



Binary studies with the Navy Precision Optical Interferometer

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+ collaborators





Some current projects

- Zeta Orionis
 - 7 year orbit, only recently finished after discovery in 2000
- Sigma Orionis
 - NPOI's most “frustrating” target
- Xi Tauri
 - Unknown origin, then “revived” by Petr Harmanec
- HR 6493
 - Forgotten, then “revived” by Shulin Ren
- b Per
- delta Lib



LESIA



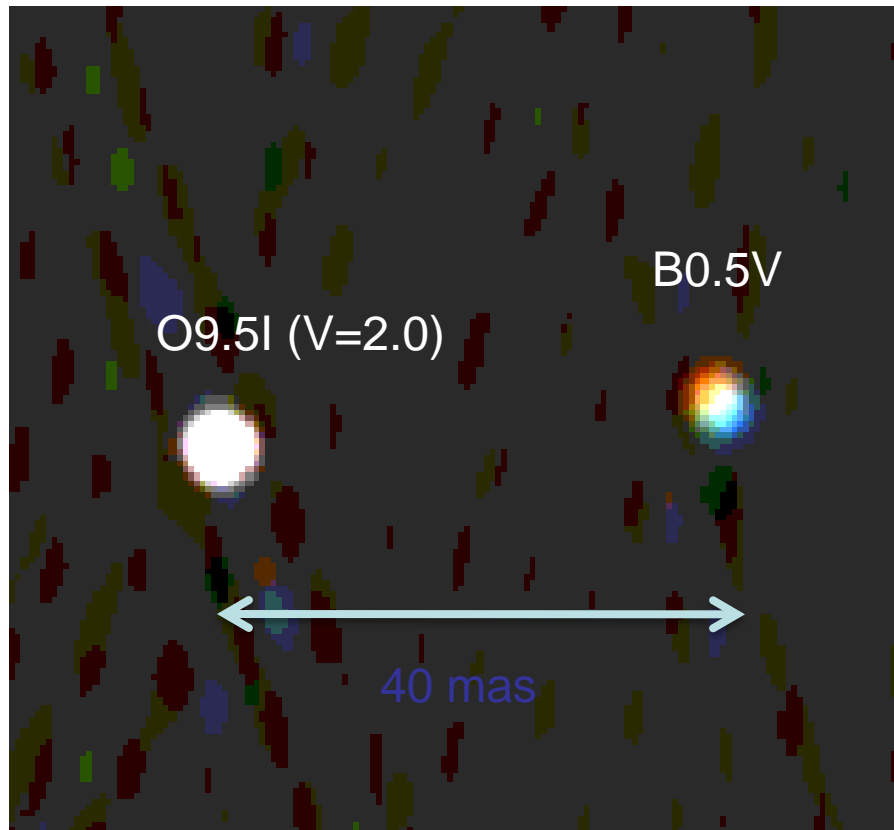
Observatoire de la CÔTE d'AZUR



ζ Ori

σ Ori

Zeta Orionis Ab



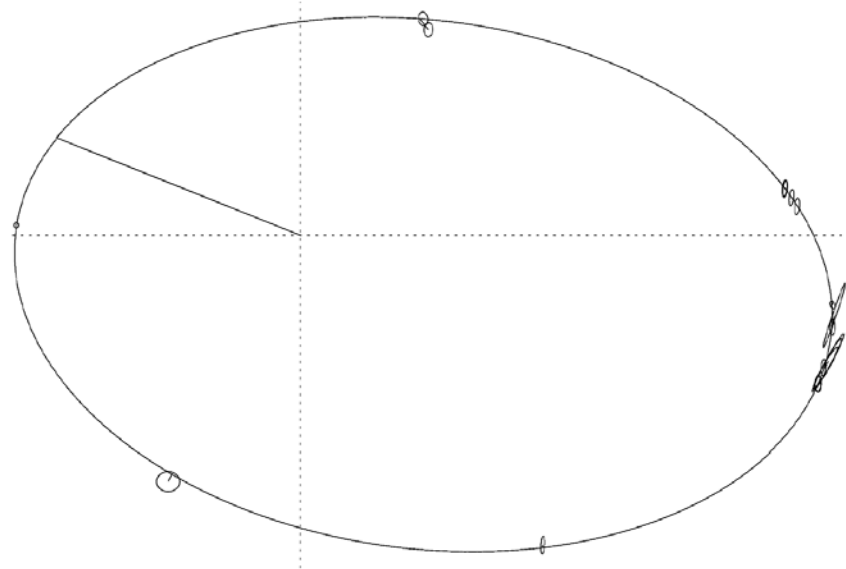
Zeta Orionis A

Discovered by Hummel et al. 2000, predicted by Hanbury Brown et al. 1974

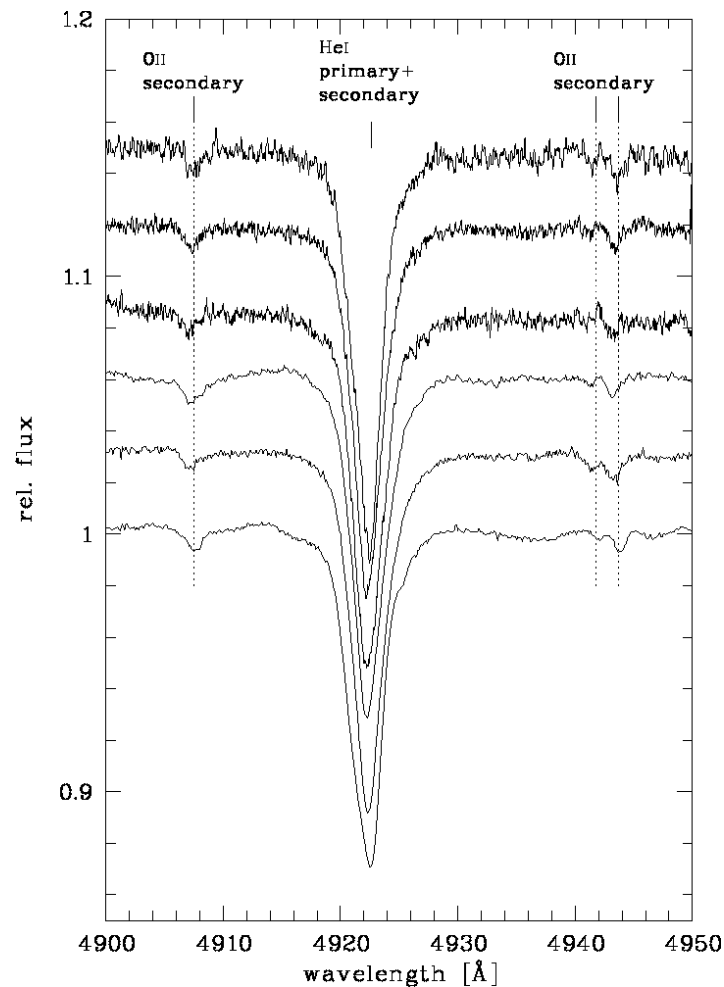
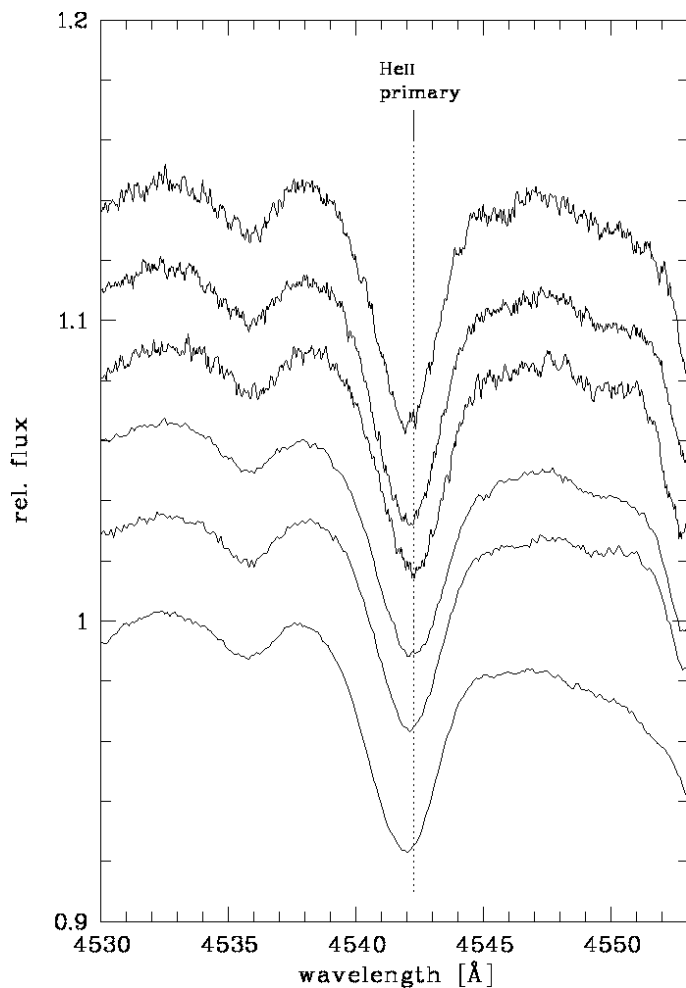
The orbit after 7 years

