

Towards solving the mystery of epsilon Aurigae

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Outline

- 1 Background
 - What is epsilon Aurigae?
 - No. What IS epsilon Aurigae, really?
 - Supporting Evidence
- 2 Dissertation Work
 - My Contribution to the story
- 3 Assembling the results
 - Is that your final answer?

What is ϵ Aurigae

- Single line spectroscopic eclipsing binary star system
- Eclipses first “discovered” in 1821
- 27.1 year period established in 1903
- Anomalously long, 21-month, primary eclipse
- No detectable secondary eclipse

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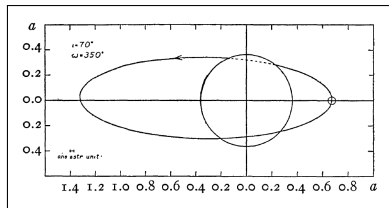


Image Credit: Kuiper et. al. 1937

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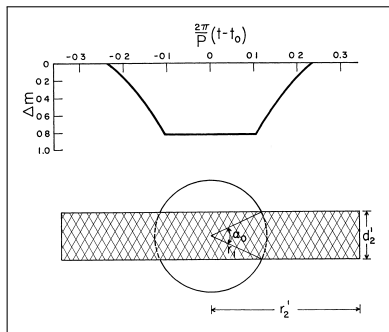


Image Credit: Huang, 1965

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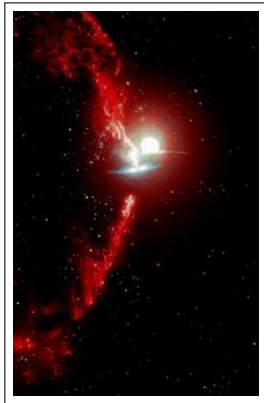


Image Credit: Dan Weeks

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(review: Webbink, 1985)

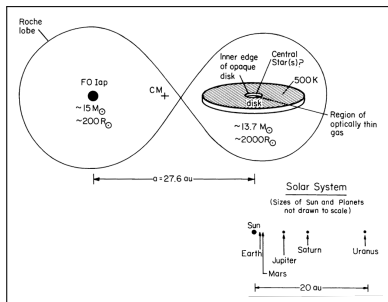


Image Credit: Carroll, S. et. al 1991

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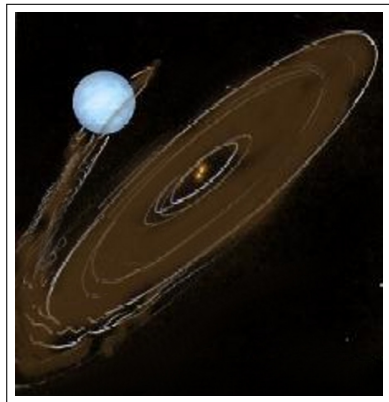


Image Credit: M. Carroll and Robert Stencel 2008

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- Binary or a trinary?
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- Low mass system
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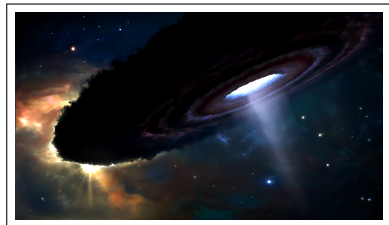


Image Credit: Brian Thieme

ϵ Aur on the HR diagram

ϵ Aur F-star Stats:

- T: 7750 K
- R: $135 R_{\odot}$
- L: $> 10^4$

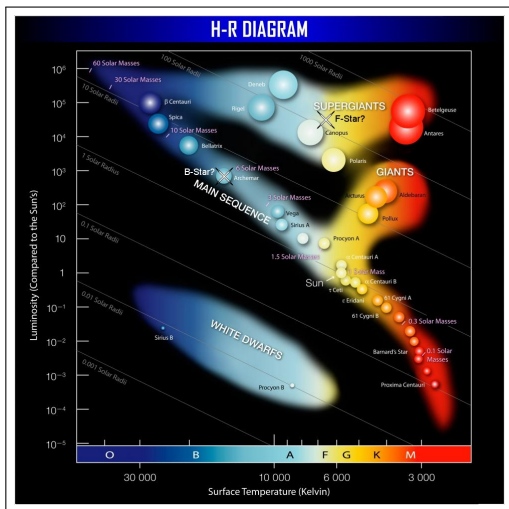
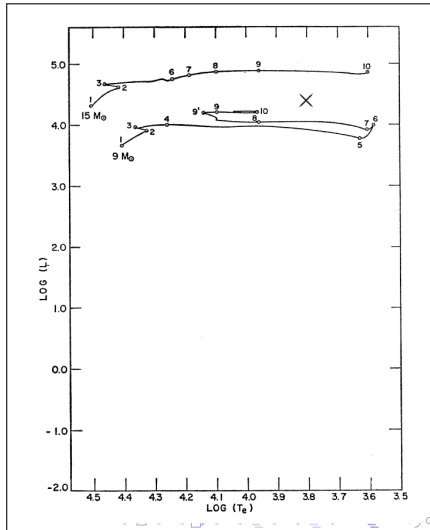


