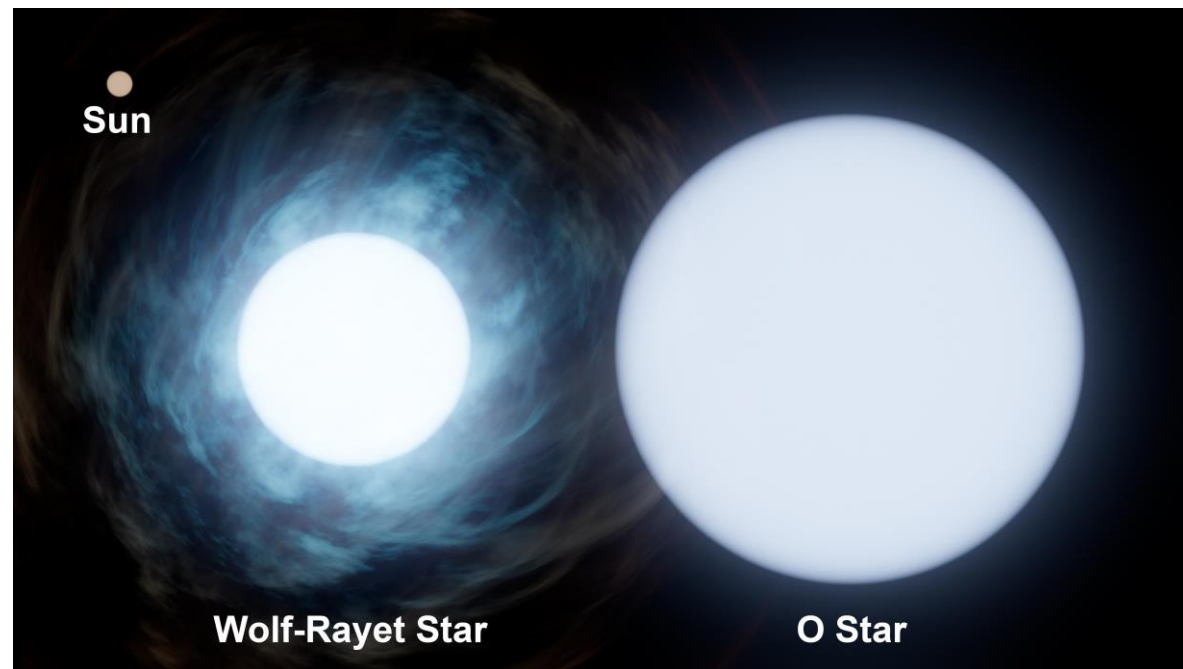
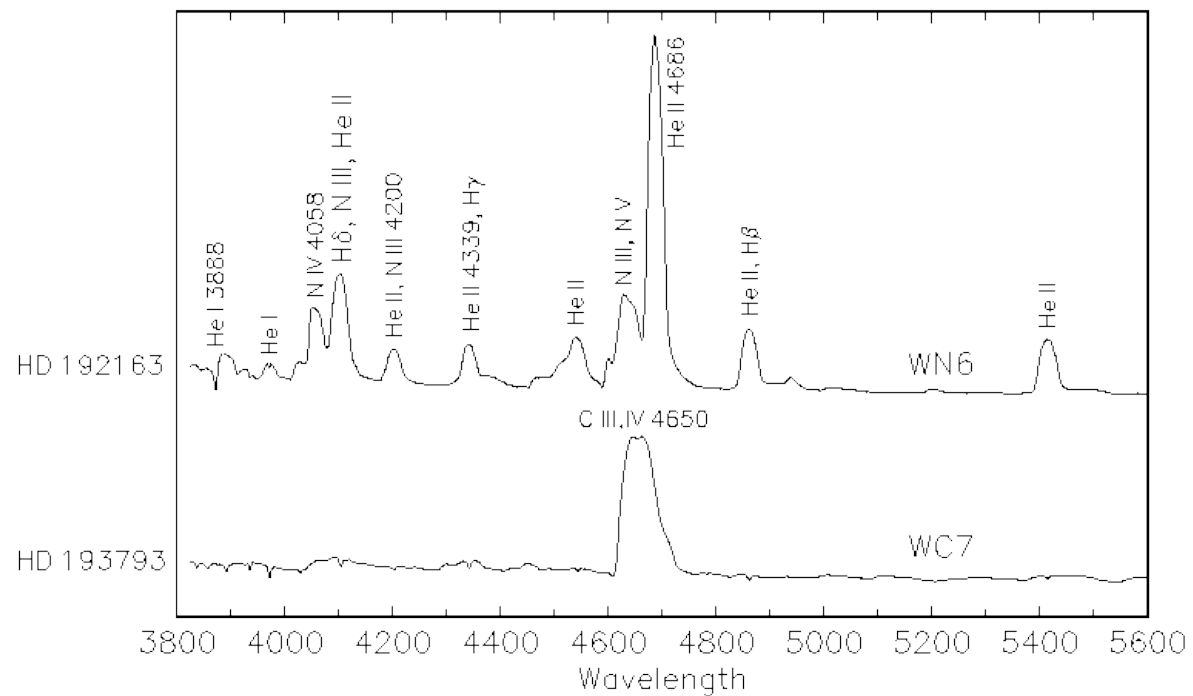


