Self-Calibrating Systems: An Update on η Orionis

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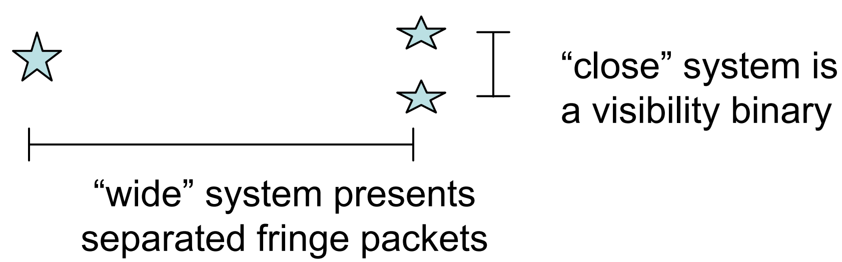
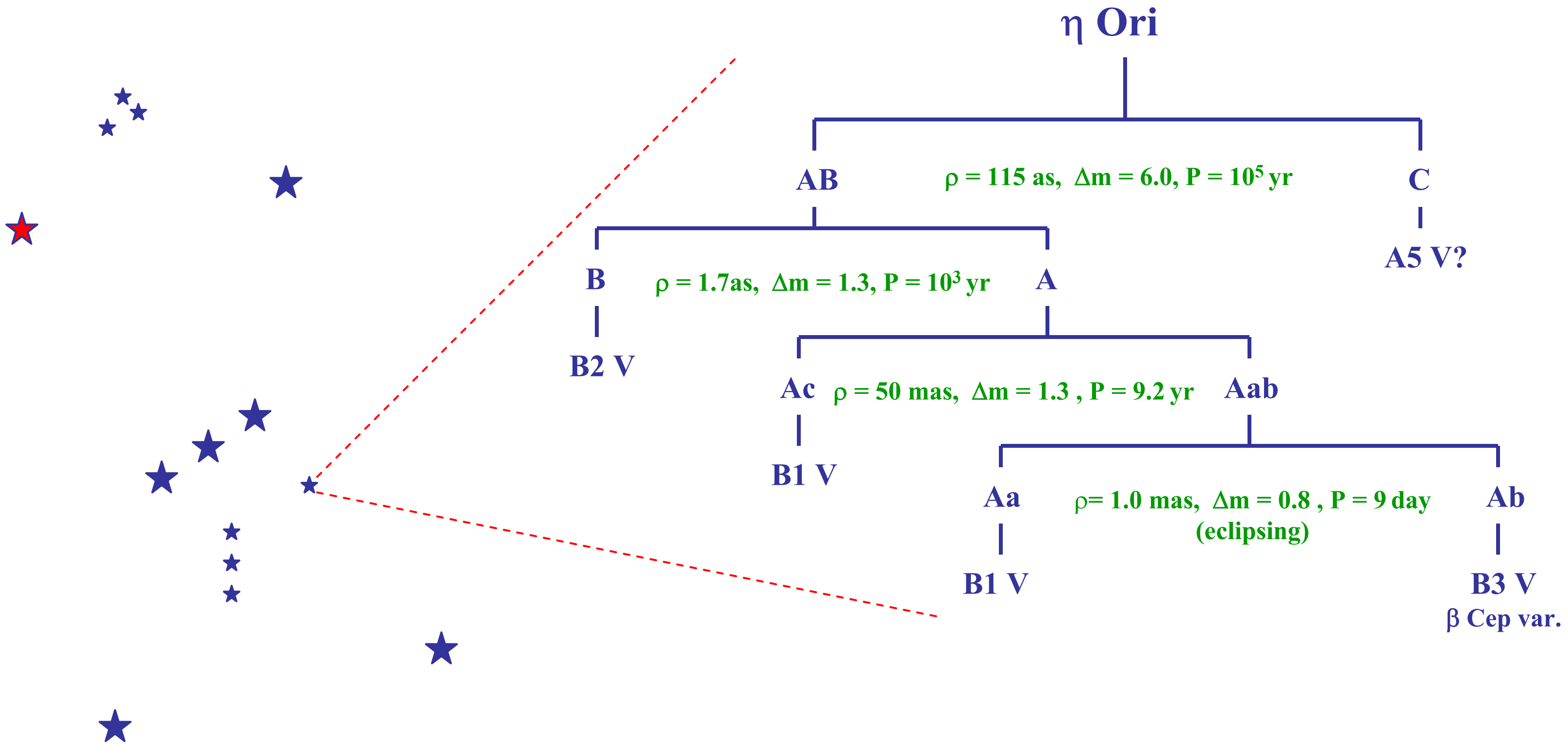
3/15/07

