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 \( \epsilon \) 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
A swarm of meteorites
(10-100 µm)
(Ludendorff, 1903)
ε Aurigae

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- Largest star in the universe
  
  (Kuiper, G. P. and Struve, O. and Strömgren, B.; 1937)

Image Credit: Kuiper et. al. 1937
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Image Credit: Dan Weeks
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Image Credit: Carroll, S. et. al 1991
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Image Credit: M. Carroll and Robert Stencel 2008
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Image Credit: Brian Thieme
**Background**
Dissertation Work
Assembling the results

**What is epsilon Aurigae?**
No. *What IS* epsilon Aurigae, really?
Supporting Evidence

**ε Aur on the HR diagram**

ε Aur F-star Stats:
- T: 7750 K
- R: 135 R☉
- L: > 10⁴

Image Courtesy of the Museum of Flight

Towards solving the mystery of epsilon Aurigae
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

post-AGB properties:

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

- Sadakane (F-star):
  Spectral Analysis: Supergiant

- Hinkle & Simon (Disk):
  \( ^{12}CO / ^{13}CO \): Post-AGB

\( \epsilon \) Aur abundances compared to HD 81471 (A7 lab supergiant) (Sadakane 2010)
Photometric Variability

Kloppenborg et. al. (2010)
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

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Dissertation Work
Assembling the results

My Contribution to the story
What’s real, what’s fake?

(Kloppenborg et. al 2011)
### Preliminary from OIFITS-sim

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

Brian Kloppenborg Towards solving the mystery of epsilon Aurigae
IR Spectroscopy

$\epsilon$ Aur IR Spectroscopy (upcoming, Stencel, Kloppenborg et. al 2011)
Long-Term photometry

$\epsilon$ Aurigae Phase

JD - 2445000

Towards solving the mystery of epsilon Aurigae

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Re-solving the orbital solution

- All published (complete) orbits inconsistent

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Re-solving the orbital solution

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

Kloppenborg (2011)
A possible conclusion

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

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