Visual Orbits of WR stars

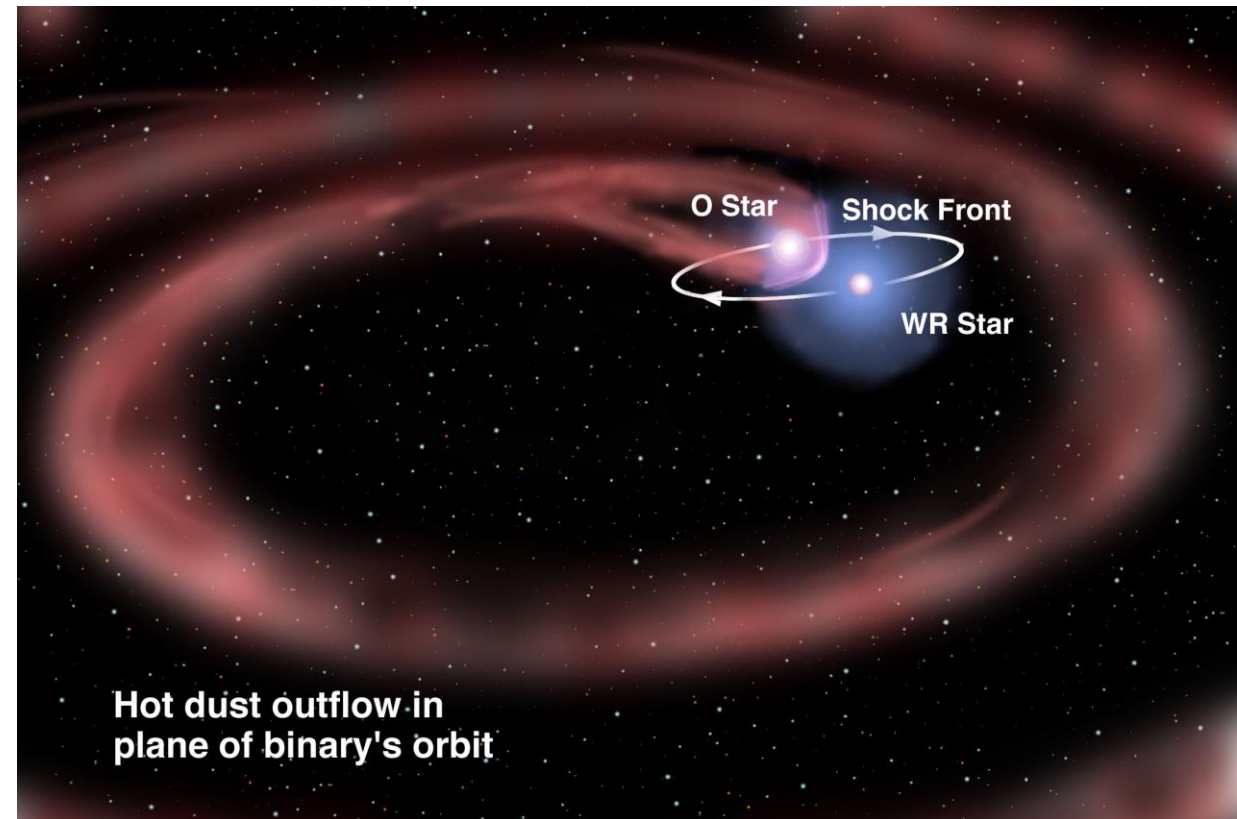
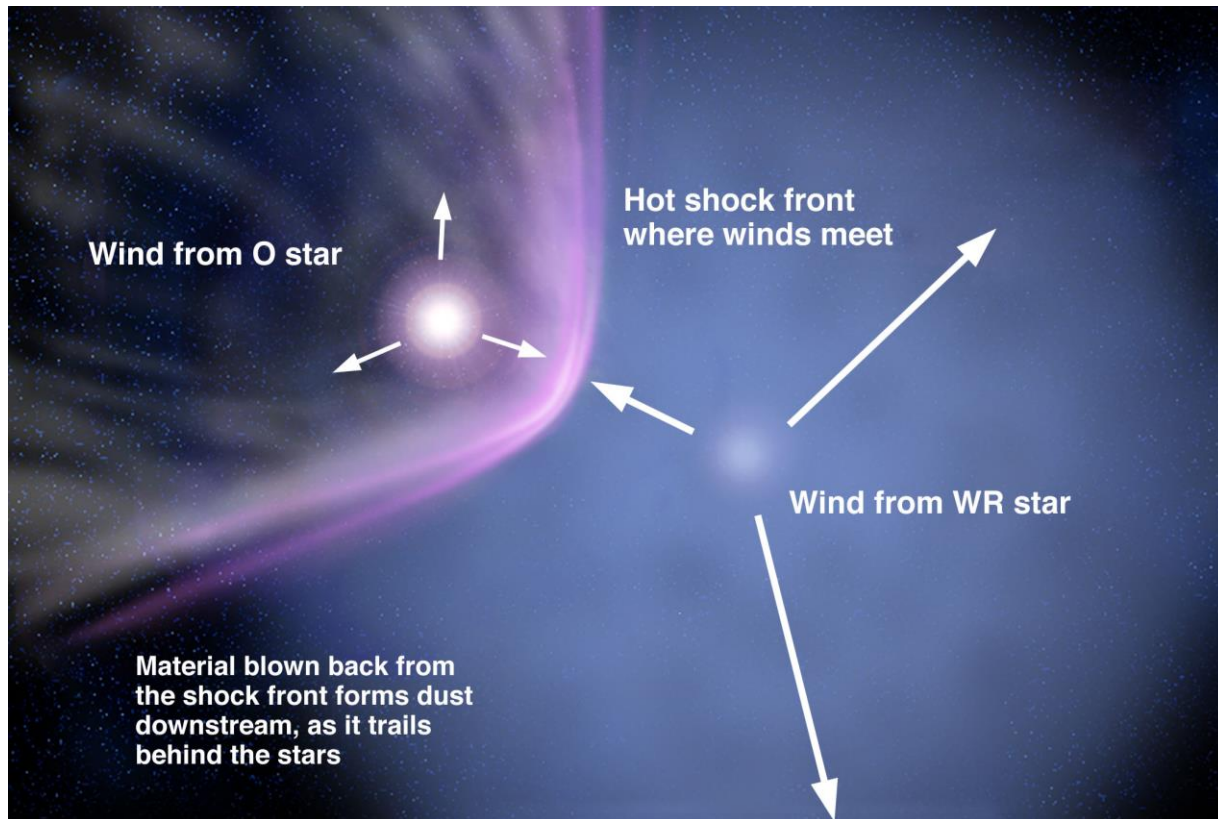
Noel Richardson, Gail Schaefer et al.

