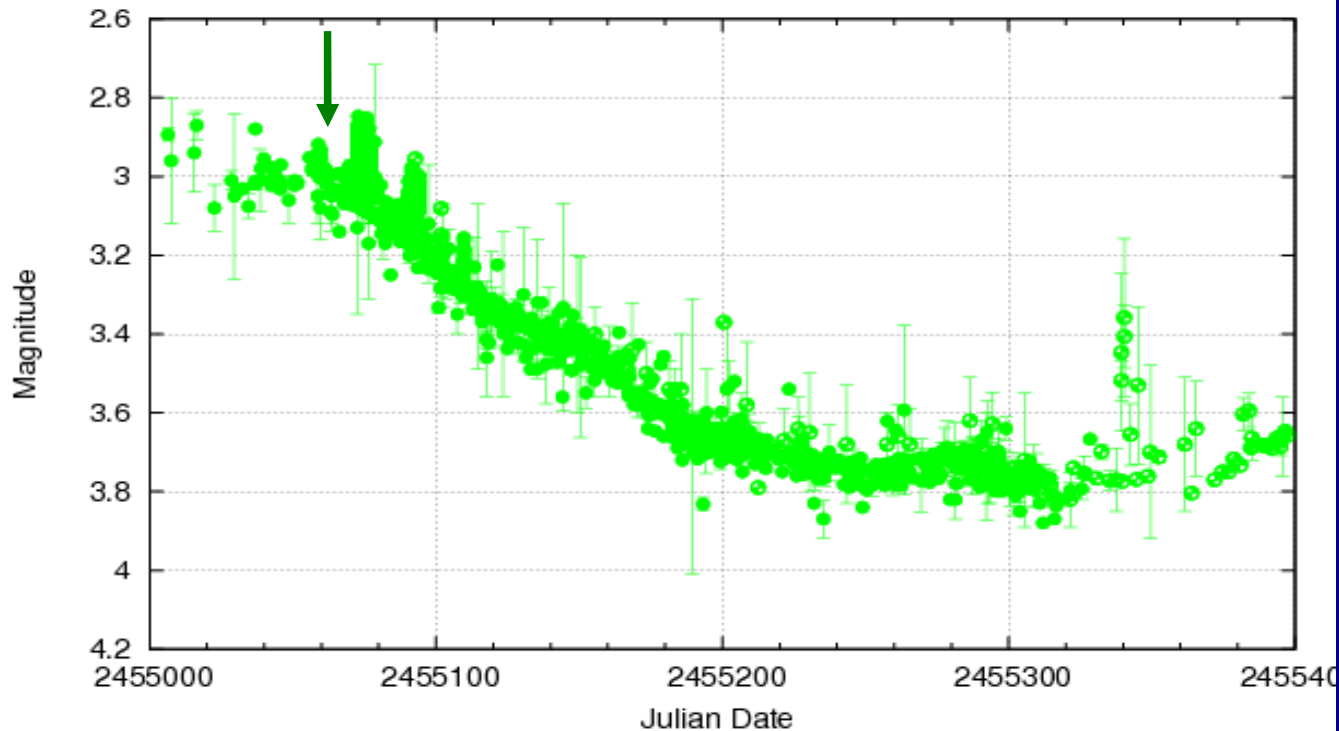


FIG. 11—The H-R diagram adapted from Iben (1985). Predicted luminosities for the primary star are shown as a function of the mass ratio α .

Developments – prior to mid-eclipse (8/4/2010)

- **First contact** was ~ on schedule, as predicted:
 - 8/15/2009 = RJD 55,060 +/- 10 days

Light Curve of EPS AUR

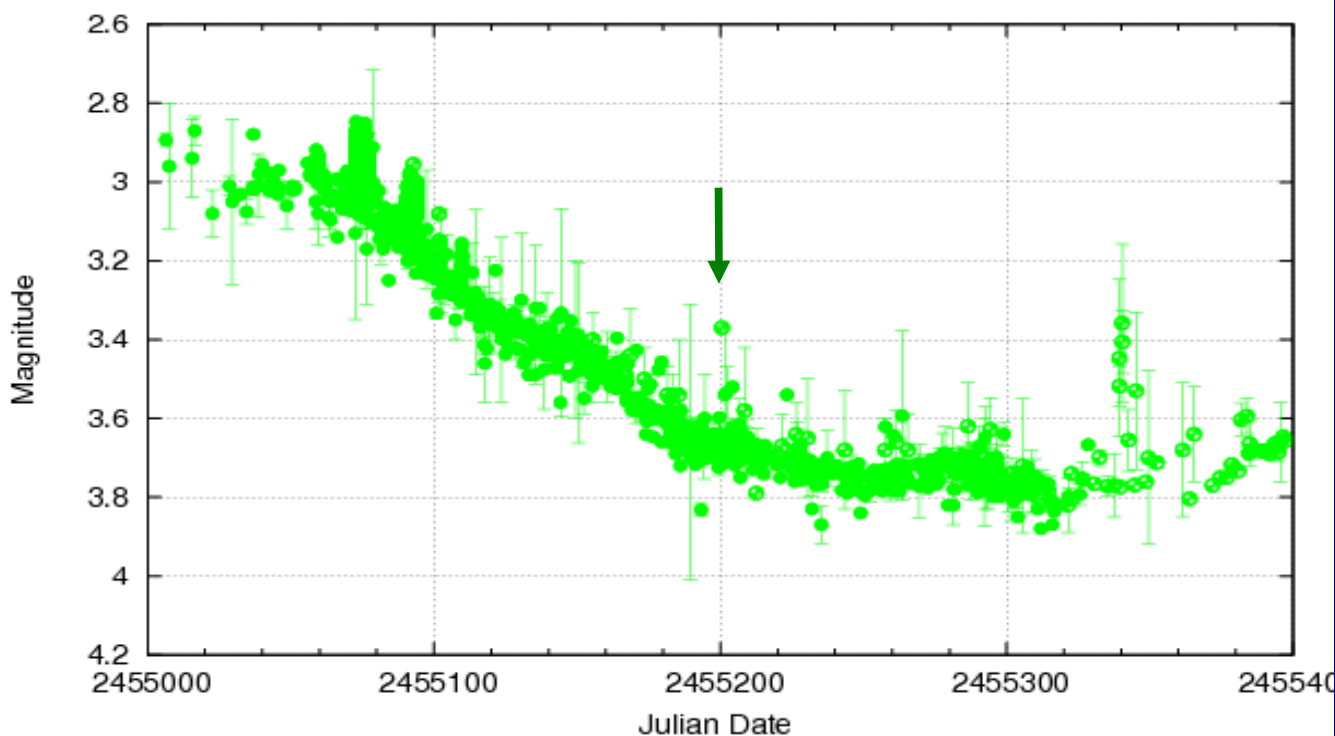


What is Julian Date?