Self-Calibrating Systems

- Systems of multiplicity 3+
- Separation of close binary and wide component
  - large enough to resolve the two components
  - small enough to allow observations of both at the same time
- Visibility of wide component is used to calibrate the visibility of the binary star



η Orionis – A Hierarchical Quintuple System



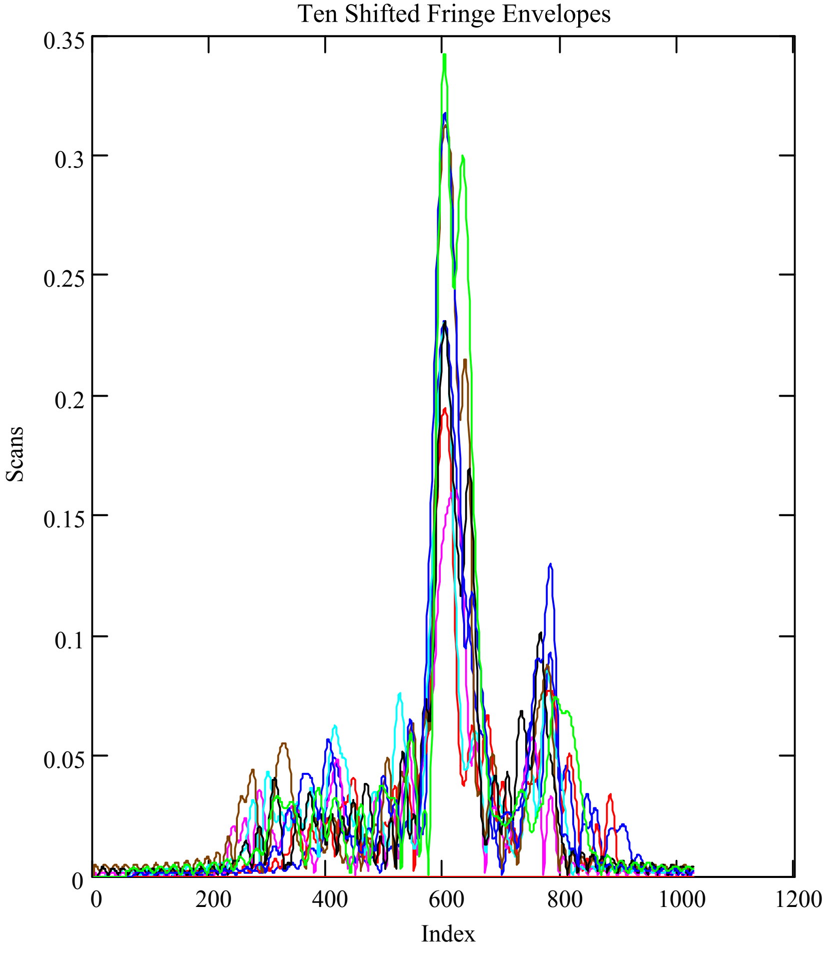
η Orionis

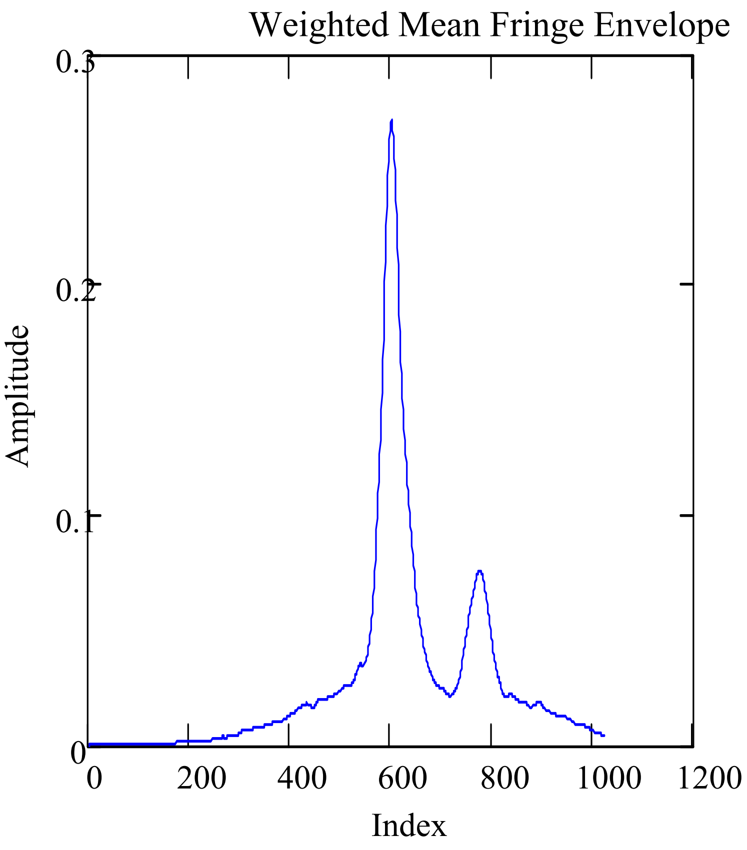
- η Ori is the prototype system for this study