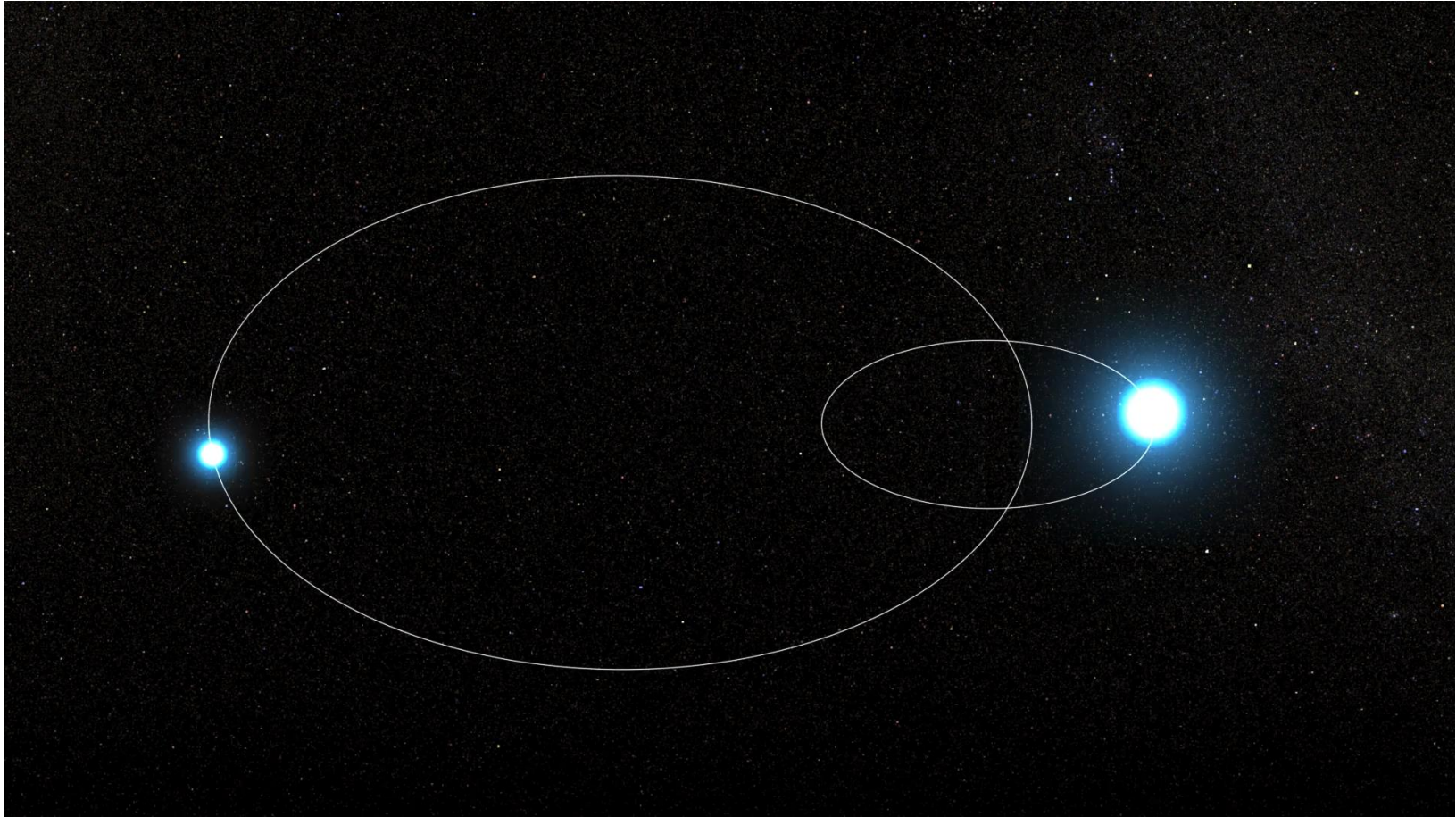
With students: Amanda Holdsworth, Randy Loberger, Laura Lee



Wolf-Rayet stars

WR + O star = colliding wind binary





γ^2 Vel at Narrabri

Mon. Not. R. astr. Soc. (1970) **148**, 103–117.

A STUDY OF γ^2 VELORUM WITH A STELLAR INTENSITY INTERFEROMETER

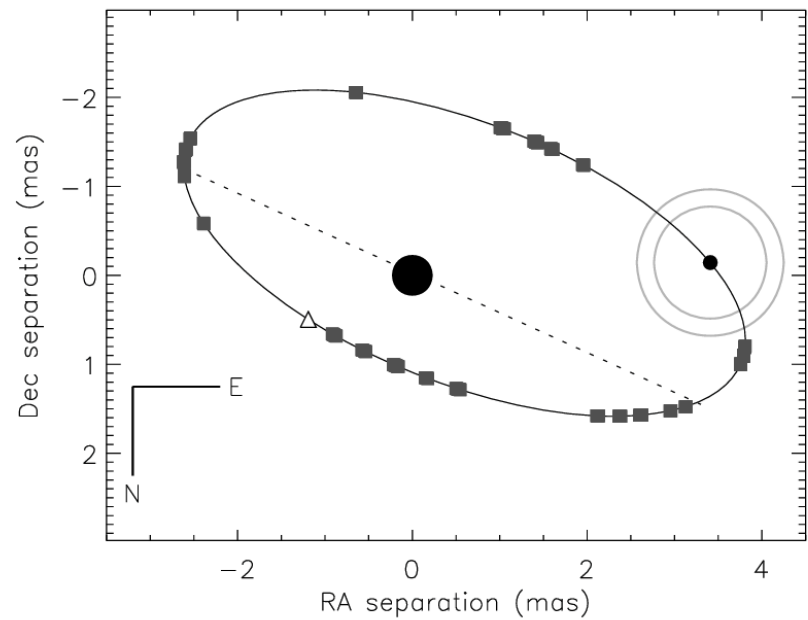
R. Hanbury Brown, J. Davis, D. Herbison-Evans and L. R. Allen

(Received 1969 November 11)

SUMMARY

The stellar intensity interferometer at Narrabri Observatory has been used, for the first time, to make observations of a multiple star (γ Vel). Measurements have been made in the continuum at $\lambda 4430$ and in the C III–IV emission feature at $\lambda 4650$. The observations at $\lambda 4430$ give the angular size of the semi-major axis of the binary system γ^2 Vel and the angular diameter of the Wolf–Rayet component, while the observations at $\lambda 4650$ give the angular size of the extended region responsible for the emission feature. The results have been