Table 3. Orbital elements and system parameters

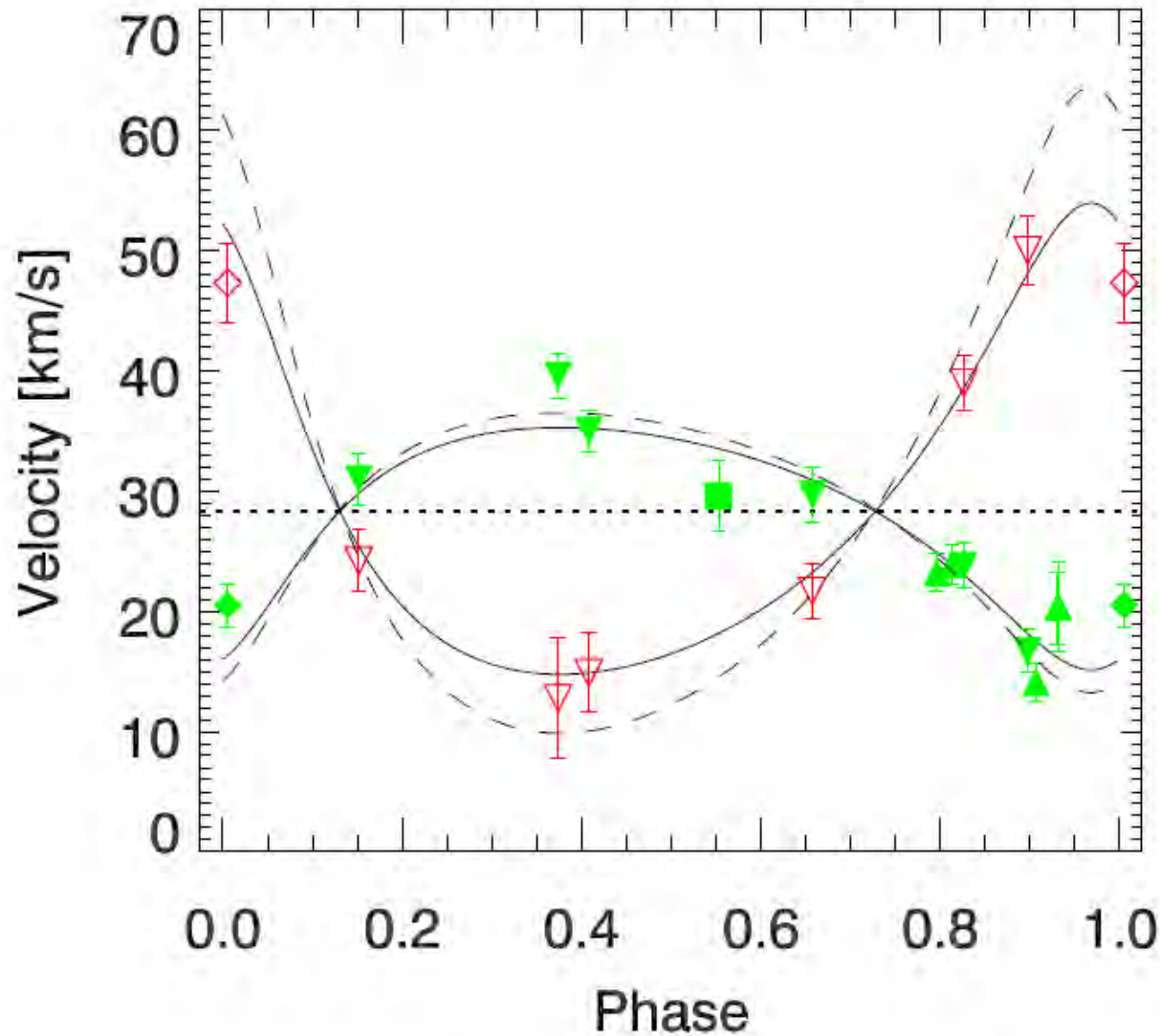
Orbital period	2687.3 ± 7.0 d
Periastron epoch	JD 2452734.2 \pm 9.0
Periastron long.	$204.2 \pm 1.2^\circ$
Eccentricity	0.338 ± 0.004
Ascending node	$83.8 \pm 0.8^\circ$
Inclination	$139.3 \pm 0.6^\circ$
Semi-major axis	35.9 ± 0.2 mas
Systemic velocity	28.3 ± 0.5 km/s
Orbital parallax	3.4 ± 0.2 mas
Visual magnitude difference	2.2 ± 0.1
M_{Aa}	$14. \pm 2.2 M_\odot$
M_{Ab}	$7.4 \pm 1.1 M_\odot$
K_1 (derived)	10.1 km/s
K_2 (derived)	19.6 km/s



Spectroscopy and radial velocities



Radial velocity fitting





System parameters

Parameter	Aa	Ab	B
Sp. type	O9.5 Iab	B1 IV	B0 III
m_V [mag]	2.1	4.3	4.0
M_V (photometry) [mag]	-6.0	-3.9	-4.1 ^a
M_V (orbit) [mag]	-5.5	-3.3	-3.6
M_\star [M_\odot]	33 ± 10	14 ± 3	—
R_\star [R_\odot]	20.0 ± 3.2	7.3 ± 1.0	—

Evolutionary status of Zeta Orionis Aa+Ab

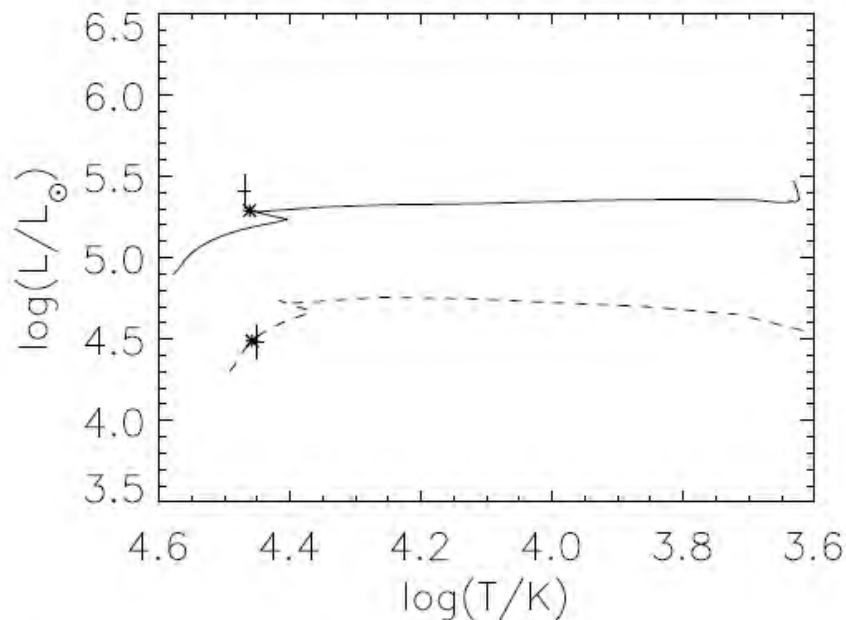
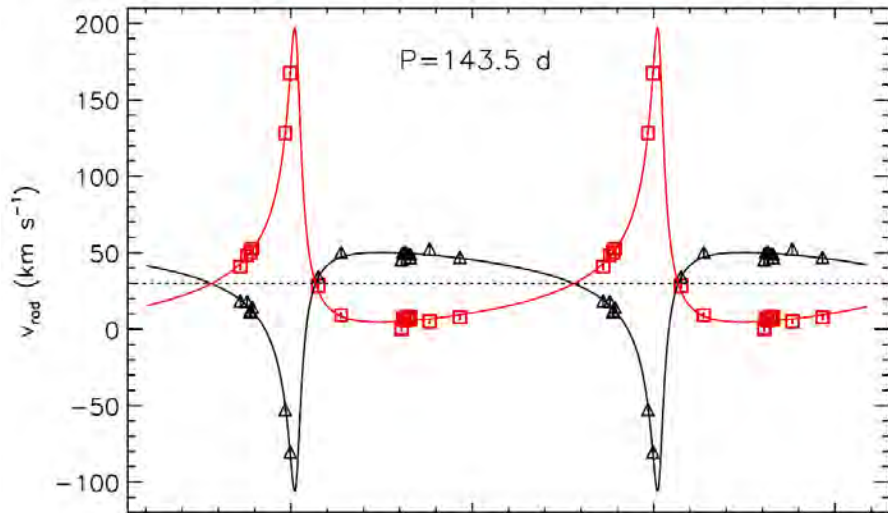