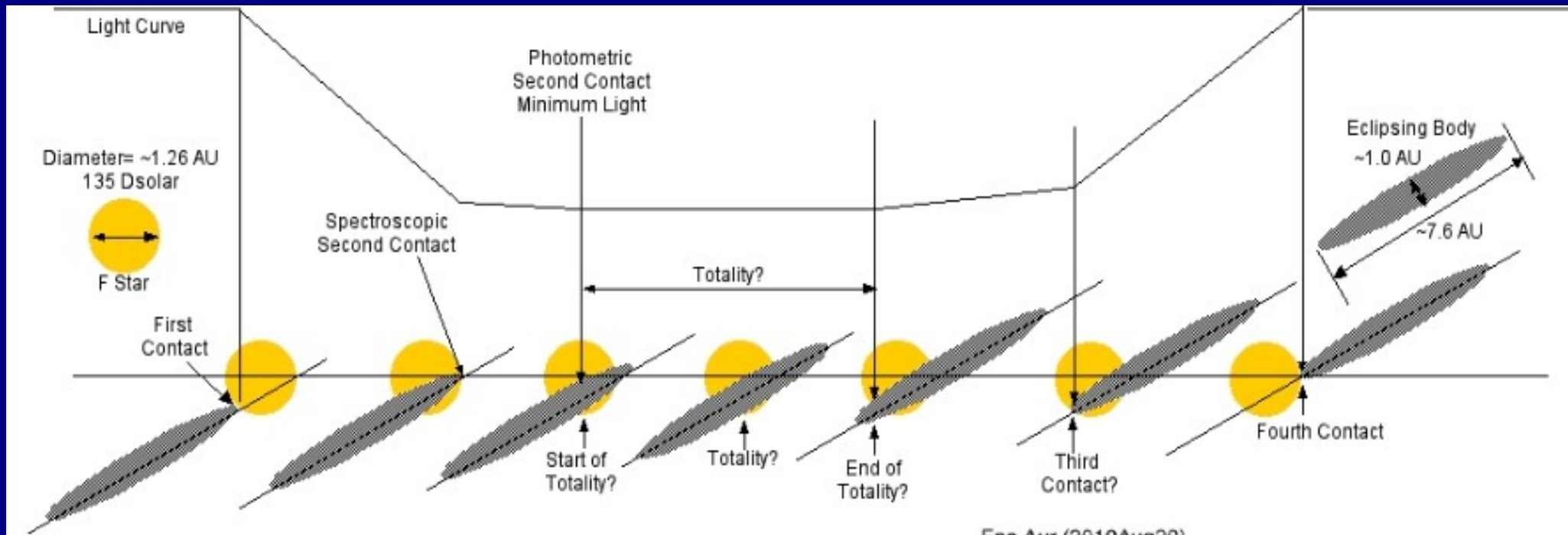
More developments – prior to mid-eclipse

- **Second contact?** Predicted for 1 Jan 2010 = 55,200
 - Maybe / slope change, but newly imaged disk changes the interpretation...

Light Curve of EPS AUR



What is Julian Date?



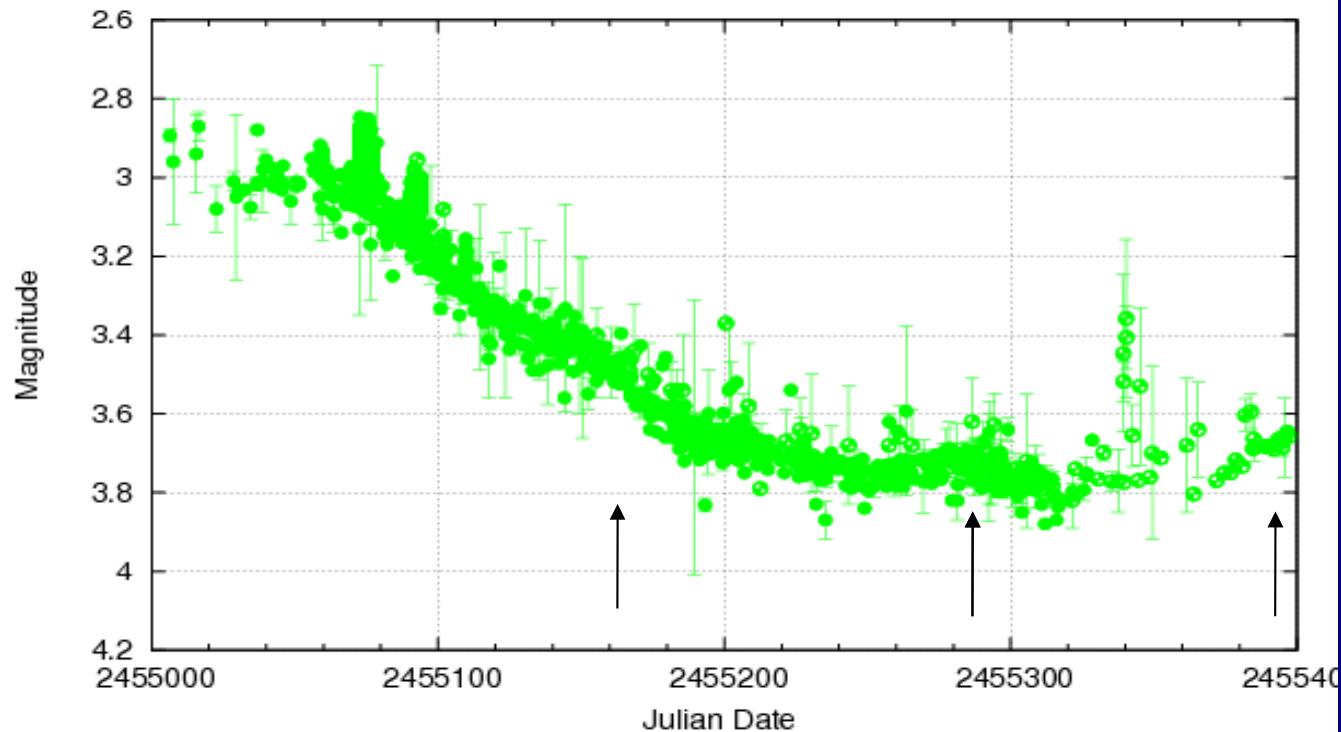
Light curve times of contact – graphic by Jeff Hopkins

Still more developments – prior to mid-eclipse

– Structure in the light curve!