Jump from 1970 to 2007



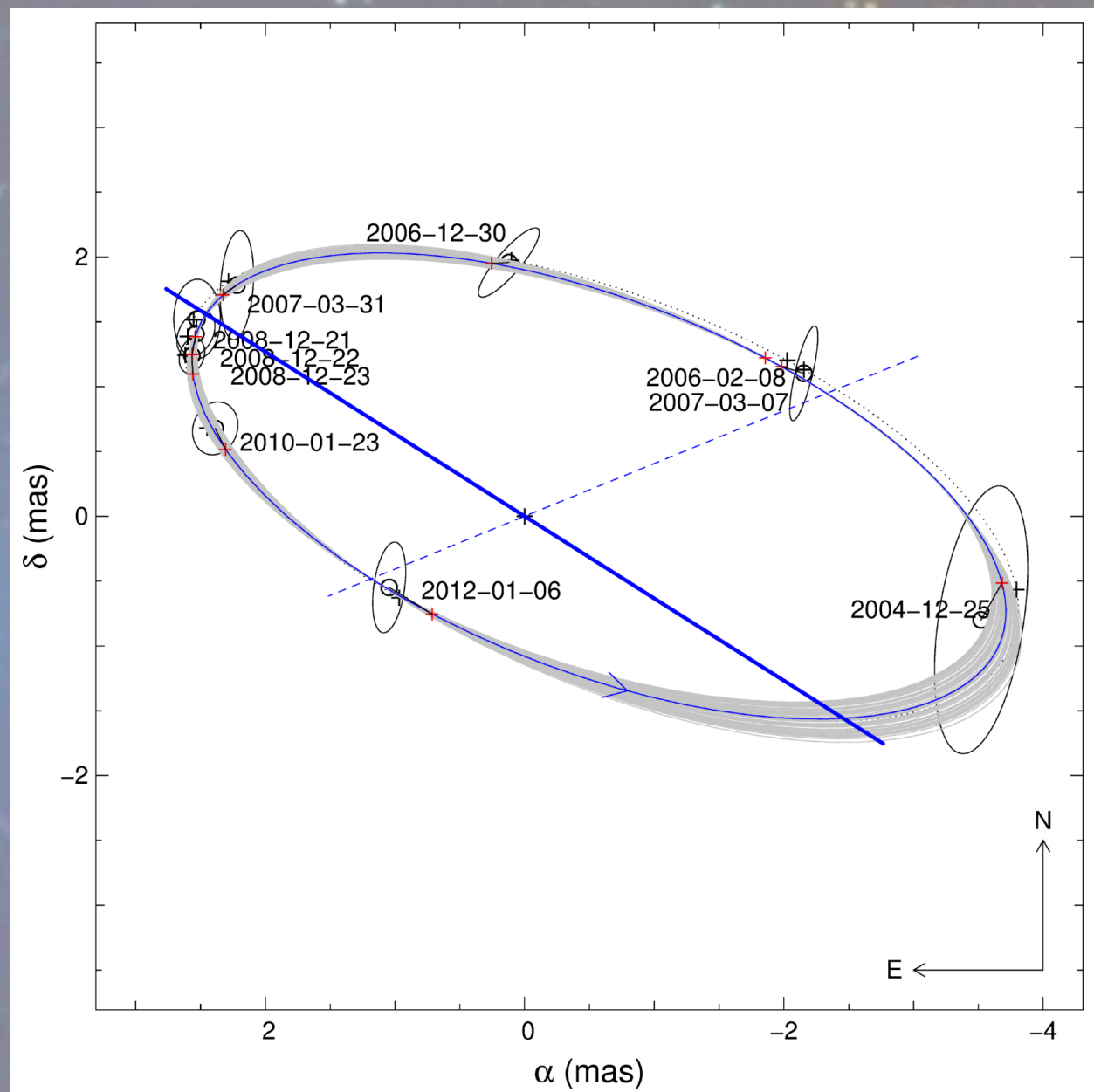
North et al. (2007)





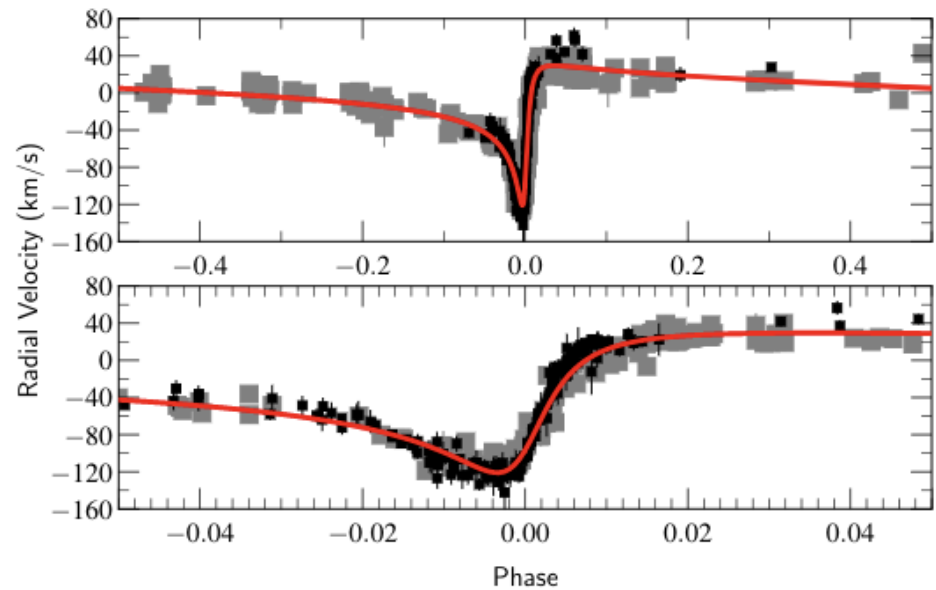
γ^2 Vel

- WC8 + O7.5III
- $P = 78.53$ d
- $e = 0.33$
- Lamberts et al. 2017 +
Richardson et al. 2017
- $M_O = 28.4$ Msun
- $M_{WR} = 9$ Msun



