EXPLORATION OF ELEVATED $^{13}\text{C}$ ABUNDANCE IN THE DISK OF EPSILON AURIGAE

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Outline

• \( \epsilon \) Aur – an F0 supergiant star + ???
  − Eclipsed every 27 years by an opaque object
  − Interferometrically imaged \( \rightarrow \) a transitional disk

• Mid eclipse: transient CO(2-0)
  − Originally seen during 1984 eclipse by Ken Hinkle, FTS

• Re-observation, modern era
  − IRTF+SpeX, 2008-2011: CO recurs, also He I 10830
  − GNIRS, 2011: high res CO(2-0)

• Interpretation & Next steps
Interferometric Imaging results & models: CHARA+MIRC → Disk

Figure 3.10: Ingress and totality images. See description in Figure 3.9 and in the text.

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<thead>
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Figure 3.11: Mid eclipse and totality images. See description in Figure 3.9 and in the text.

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Original CO appearance, 1984

- KPNO FTS (Hinkle & Simon, 1987)
  \[ T(\text{exc}) = 1000 \pm 150 \text{K}; \, n(\text{CO}) = 3 \times 10^{20} \text{ cm}^{-2} \]

- Pre-eclipse
- Mid-eclipse
- Post-eclipse
$^{13}\text{C}$ reported detection

- 2-0 band at 2.3445 microns (4265 /cm)
- Strength $\rightarrow$ 12/13 ratio = 10 +/- 3 $\rightarrow$ evolved star
- $^{13}\text{CO}$ Data not shown in publication
- Ken Hinkle kindly shared these data w/me
  - Telluric corrections are substantial...
Re-observation, modern era: IRTF+SpeX, 2008-2011

Re-observation, modern era: IRTF+SpeX, 2008-2011
Re-observation, modern era: GNIRS, 2011

(SV, many thanks to Tom Geballe for support with same)
Re-observation, modern era: GNIRS, 2012 (DT)


GNIRS does not appear to show 13CO or Pfund lines as expected. High airmass, strong tellurics could be a factor in 2012 data...
Expectations, early F supergiants:


**Figure 5.4:** Spectral features in the spectra of A and F giants and supergiants. The flux scale is in Jy, normalised to 1 at 3.8 \( \mu \)m and offset for the different spectra.
Interpretation/so what...

- **ε Aur:**
  - Reduced 12C/13C ratio, a result of dredge-up
  - More evolved object, possibly post-AGB
  - CO velocities add constraint on secondary's mass:
    - Keplerian motion → $M_2 < 10$ solar
    - SB1 mass function, $f(M) = 2.53 \rightarrow$
    - Binary star mass ratio $\sim 0.5 \rightarrow$ primary $< 5$ solar
  - Overall system evolutionary status
    - Constrains disk age, structure, composition...
DISK MODELS with Monte Carlo photon tracking:
Pequetté/Whitney&Robitaille; Pearson/Dullemond -
2012 JAAVSO, special $\varepsilon$ Aur issue
Muthumariappan & Parthasarathy, 2012 MNRAS

$$T^{\text{Observed}}_{\text{midNt}} = 550 \; K$$

$$B(V?)$$

$$1150 \; K = T^{\text{Observed}}_{\text{noon}}$$

$\theta_{\text{disk}}$

$\alpha_{\text{separation}}$

$\alpha_{\text{separation}}$

to Earth

$R_{\text{in}} \rightarrow R_{\text{out}}$

noon

dawn
Next steps...

• Post eclipse re-observation needed
  - Confirm presence of F star Pfund lines
  - Enable more careful subtraction from 13CO
  - Discretionary time attempt, April 2012: clouds...

• Synthetic spectra
Thanks for listening.
Any questions?

http://apod.nasa.gov/apod/ap091205.html