- Bumps in the night: “OOE” or disk-related?

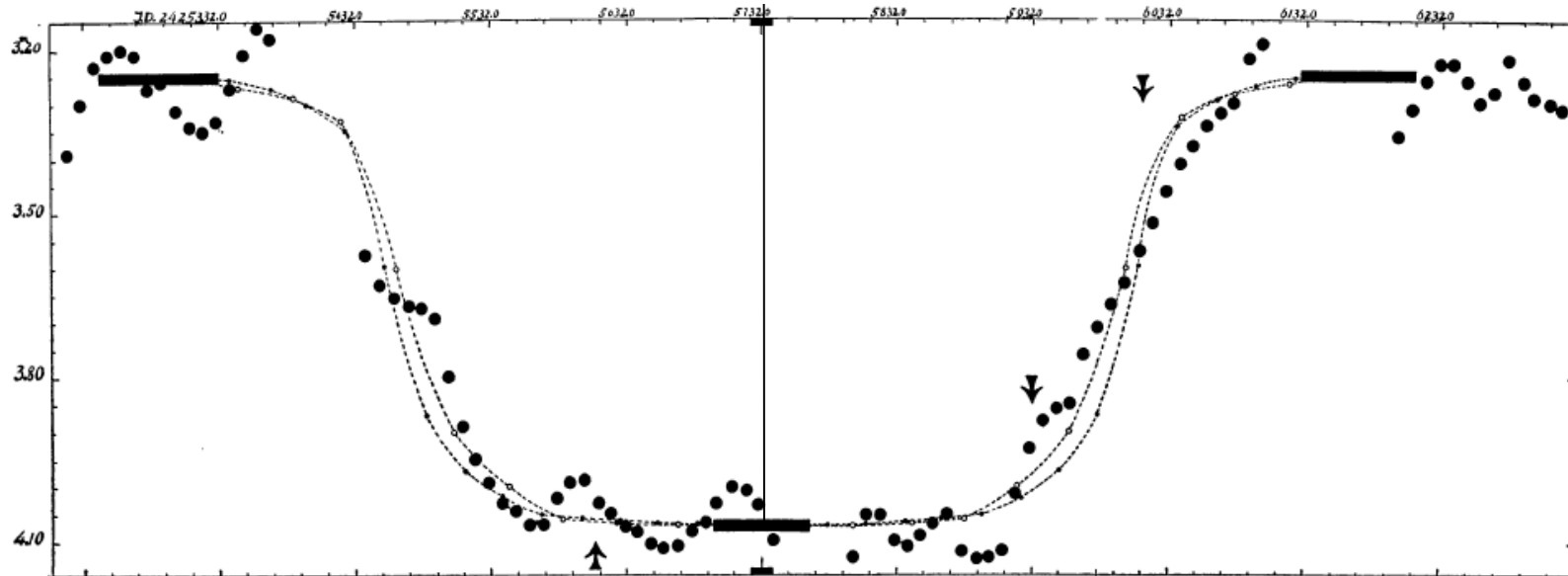
Light Curve of EPS AUR



What is Julian Date?

Now: the HALF-TIME SHOW --

“It ain't over 'til it's over” - prior eclipses (e.g. 1929) showed sub-structure...



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SERGEI GAPOSCHKIN

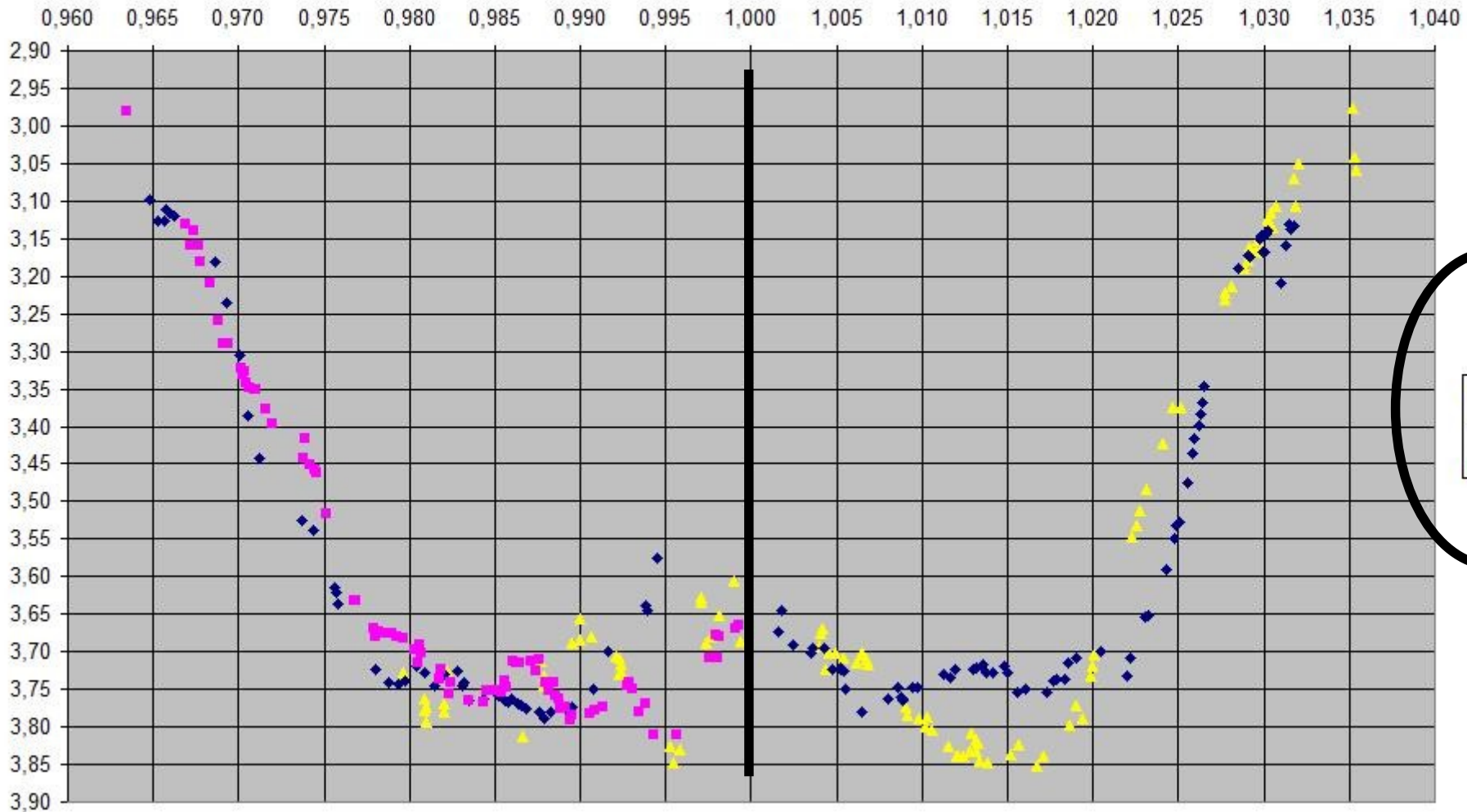
FIG. 1.—The plot represents the eclipse of ϵ Aurigae in 1929. Abscissae are Julian Days; ordinates, photographic magnitudes; and large dots, photoelectric means as compiled and reduced by Güssow. Observe the large fluctuations and the ragged light-curve even during maximum. Dashed curves are from two schematic eclipses as explored by Mrs. Gaposchkin and myself. The short black bars indicate (at the top) the adopted magnitude at maximum brightness (3.25), and (at the bottom) that of minimum (4.07). I have marked the position of the middle of the eclipse (JD 242 5732.0) and, with arrows, the times of the three Mount Wilson plates mentioned in the text.