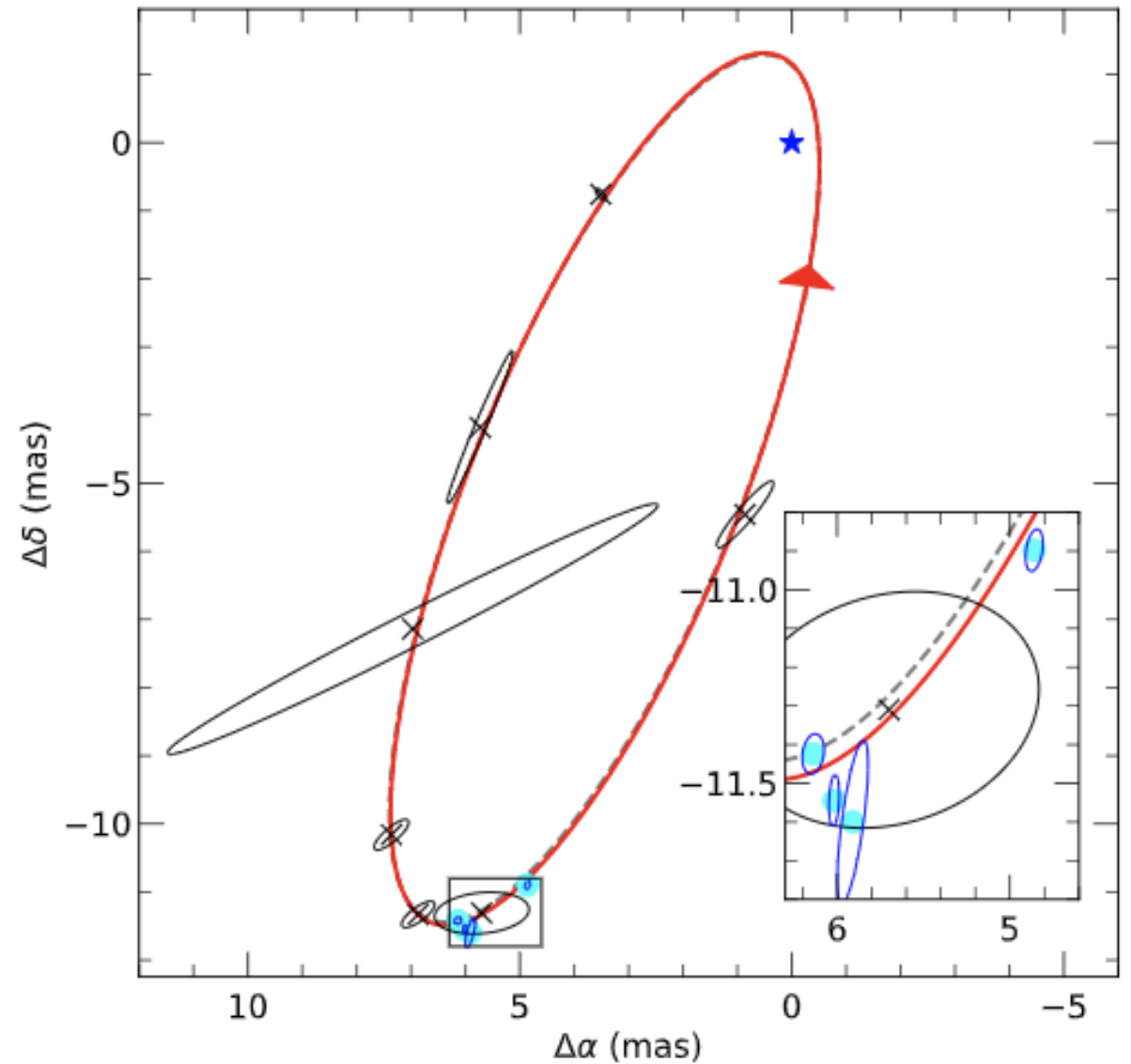
Coming soon for gamma Vel:

- Thanks to Peter for helping retrieve the original SUSI data!
- Include all VLTI and SUSI data, along with 1000+ radial velocities to obtain super-precise orbit
- Work of student Randy Loberger for senior capstone project.



WR140 –
 Monnier et al.
 (2004, 2011);
 Thomas et al.
 (2022)

- WC7pd + O5.5fc
- $P = 7.93$ years
- $e = 0.8993$
- $M_{\text{O}} = 29.3 M_{\text{sun}}$
- $M_{\text{WR}} = 10.3 M_{\text{sun}}$

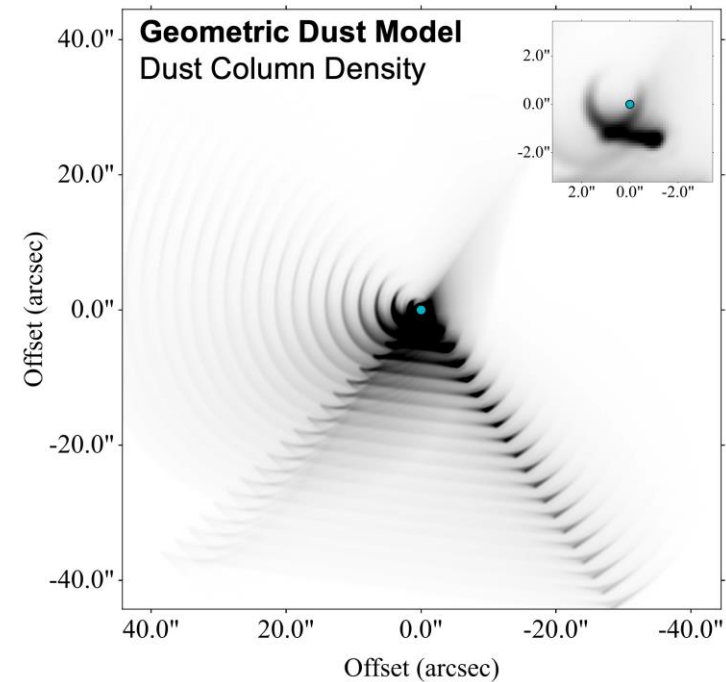
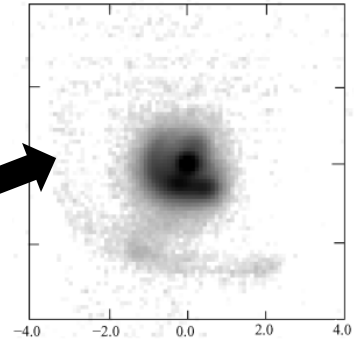


Orbit is very useful

Lau et al. (2022)
Han et al. (2022)