- Aab,c system (ρ ~ 50 mas) was first resolved by speckle interferometry (McAlister 1976).
- Aab system (ρ ~ 1 mas) is an eclipsing binary and should be resolved at Array's longest baselines.
- Aab = target system, Ac = calibrator

Observations

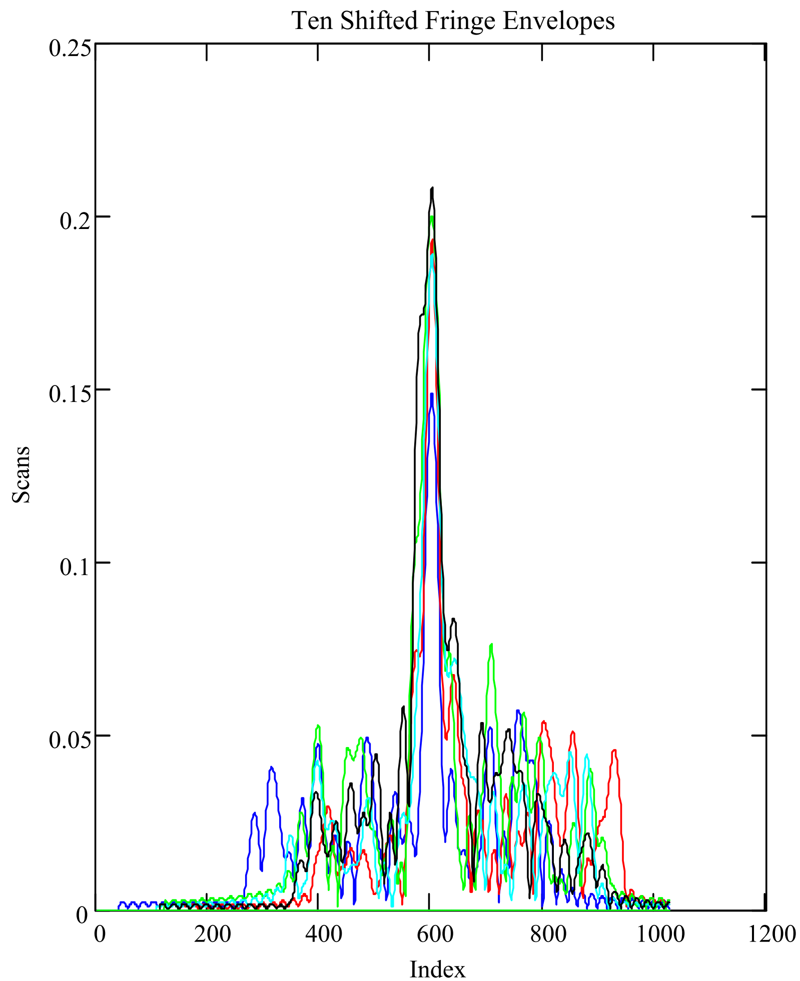
- η Ori observed 128 times between Nov. 10, 2004 and Dec. 16, 2005; most of them on a 313 m baseline.
- Most observations lasted several minutes each; a few had durations of nearly 30 minutes.
- Shift-and-added separated fringe packet envelopes were produced to determine V_{Aab} and V_{Ac}.