The diagram illustrates the schematic eclipse of a brighter and larger star with an extended atmosphere by a much darker, smaller component. The situation is depicted at the beginning of the phase that is conventionally called total, a phase which should be called annular, if the model of the present paper is the correct one.

prior eclipses (1956, 1983 and 2009-to date) ...
... consistent “mid-eclipse brightening” ?

Epsilon Aurigae, V-band phase diagram, period 9892 days.

1956 - Gunnar Larsson-Leander, 1983 - Stig Ingvarsson, 2010 - Thomas Karlsson



Mid-eclipse brightening?

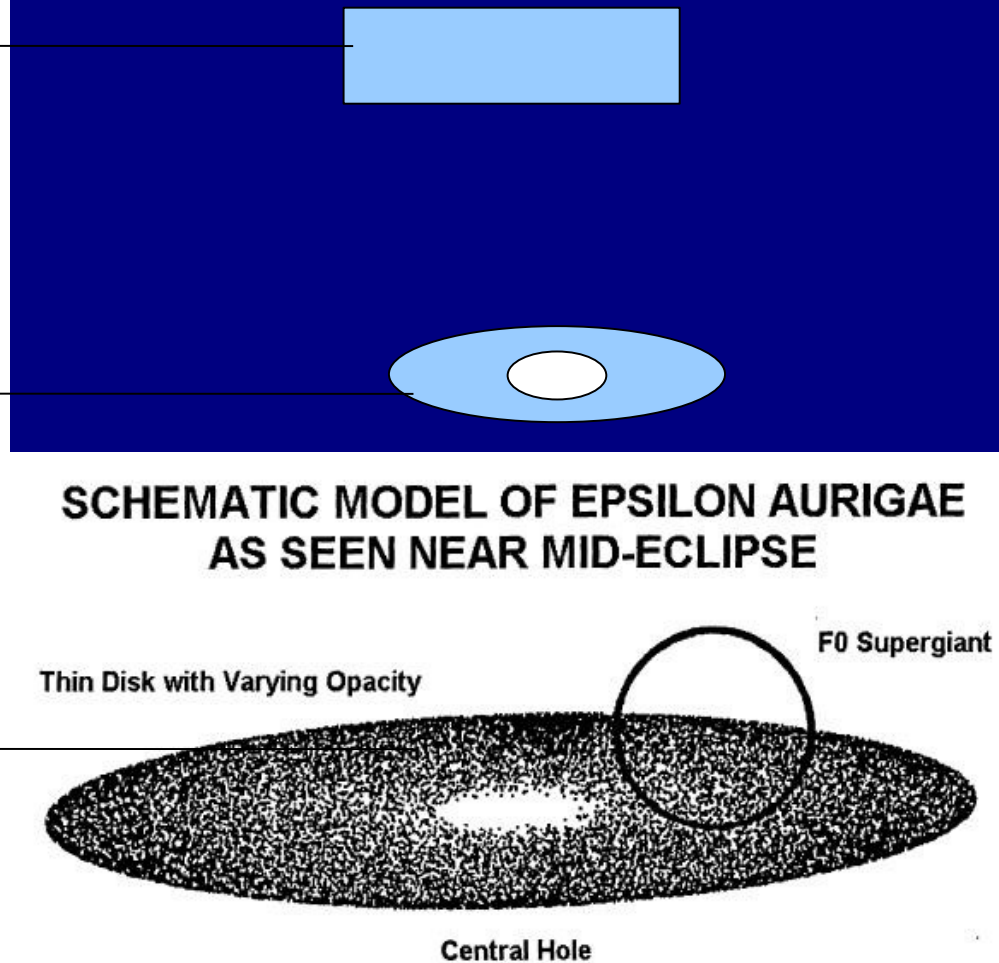
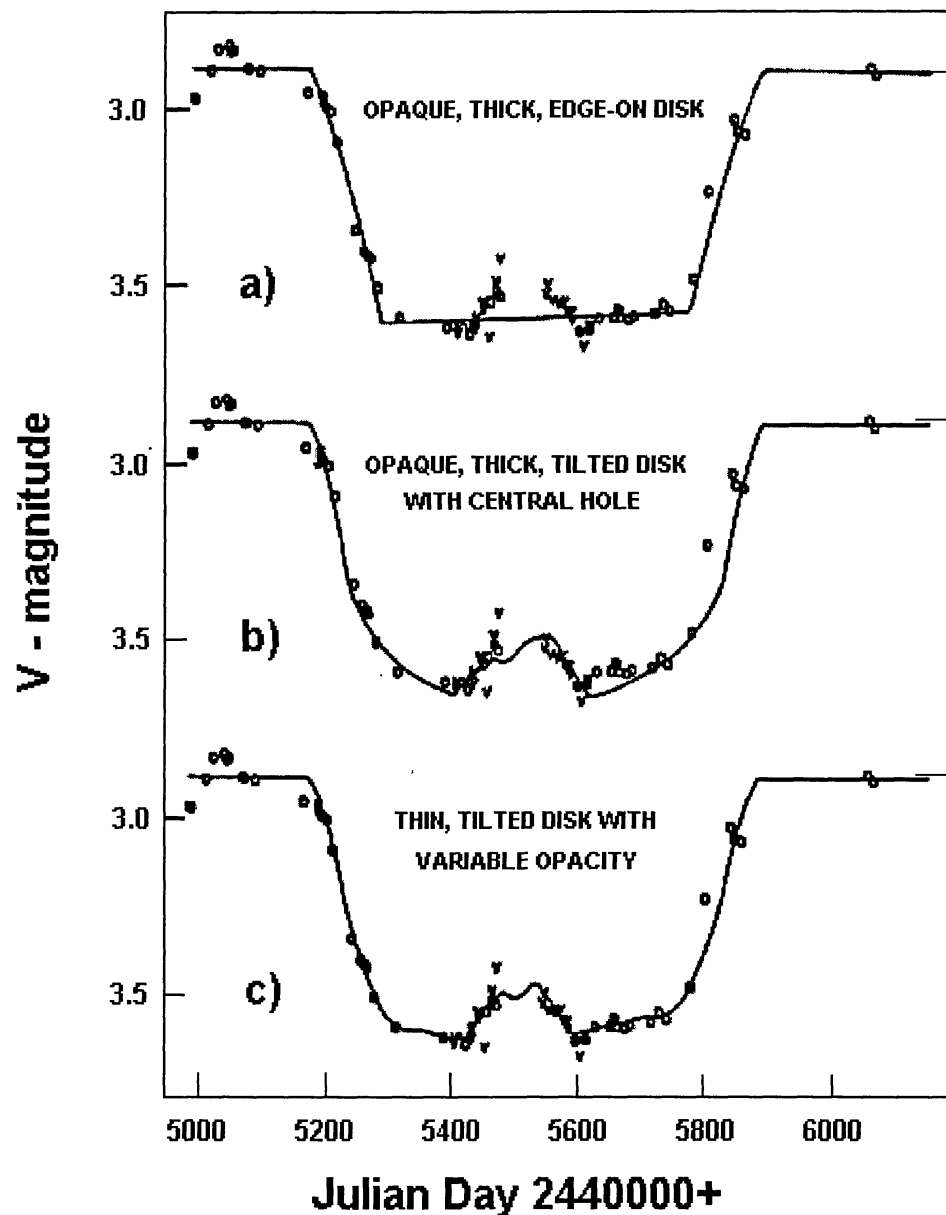