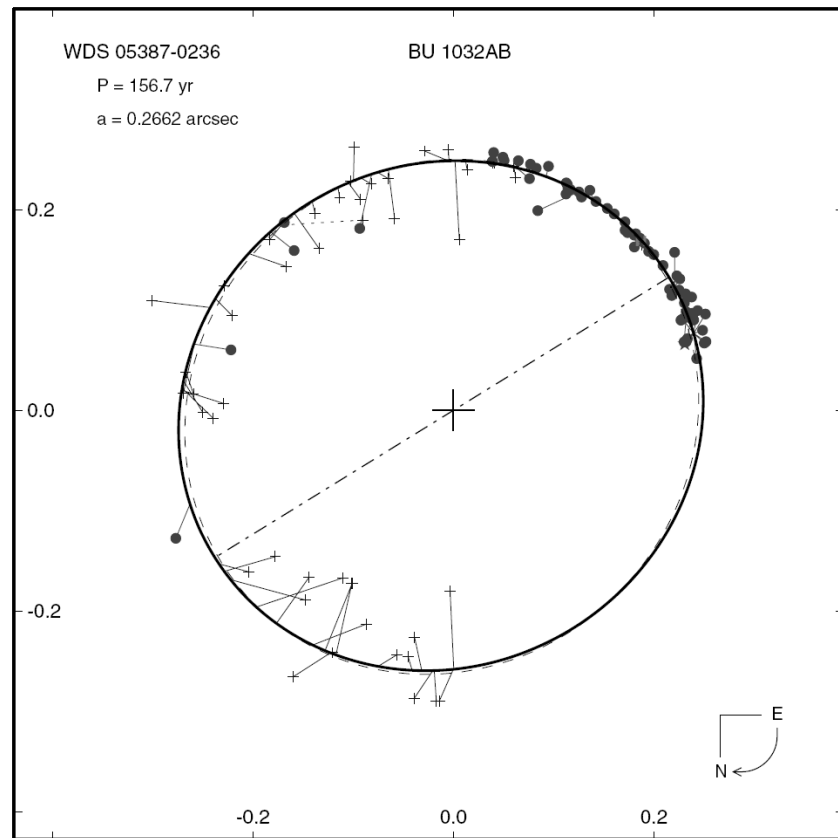
Fig. 6. The location of the components (+ symbols) of ζ Orionis A in the theoretical plane of the HR diagram, based on the photometric parallax of 2.6 mas and bolometric corrections of -2.84 and -2.72 magnitudes for primary and secondary, respectively (Flower 1996). The nearest locations have been marked on stellar evolution models for a primary of $25 M_{\odot}$ and secondary of $15 M_{\odot}$ (dashed line), at ages of 6.4 Myrs and 7.2 Myrs, respectively.

Sigma Orionis

- AB = O9.5V + early BV, P = 157 yrs
- Member of Sigma Ori cluster
- Aa – Ab: 143 days
- Ab: B0.5 V