Image Courtesy of the Museum of Flight

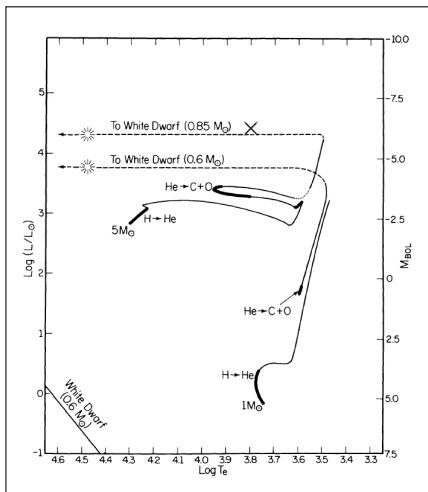
Case 1: F-Supergiant

F-type Supergiant Properties

- $M_0 > 10M_{\odot}$
- $[Na/Fe] > 0$
(overabundance)
- Stable photometrically
- Low surface gravity
- Disk would be leftovers from system formation



Case 2: post-AGB



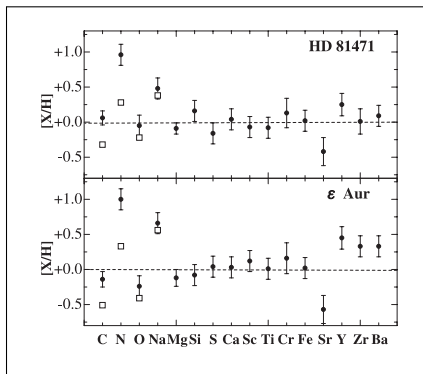
Evolutionary Tracks, adapted from Iben (1991)

post-AGB properties:

- $M_0 < 8M_{\odot}$
- Advanced (s-) processing of materials
- Dust Production
- $\Delta P / \Delta T_{\text{eff}} = 0.047 \text{ days} / \text{K}$
- Disk is debris from mass loss on AGB.

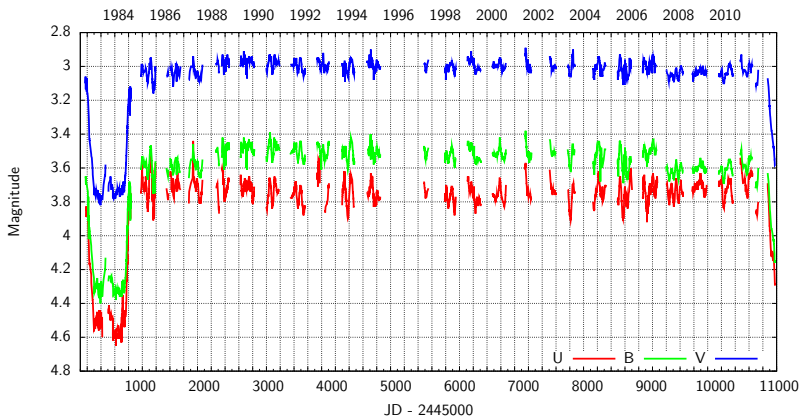
Spectroscopic Support?