Figure 2. Tilted, Thin Disk Model for ϵ Aurigae. The tilted, thin disk model with a central hole and varying opacity is shown. This is the model for ϵ Aurigae adopted by Carroll et al. (1990). The disk is completely opaque near the rim, has a semi-transparent transitional region, and a completely transparent center.

Epsilon Aurigae Eclipse 2009/2011 V Band Data

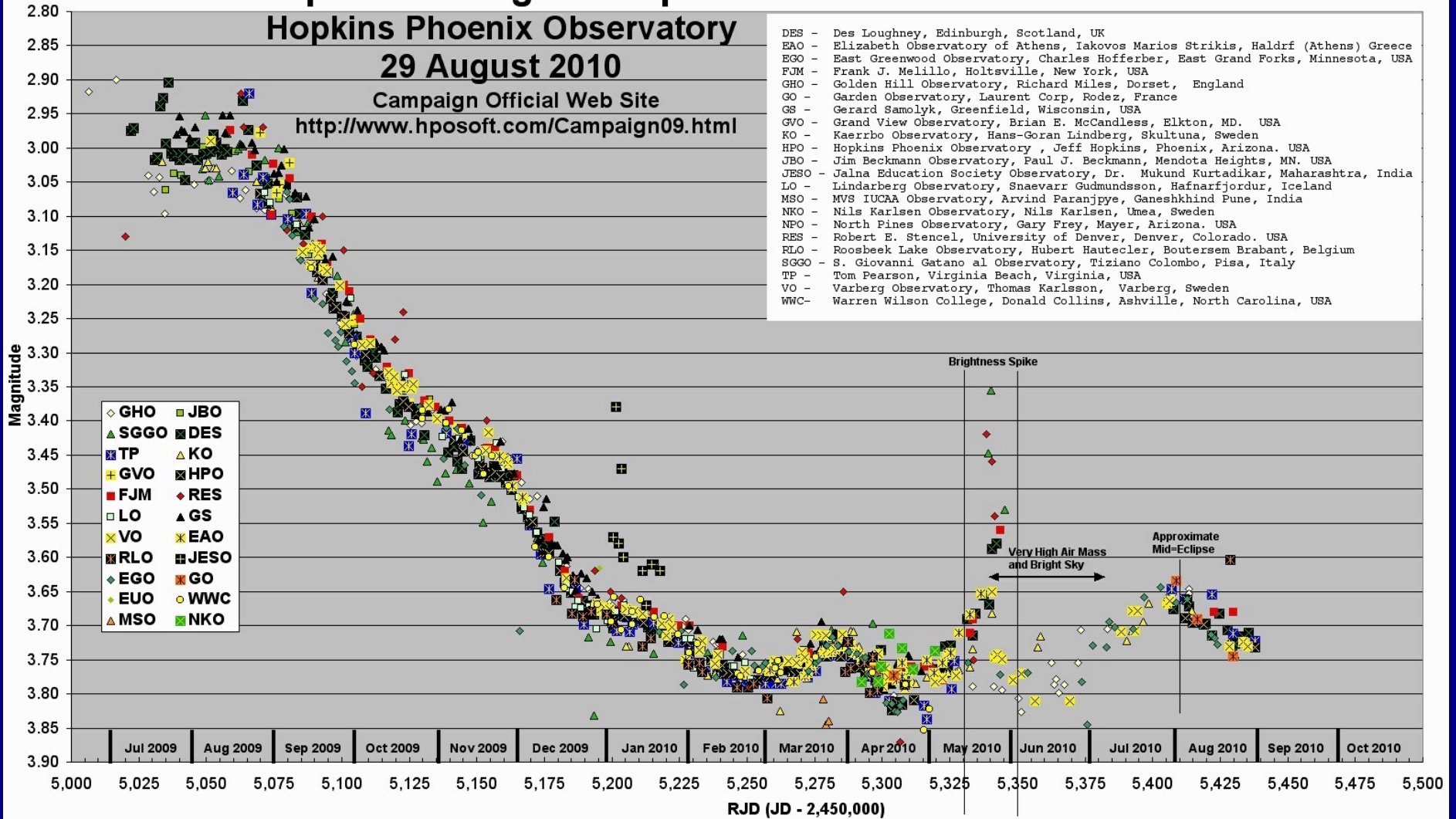
Hopkins Phoenix Observatory

29 August 2010

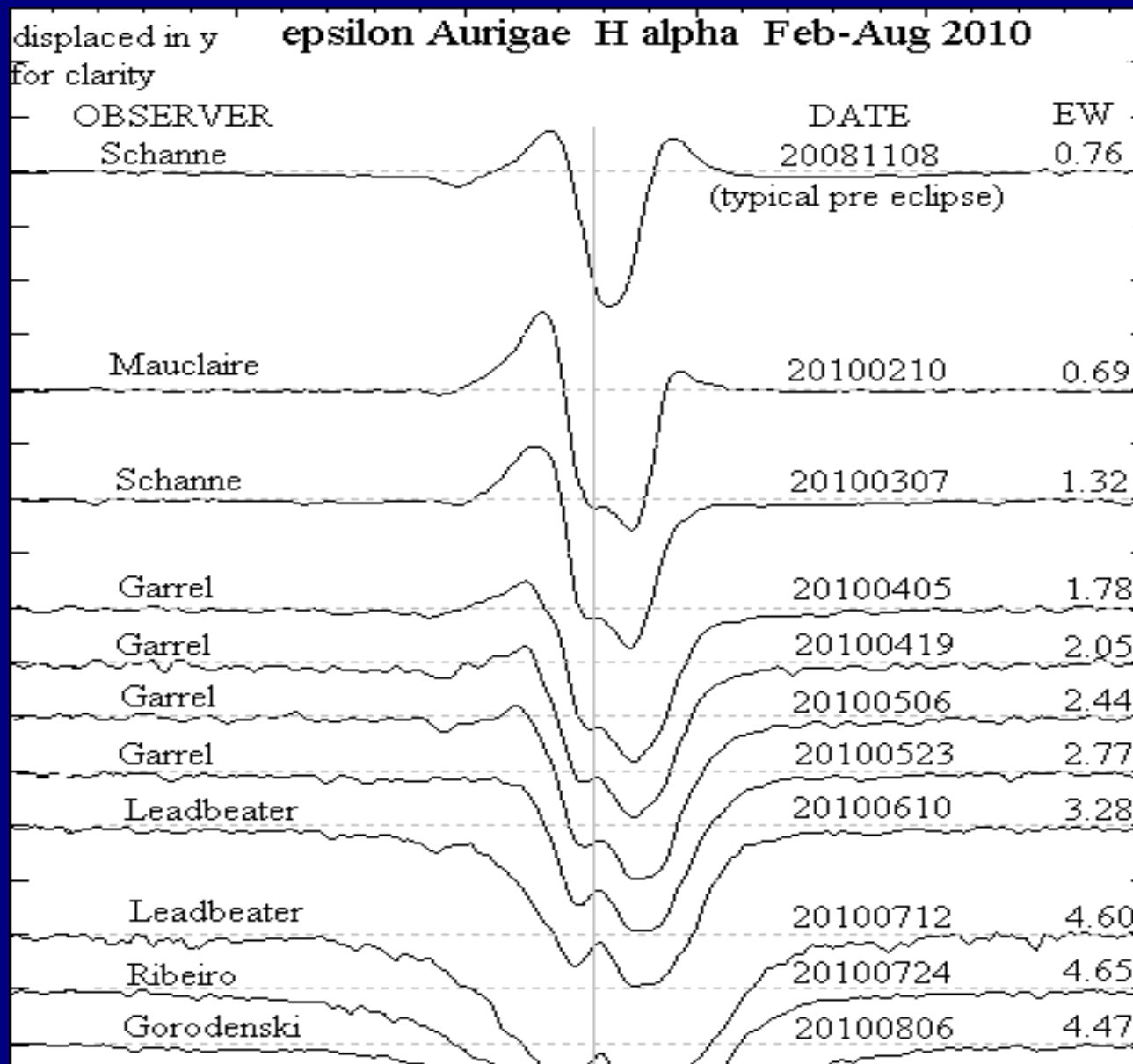
Campaign Official Web Site

<http://www.hposoft.com/Campaign09.html>

- DES - Des Loughney, Edinburgh, Scotland, UK
- EAO - Elizabeth Observatory of Athens, Iakovos Marios Strikis, Haldrf (Athens) Greece
- EGO - East Greenwood Observatory, Charles Hofferber, East Grand Forks, Minnesota, USA
- FJM - Frank J. Melillo, Holtsville, New York, USA
- GHO - Golden Hill Observatory, Richard Miles, Dorset, England
- GO - Garden Observatory, Laurent Corp, Rodez, France
- GS - Gerard Samolyk, Greenfield, Wisconsin, USA