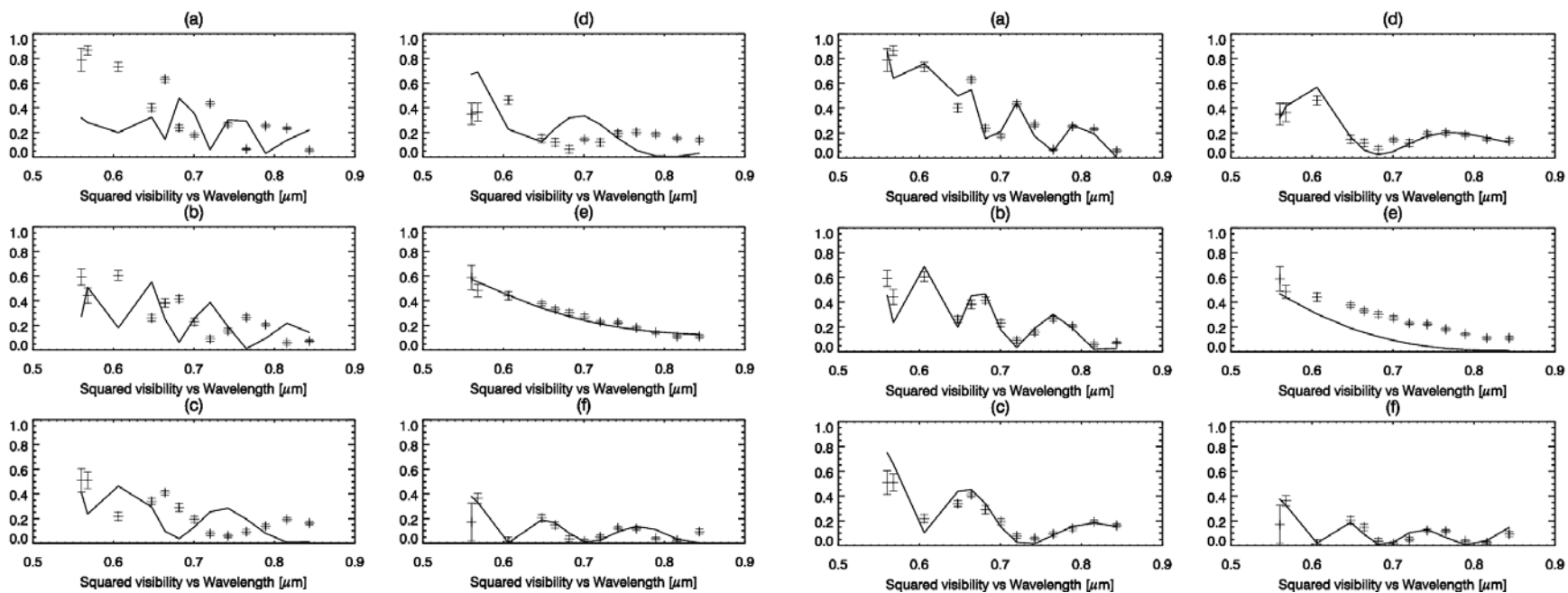
Simon-Diaz et al. 2011



Turner et al. 2008

Tertiary component detected by NPOI

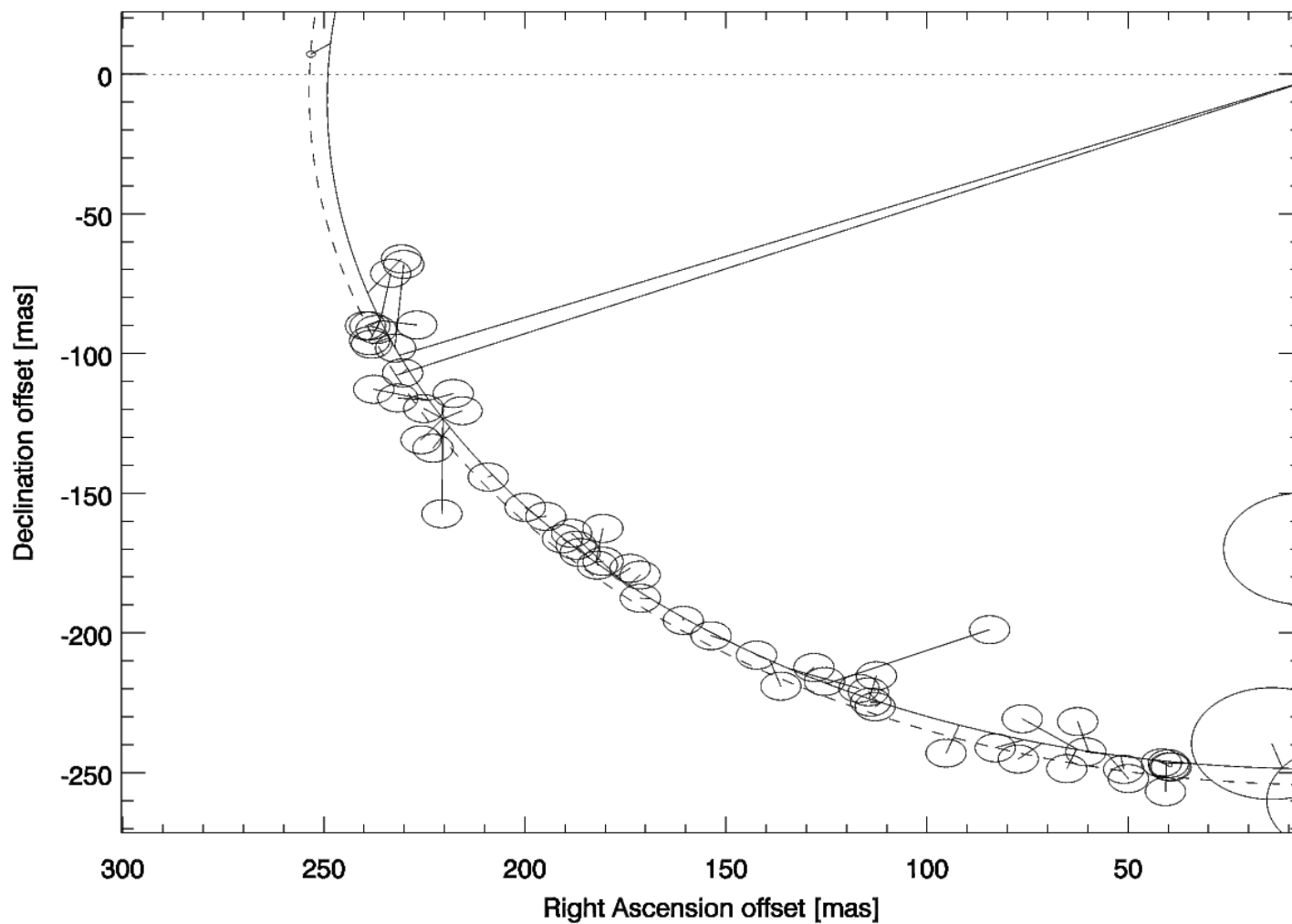
Data from March 25, 2010



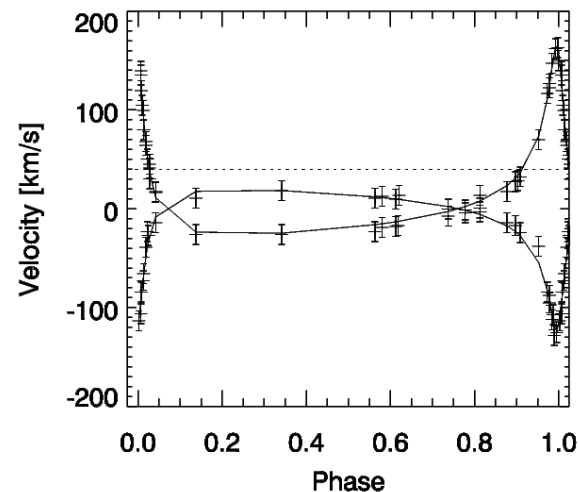