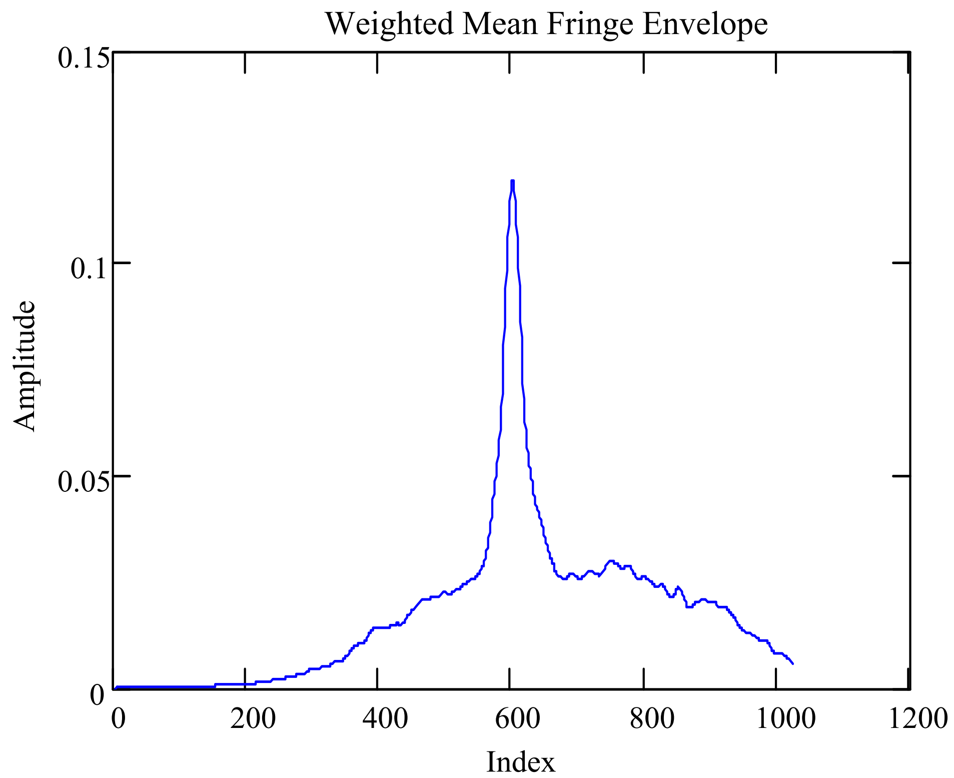
Observations: The Good



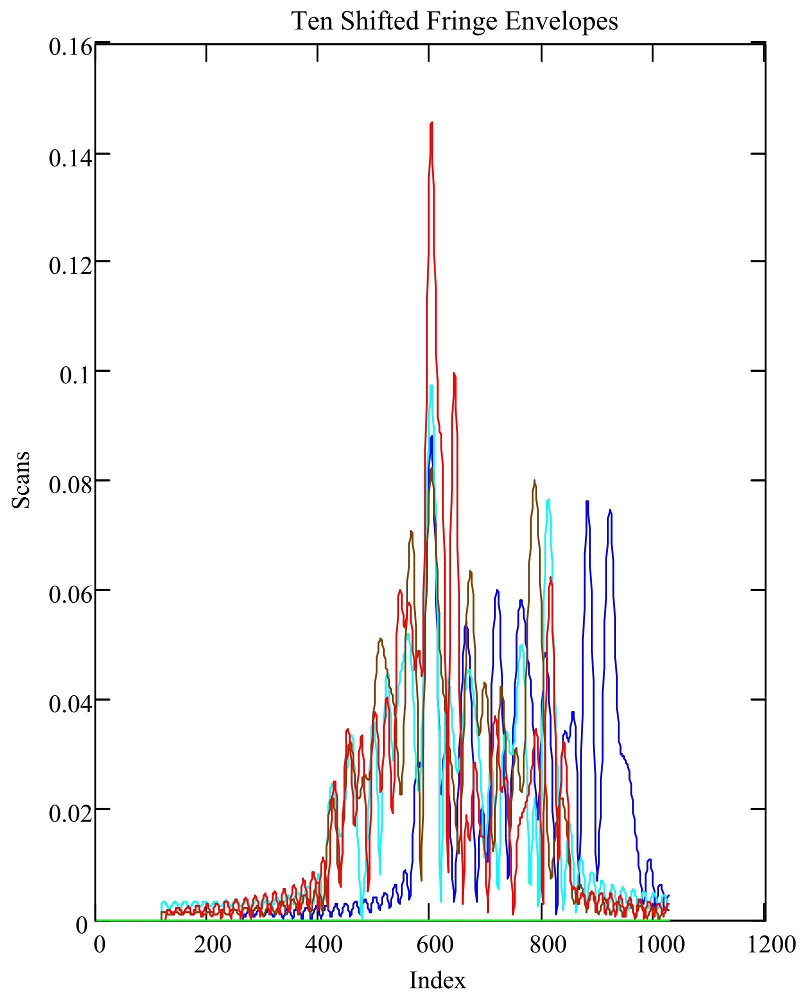


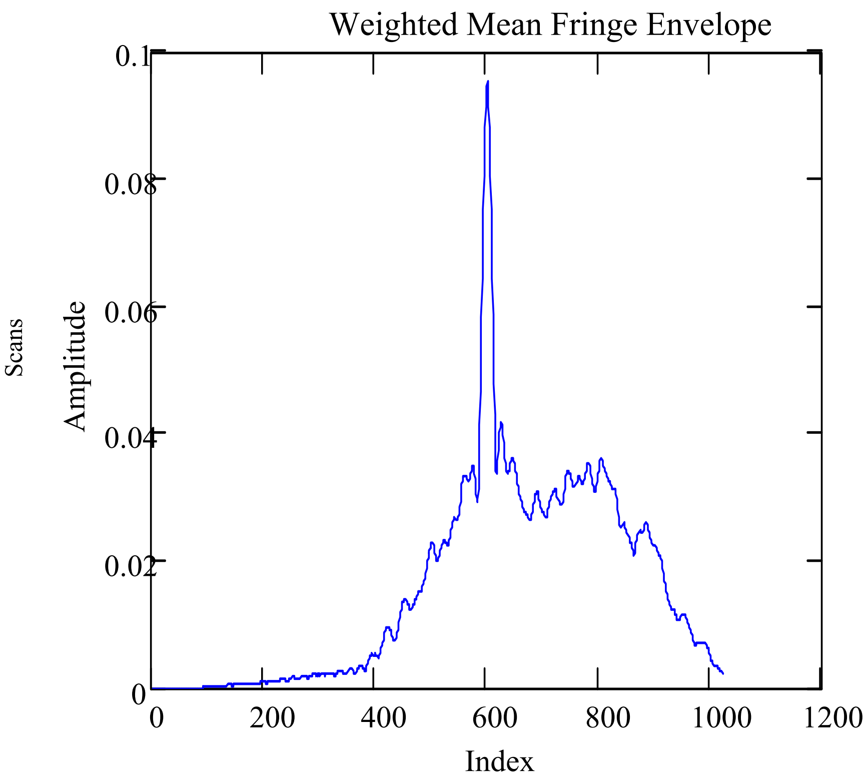
Observations: The Bad





Observations: The Ugly





Calibration

(Following ten Brummelaar)

- First, must correct normalized visibility:

  Normalized V: $V_A = A_A/\langle I_A \rangle$

  $V_B = A_B/\langle I_B \rangle$

  where A is the amplitude of the fringe and $\langle I \rangle$ is the mean intensity of the scan

- For a single star, this is no problem, because the mean intensity of the scan is equal to the mean intensity of the star

Calibration

- When two stars are observed in the same scan, the mean intensity becomes the sum of the mean intensities of both components:

$$V_A' = A_A/\langle I_A + I_B\rangle, \qquad V_B' = A_B/\langle I_A + I_B\rangle$$