- GVO - Grand View Observatory, Brian E. McCandless, Elkton, MD, USA
- KO - Kaerbo Observatory, Hans-Goran Lindberg, Skultuna, Sweden
- HPO - Hopkins Phoenix Observatory, Jeff Hopkins, Phoenix, Arizona, USA
- JBO - Jim Beckmann Observatory, Paul J. Beckmann, Mendota Heights, MN, USA
- JESO - Jalna Education Society Observatory, Dr. Mukund Kurtadikar, Maharashtra, India
- LO - Lindarberg Observatory, Snaevarr Gudmundsson, Hafnarfjordur, Iceland
- MSO - MVS IUCAA Observatory, Arvind Paranjpye, Ganeshkhind Pune, India
- NKO - Nils Karlsen Observatory, Nils Karlsen, Umea, Sweden
- NPO - North Pines Observatory, Gary Frey, Mayer, Arizona, USA
- RES - Robert E. Stencel, University of Denver, Denver, Colorado, USA
- RLO - Roosbeek Lake Observatory, Hubert Hautecler, Boutersem Brabant, Belgium
- SGGO - S. Giovanni Gatano al Observatory, Tiziano Colombo, Pisa, Italy
- TP - Tom Pearson, Virginia Beach, Virginia, USA
- VO - Varberg Observatory, Thomas Karlsson, Varberg, Sweden
- WWC - Warren Wilson College, Donald Collins, Ashville, North Carolina, USA