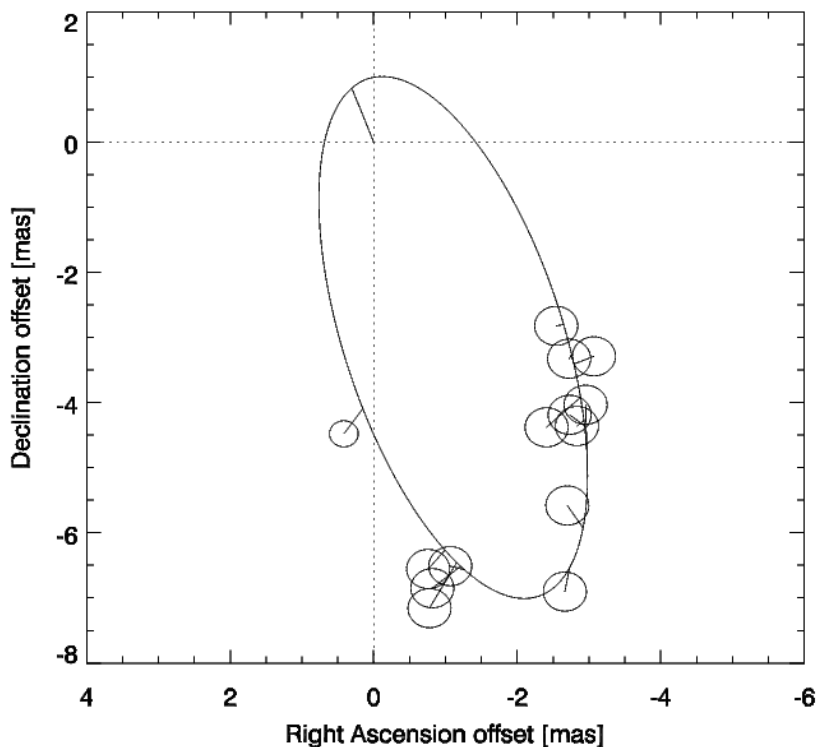
Turner et al. 2008 prediction

Fit with improved orbit

Modifying Turner's 2008 orbit



Sigma Orionis: close-pair orbit

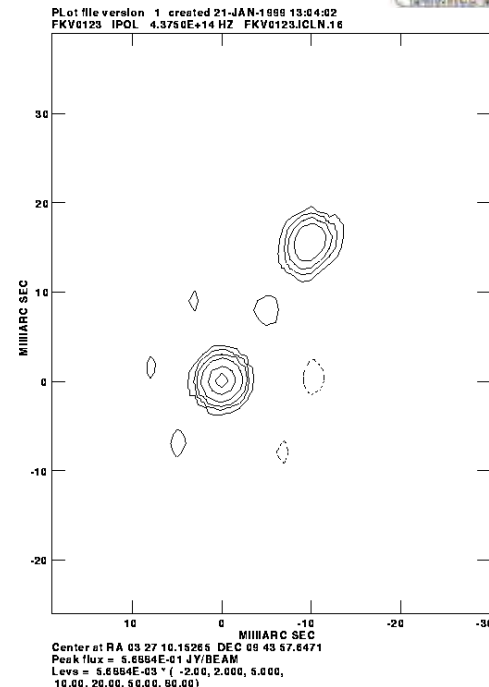
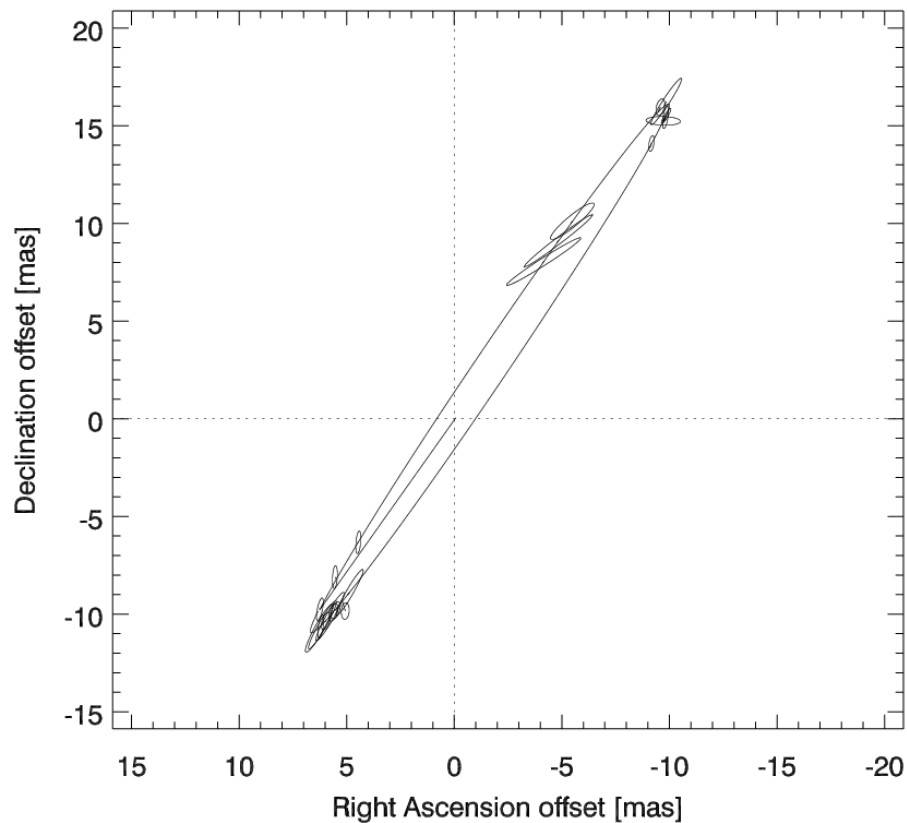


Peterson (priv. comm.)