- Sadakane (F-star):
Spectral Analysis:
Supergiant
- Hinkle & Simon (Disk):
 $^{12}\text{C}/^{13}\text{C}$: Post-AGB



ϵ Aur abundances compared to HD 81471 (A7 lab supergiant)
(Sadakane 2010)

Photometric Variability



Kloppenborg et. al. (2010)

My Dissertation

Hypothesis

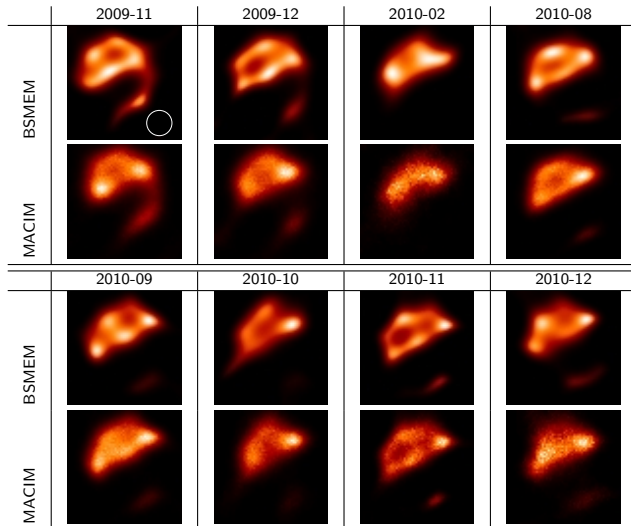
The F-star is not a massive supergiant as presently assumed, but instead is a lower-mass post-AGB star that has recently (in the evolutionary sense) lost a few solar masses of material which has largely ended up in and around the B-type companion and in a circumbinary disk.

Towards proving the hypothesis

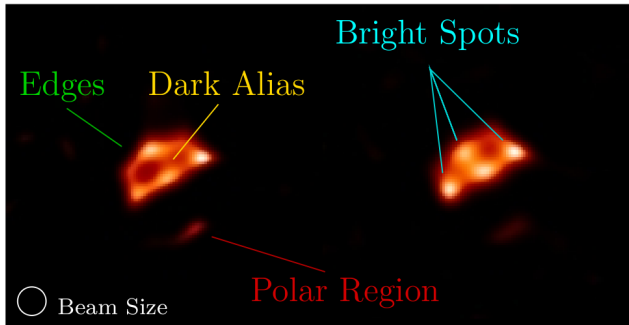
- 1 Establish that the disk is not composed of copious amounts of gas and is more akin to debris-disks than YSOs,
- 2 Find a change in period and temperature over 100 years of observations which is indicative of post-AGB stars,
- 3 Find s-process elements in sufficient quantities to establish the post-AGB nature of the system.

Interferometry

Interferometry

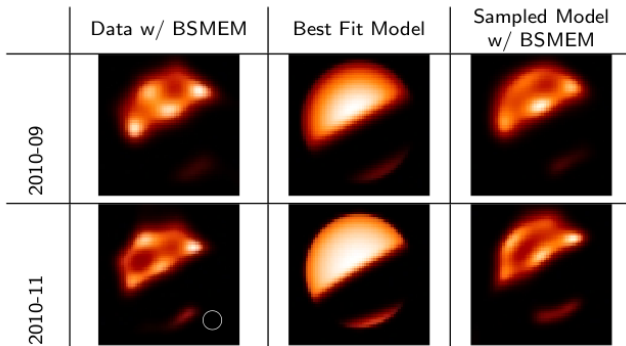


What's real, what's fake?



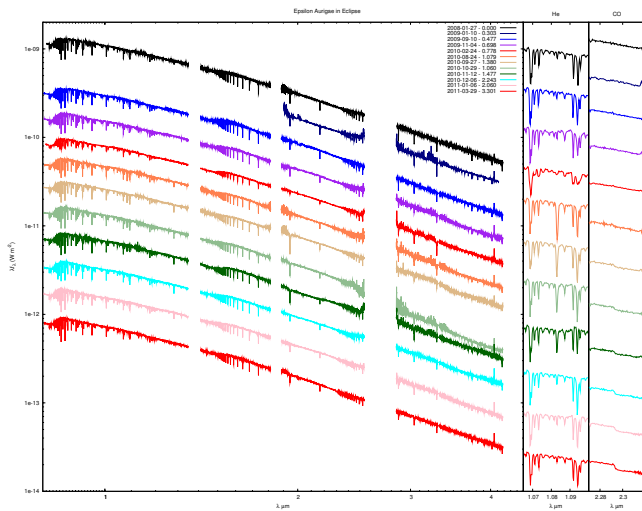
(Kloppenborg et. al 2011)