Mid-eclipse brightening? No, and yes. Limited photometric evidence but moreso in spectra and interferometrically, perhaps. The analysis begins...



Mid-eclipse was predicted for early August 2010

RJD 55,413 (55,406)

A relative brightening, from $V \sim 3.75$ up to $V \sim 3.65$
started ~ 55375 and peaked around 55405...

...but this ~ 60 day cycle is similar to OOE...

...transient emission lines (6604A, 6678A...)

“Third contact” is predicted for 2011 March, $\sim 55,640$

Fourth contact (end of optical eclipse) $\sim 55,700$ (May)

& Post-eclipse spectroscopic phenomena persist!

*We're not being idle: second half of eclipse, the disk
reveals its secrets, to those willing to look...*

Observing plans, second half of eclipse, and beyond:

Continuation of interferometric imaging

CHARA sessions: Sep, Oct, Dec

Continuation of infrared spectroscopy

Sessions at IRTF with SpeX instrument: Aug-Jan

Sessions at Mt.Hopkins 8 meter MIRAC instrument

Continuing IRAC/Spitzer photometry: Oct & March

New far-ultraviolet spectroscopy: HST, this week!

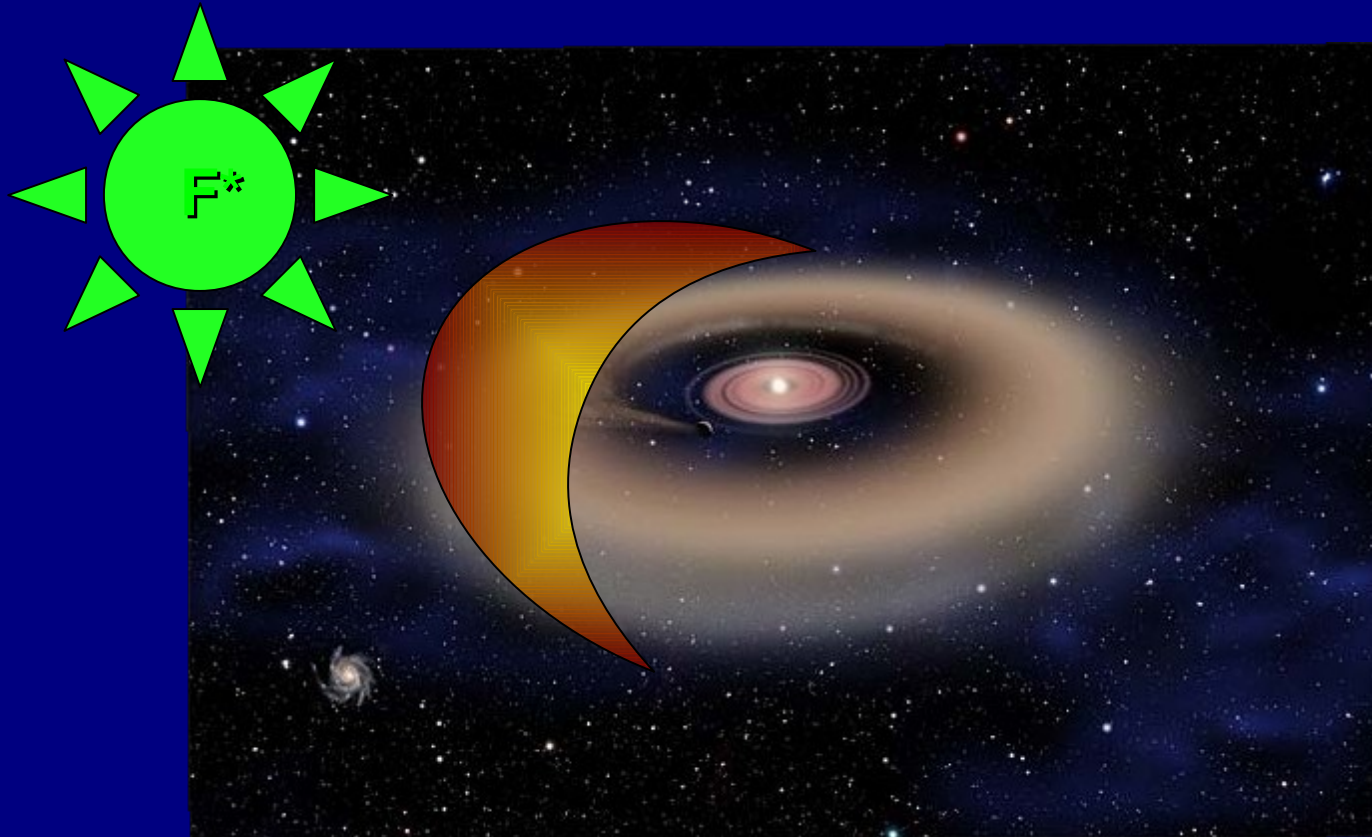
Proposed far infrared imaging & spectroscopy

- Herschel Space Observatory, PACS & SPIRE
- SOFIA, GREAT far-IR spectrometer

Polarimetry efforts continuing (Cole, Henson...)

These observations are designed to help...

- Explore heating of, and the nature of material in the dark disk;
- Explore disk substructures;
- Understanding those will help constrain the the evolutionary status of the F star.