Best ground-based 12.9 μm image of dust

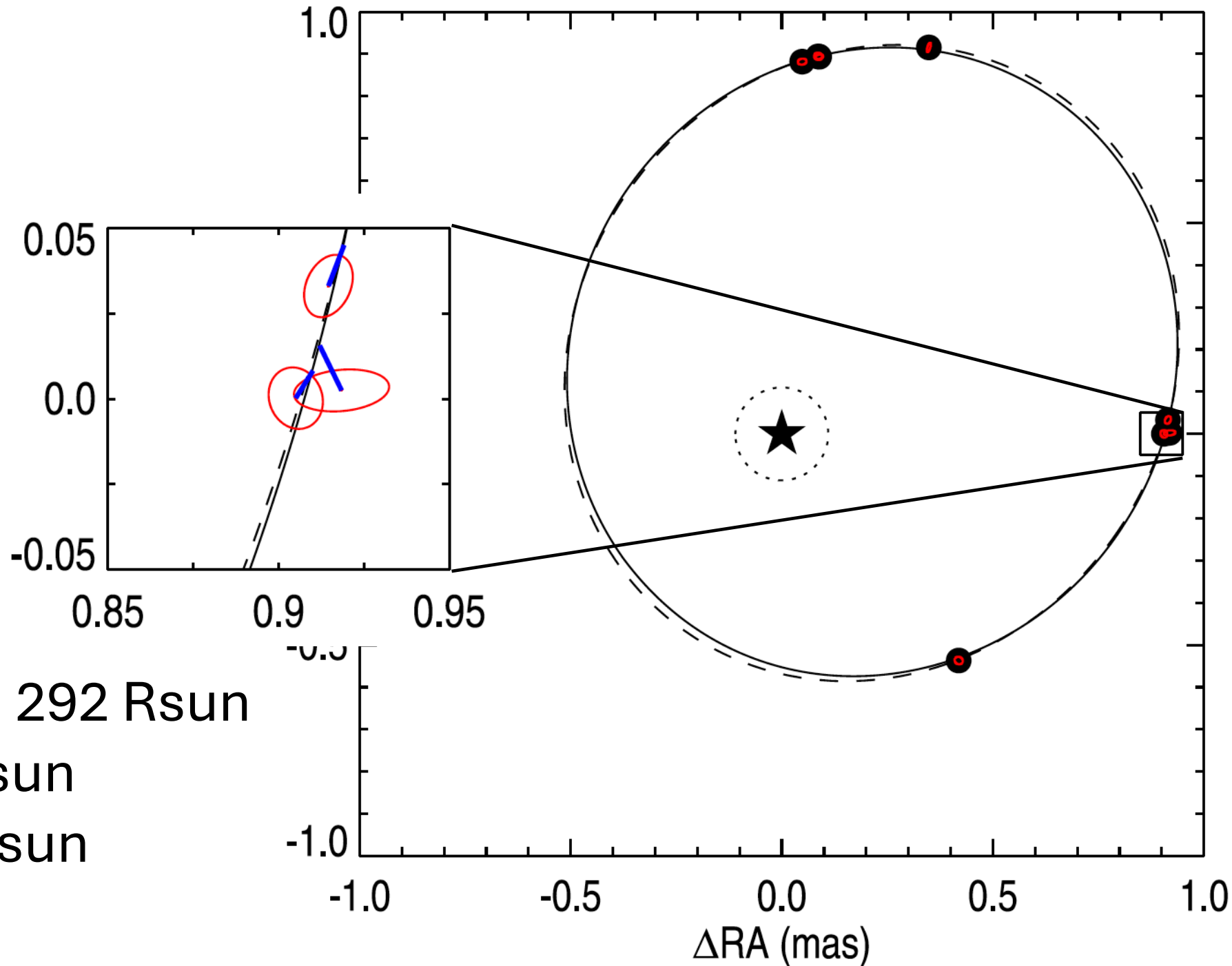


WR 133 - background

- Results in Richardson et al. (2021)
- WN5o + O9I
- Known SB2 orbit with $P=113$ d, but relatively understudied.
- member of NGC 6871
- Inclination at least 115° from polarimetric analysis

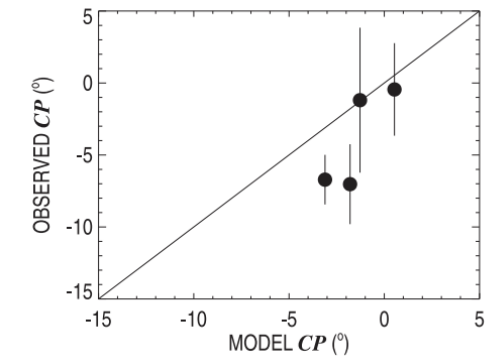
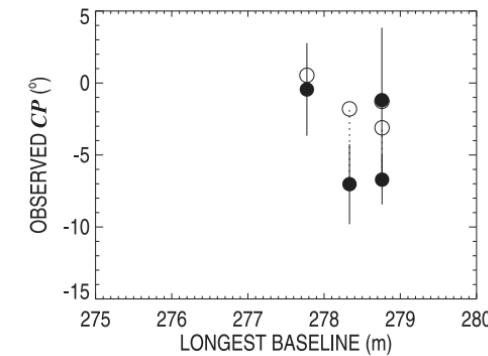
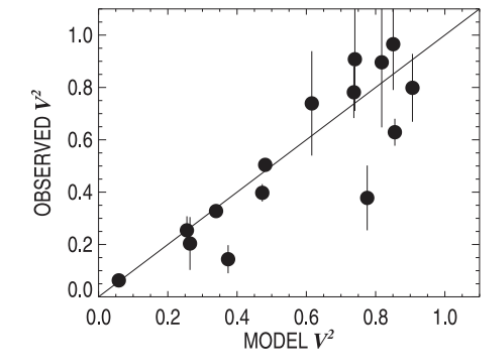
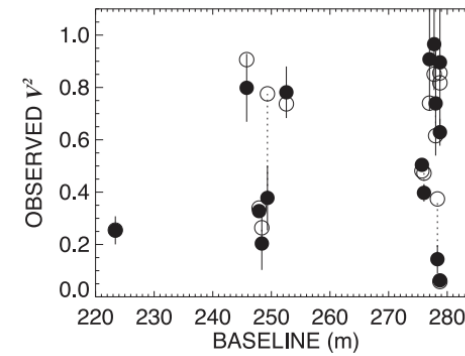
CHARA

- $P = 112.78$ d
- $e = 0.36$
- $d = 1.73$ kpc
- $a = 0.79$ mas = $292 R_{\text{sun}}$
- $M_{\text{O}} = 18.1 M_{\text{sun}}$
- $M_{\text{WR}} = 8.2 M_{\text{sun}}$



WR137, WR138 – resolved with CHARA (Richardson et al. 2016)

- WR 137
 - WC7 + O
 - P = 13 yr
 - Dust formation at periastron
- WR 138
 - WN + O
 - P ~4 yr?
- CLIMB observations resolved the binaries
 - began a long-term ~~NOAO~~ NOIRLab program for orbits.
 - Upgraded MIRC-X made the program finally take off!