- $a = 4.3$ mas
- $e = 0.784$
- $i = 56.3$ deg
- $\omega = 202.2$ deg
- $\Omega = 7.5$ deg
- $P = 143.22$ d
- $T = \text{JD } 2454163.2$
- $M1 = 16.7 M_{\odot}$
- $M2 = 12.4 M_{\odot}$
- $\pi = 2.6$ mas (385 pc)

Xi Tauri

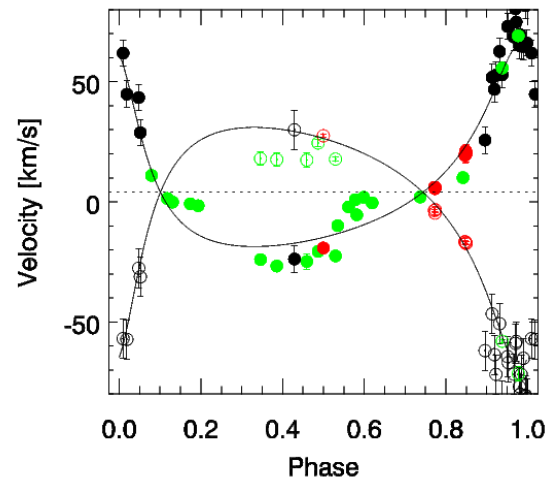
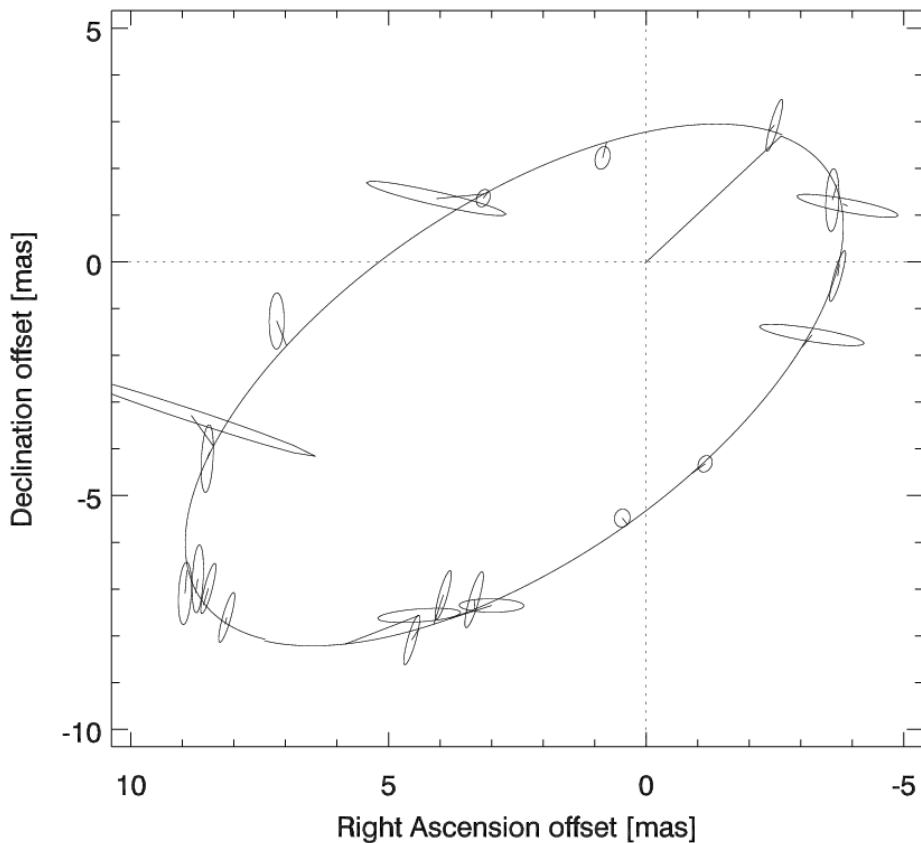
- Quadruple, 51 yr F-type C too faint for NPOI
- 7d eclipsing pair of A stars too close to be resolved
- Collaboration with Jana Nemravová, Petr Harmanec



- $a = 15.9$ mas
- $e = 0.207$
- $i = 87.1$ deg
- $\omega = 157.9$ deg
- $\Omega = 148.4$ deg
- $P = 145.15$ d
- $T = \text{JD } 2453710.9$

HR 6493 (F3V)

- $a = 7.7$ mas
- $e = 0.49$
- $i = 57.1$ deg
- $\omega = 198.4$ deg
- $\Omega = 305.6$ deg
- $P = 26.277$ d
- $T = \text{JD } 2448102.9$