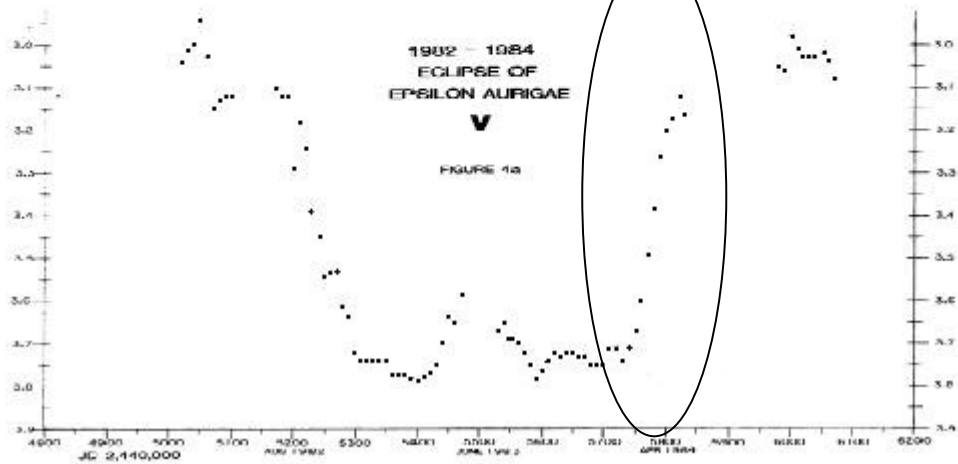
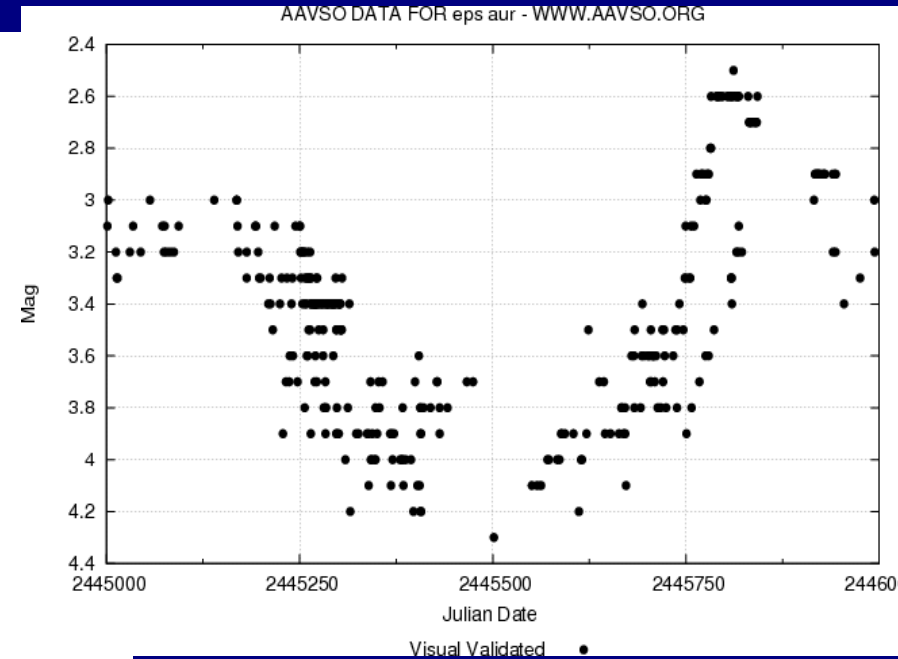
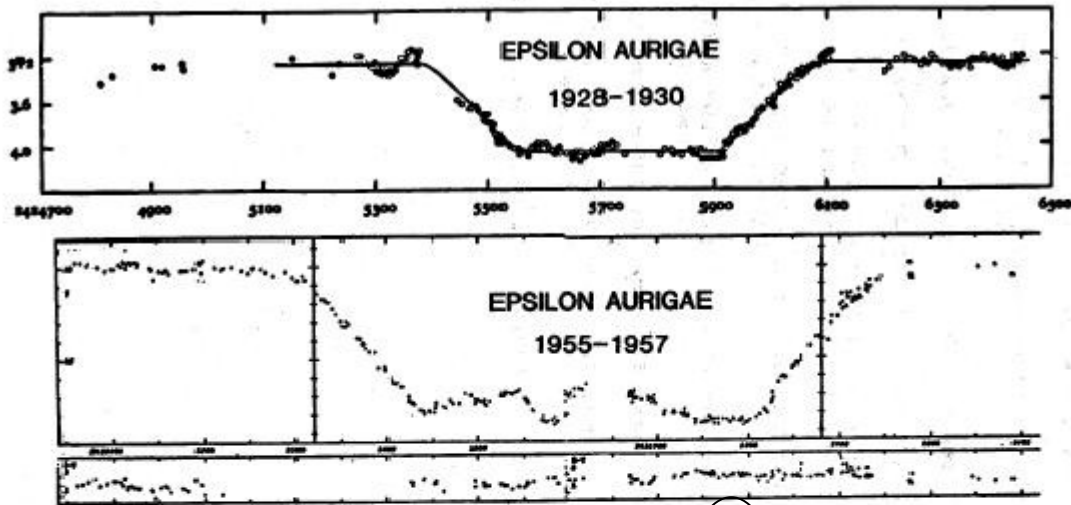


Our goals:

- Add to the astronomical knowledge base on epsilon Aurigae
- Help report your findings
- Increase your opportunities with AAVSO!

Are you ready for egress?

Forecast for March/April 2011, 0.8 mag up in ~4 wks...



The opportunities for YOU:

- Keep up the observing – there's still a year to go!
- Light curve analysis – bumps and wiggles, comparisons with archival/your data
- Learn from this workshop, how to participate & make the most of what AAVSO has to offer! &...



& many thanks to:

- *Brian Kloppenborg, DU thesis student
- AAVSO: Aaron Price, Rebecca Turner, Arne Hendon
- Our hosts here at California Academy of Sciences
- Jeff Hopkins, Robin Leadbeater, Steve Howell, Don Hoard, PJ Goldfinger, John Clover and all the observers!
- The Bequest of William Herschel Womble in support of Astronomy at the University of Denver

And YOU for helping to make it happen!

*Thanks for listening –
any questions?*



CSky2 - Calif. Academy of Sciences

Capella and her Kids... at Mt. Evans, Colo.