- Eventually, end up with

$$V_A/V_B = \beta(V_A'/V_B')$$

where $\beta = \langle I_B\rangle/\langle I_A\rangle = 10^{0.4\Delta m}$

and component B is designated as the fainter component

Determining β for η Ori

- In η Ori, Ac is the fainter component, so

$$V_{Aab}/V_{Ac} = \beta(V_{Aab}'/V_{Ac}')$$

- Assume a value for V_{Aab} and V_{Ac} for observations obtained at eclipse phases near 0º and 180º where the Aab system is unresolved and combine with observed V_{Aab}'/V_{Ac}' to get β.

Determining β for η Ori

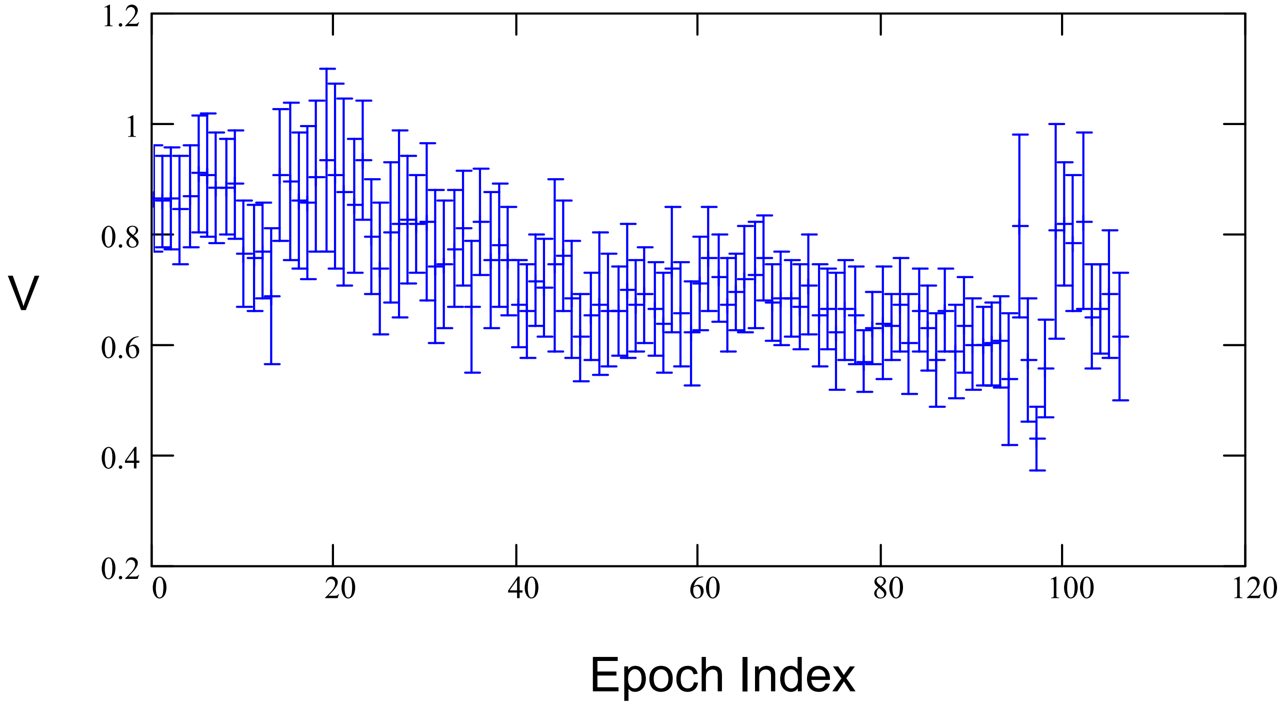
- For a nearly edge-on orbit, angular diameters of 0.21 and 0.17 mas for Aa and Ab (De Mey 1996), semi-major axis of 0.5 mas, and an orbital phase of 25º, $V_{Aab} = 0.876$
- Furthermore, for orbital phases around 0º and 180º ($\pm$25º) in Aab, visibility difference between Aab and Ac is primarily dependent on Δm.
- For angular diameter of 0.17 mas, $V_{Ac} = 0.98$

Determining β for η Ori

- $V_{Aab} = 0.876$ and $V_{Ac} = 0.98$, combined with data from JD 53319 (where orbital phase was 25º) gives $\beta = 0.303$ and $\Delta m_K = -1.298$

- Apply this β value, along with $V_{Ac} = 0.98$ to all other data sets to get calibrated visibility V_{Aab}.