Preliminary from OIFITS-sim

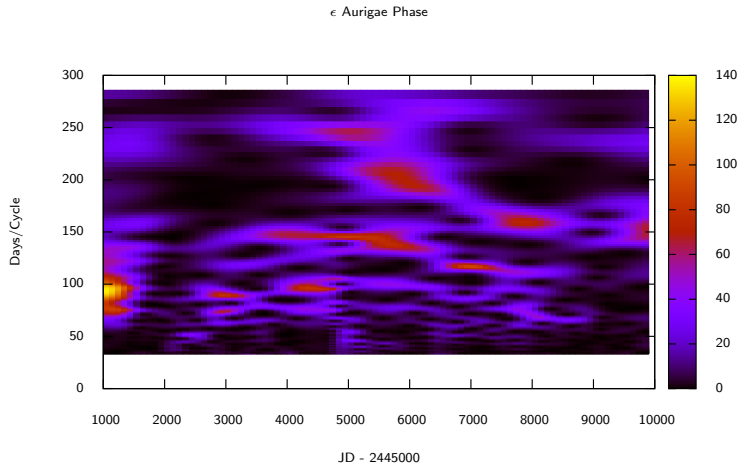


Initial results in Kloppenborg et. al 2011, OIFITS-sim publication upcoming.

IR Spectroscopy

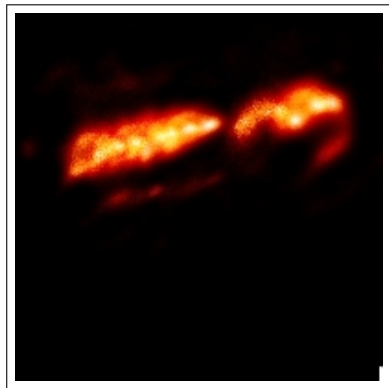


Long-Term photometry



Re-solving the orbital solution

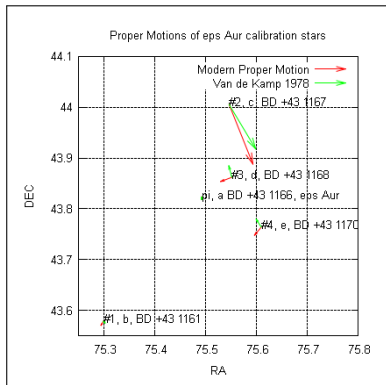
- All published (complete) orbits inconsistent



Kloppenborg (2011)

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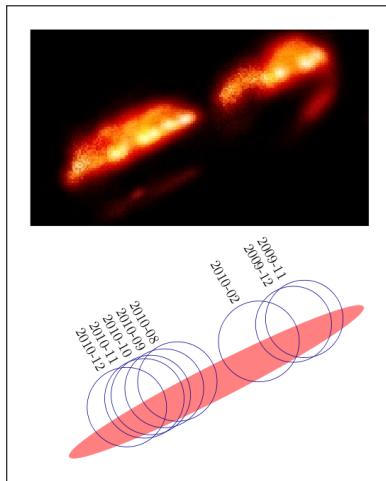
- All published (complete) orbits inconsistent
- Best astrometric data 1939.82 - 1977.1302
- Incorrect assumptions corrupted solution.



Kloppenborg (2011)

Re-solving the orbital solution

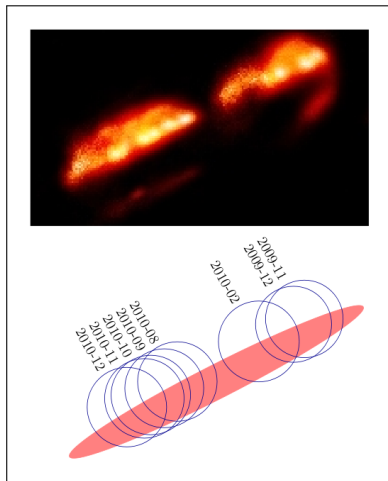
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Kloppenborg (2011)

Re-solving the orbital solution

- All published (complete) orbits inconsistent
- Best astrometric data 1939.82 - 1977.1302
- Incorrect assumptions corrupted solution.
- An accurate distance resolves the entire problem.



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A possible conclusion

- Disk: YSO or YS-No
 - $^{12}\text{CO}/^{13}\text{CO}$ is indicative of debris disks, not YSOs
 - If system is at < 625 pc, scale height agrees with debris disk
- Change in T_{eff} or P
 - Qualitative agreement with post-AGB interpretation ($\downarrow P$, unknown ΔT_{eff})
- s-process elements
 - Work completed by other folks.
- Orbit Work
 - Initial results looking good
 - Full analysis under way.