S. Ren (priv. comm.)

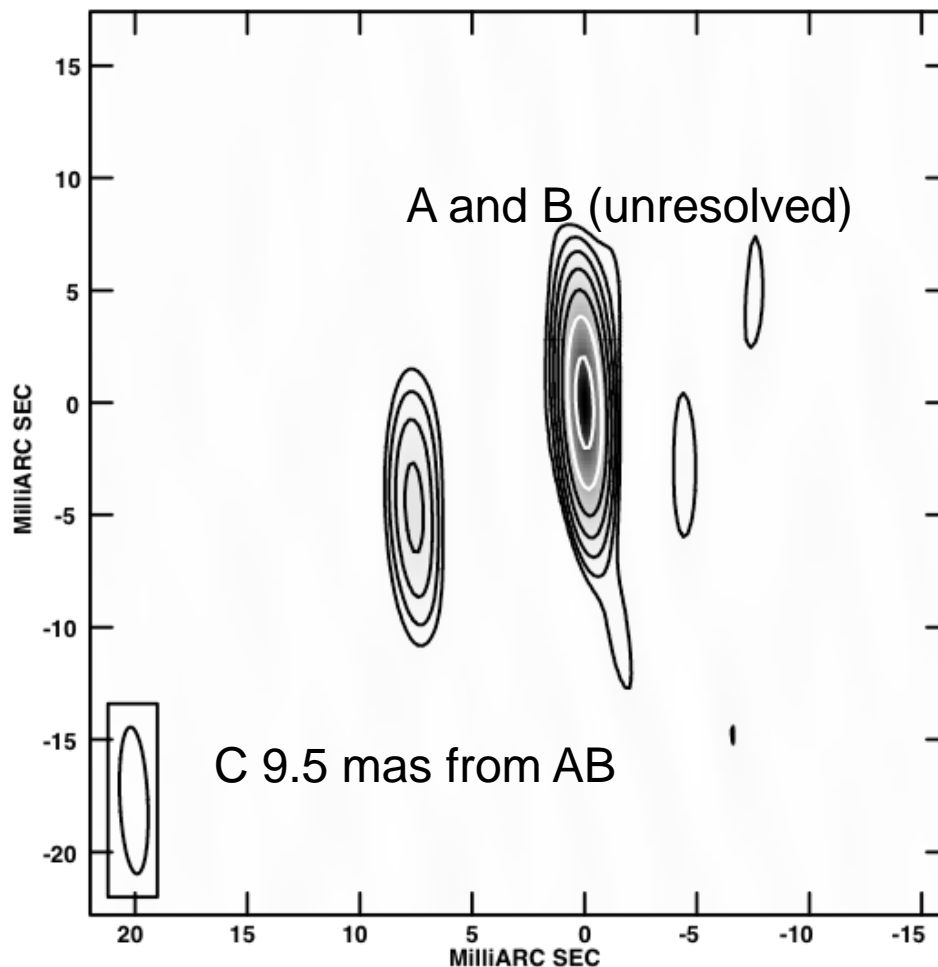


Radio stars, motivation

- ▶ NPOI produces wide-angle astrometry for USNO
- ▶ Radio stars link the optical -> radio reference frame
- ▶ Radio stars are often multiples
- ▶ Observe radio stars to improve/determine orbits
- ▶ NPOI observables include flux ratios (usually a modeled parameter)
- ▶ 5/12 HIPPARCOS link stars are brighter than 6.0 mag.
- ▶ Many other radio stars with good (+/- 10 mas) absolute astrometry
- ▶ Algol, b Per, Delta Lib ...

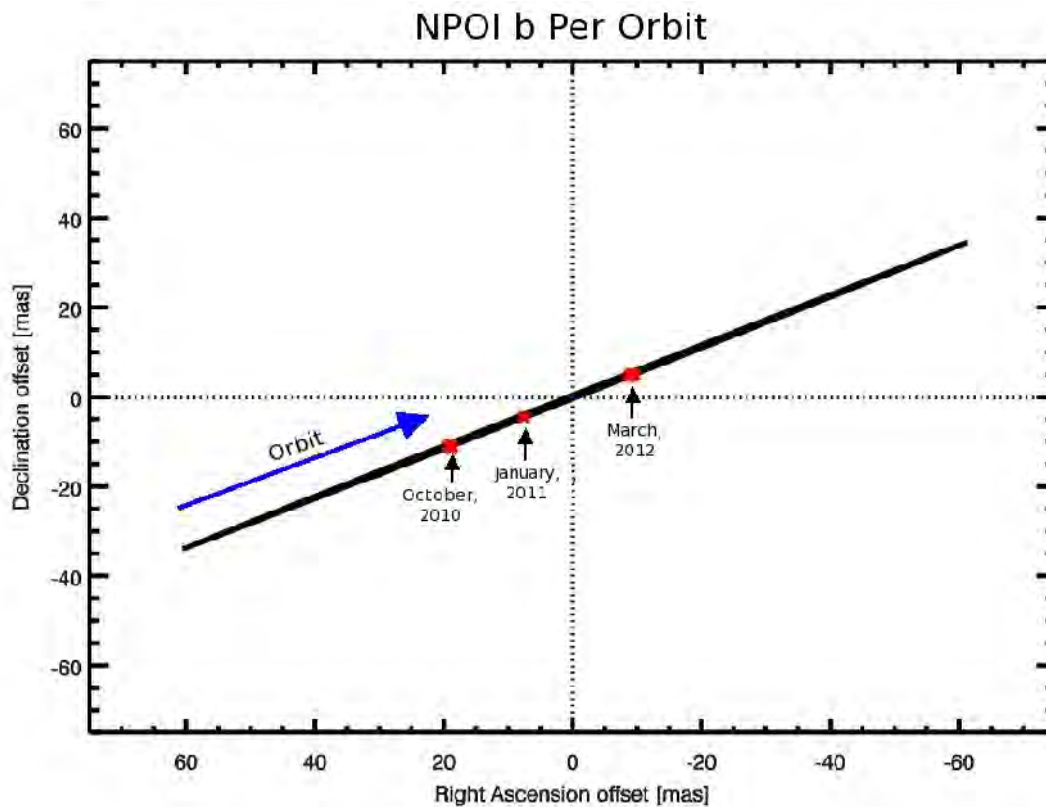
b Per 2011 Jan 30

- ▶ Ellipsoidal variable in a triple
- ▶ $P_{AB-C} = 1.92$ yrs
- ▶ $P_{A-B} = 1.527$ days
- ▶ Radio star



b Per AB-C: Edge-on orbit and eclipses

- ▶ Hill et al. (1976): spectra suggest eclipses of AB by C possible
- ▶ Astrometry consistent with high inclination



b Per eclipse

Courtesy of Bob Zavala, east coast observer with DSLR