Calibrated Visibilities

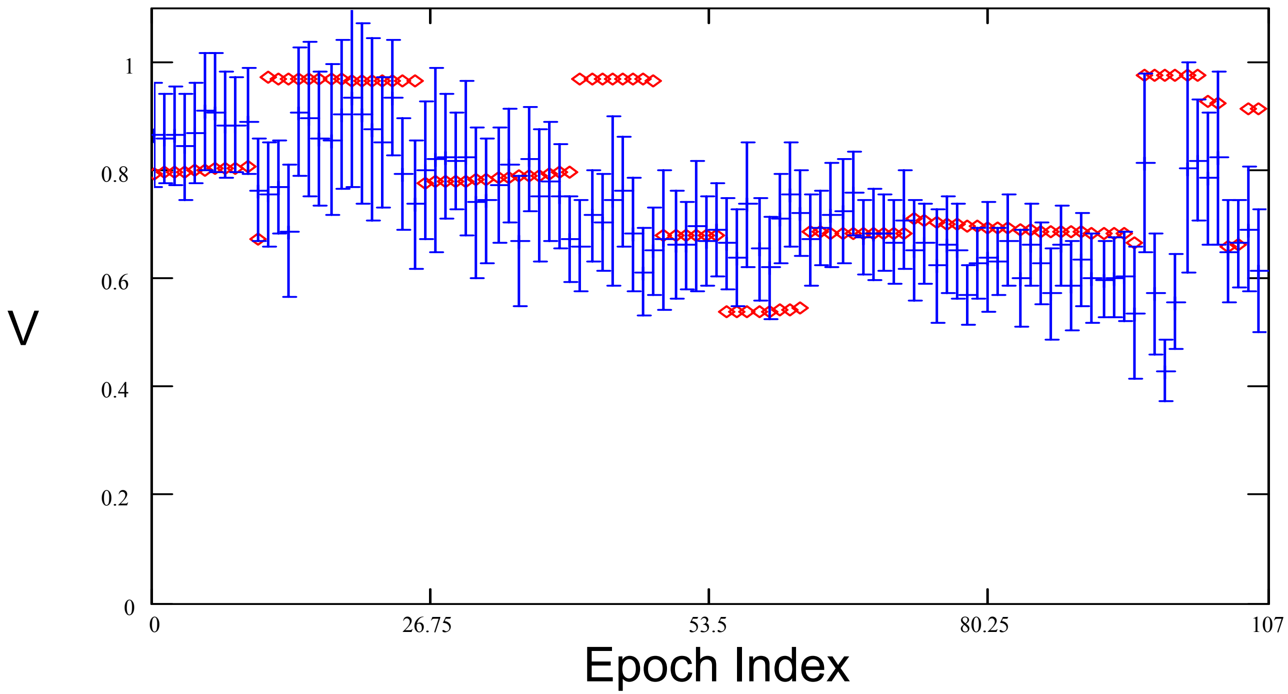


Orbit Results from OrbGrid

- OrbGrid performs a search within a definable grid space and calculates reduced χ^2 at each grid point. It typically adopts the spectroscopically determined elements P, T, e, ω and performs the search within a grid involving a, i, Δm, Θ_A, Θ_B, and Ω.

- For η Ori Aab, the simplest set of unknown orbital elements are the semi-major axis a and the nodal longitude Ω as the remaining parameters are available elsewhere (or don't matter much).

Orbit Results from ORBGRID



Input (De Mey et al. 1996):

P = 7.9893 days
T = 46392.128
e = 0.0
i = 87.5°
ω = 0.0°

Best Fit:

a = 1.1 mas
Ω = 168°
with
χ^2 = 2.9 for this fit

Future work

- Hmm, not so good… For a better fit, we'll try varying some of the other parameters, namely T and/or Δm_{Aab}
- We hope to use this approach to derive orbits for 18 other self-calibrating systems. Some data for these has already been obtained.