WR 137 (nearing completion)

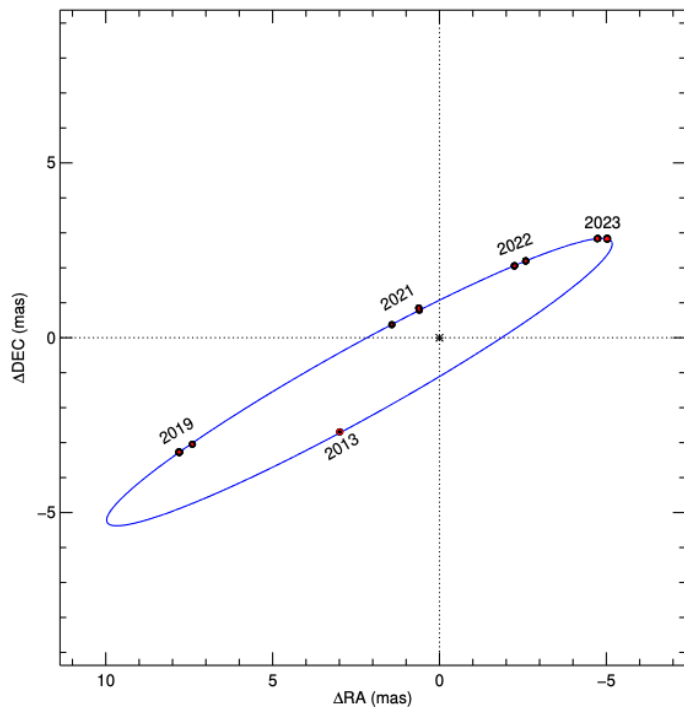
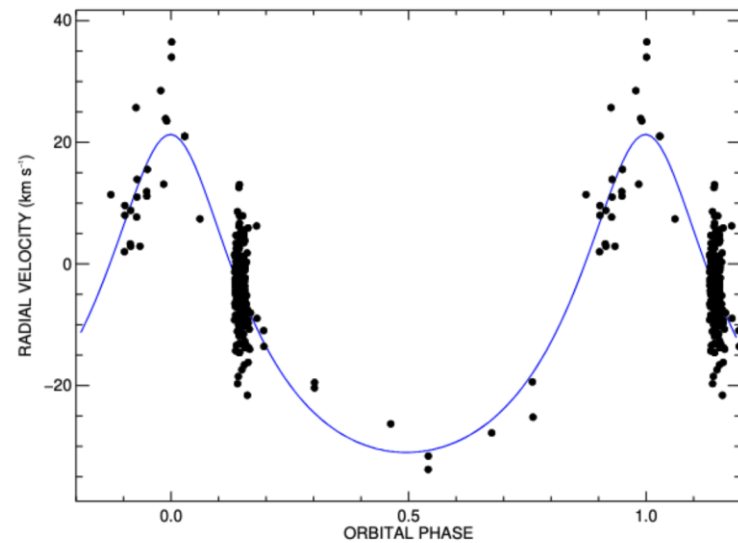
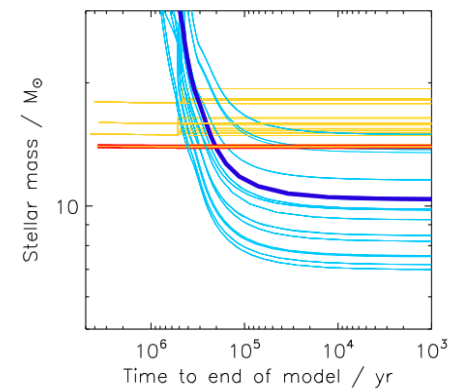
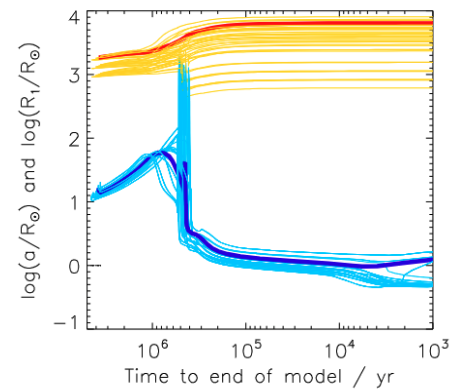
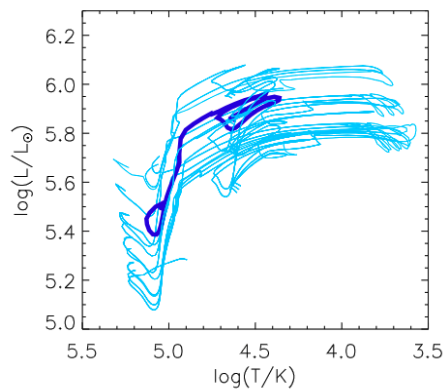
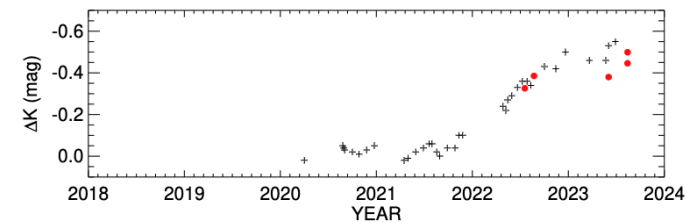
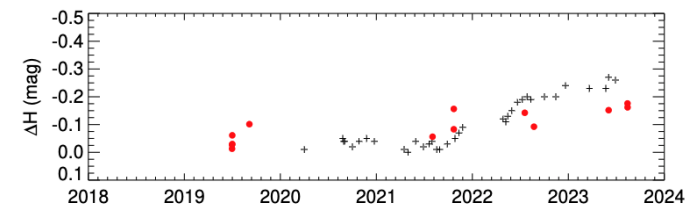
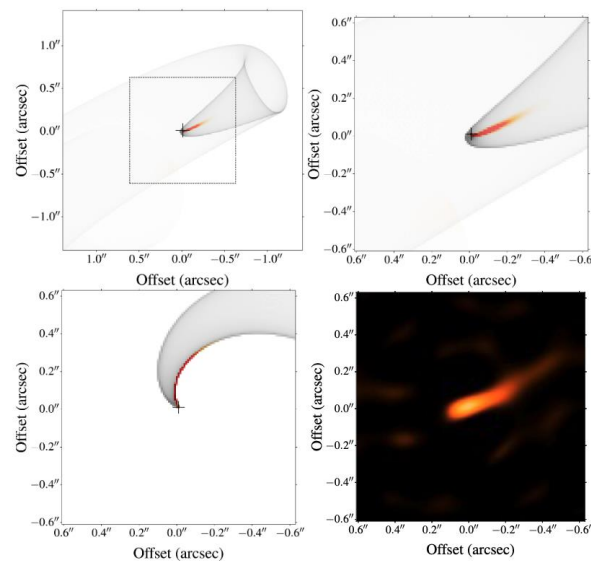


Table 4. Orbital Elements

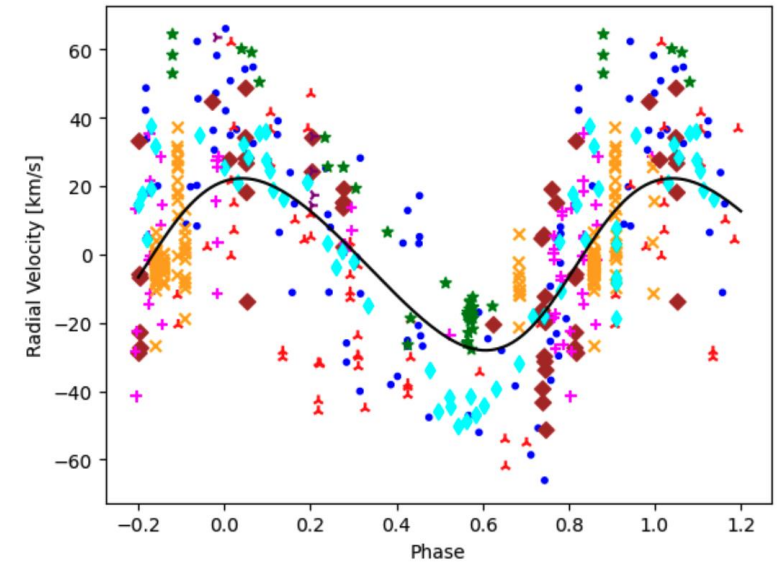
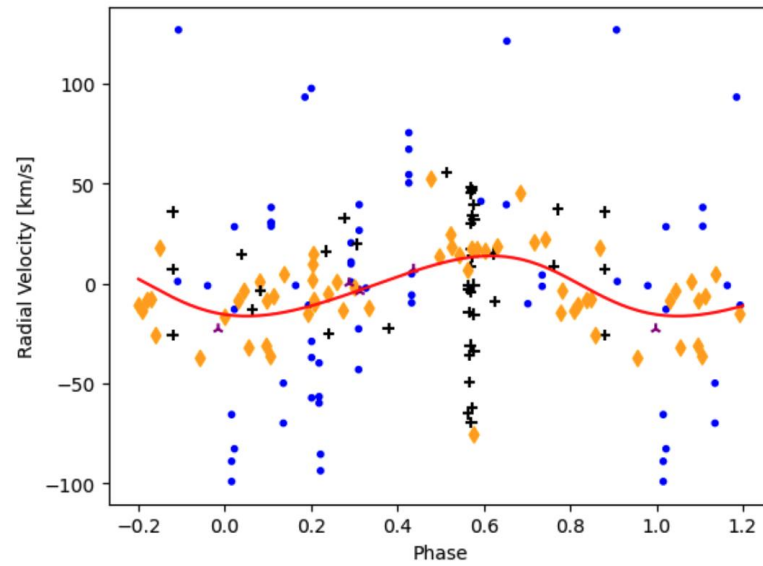
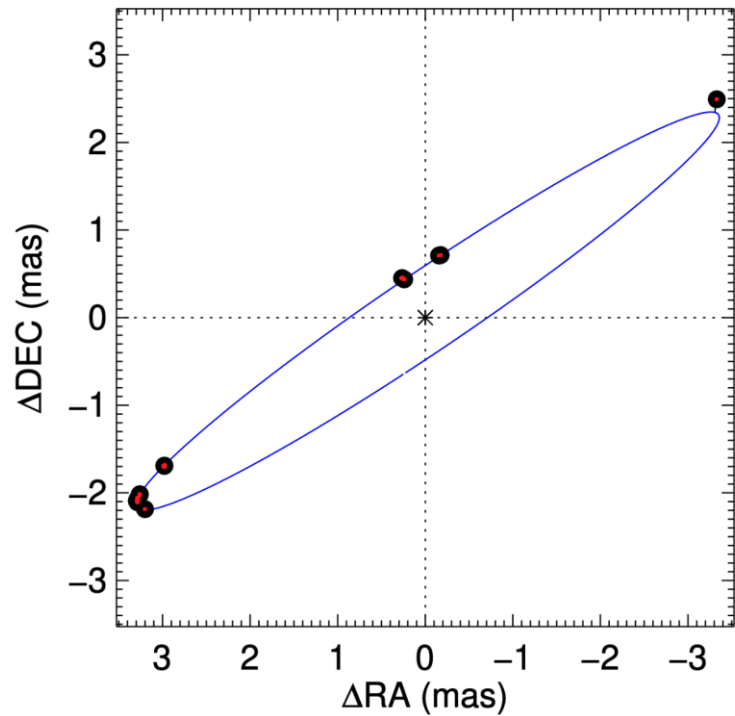
Measured Quantities			
Orbital Element	Value		
P (d)	4785.2 ± 6.5		
P (yr)	13.101 ± 0.018		
T (JD)	$2,460,255.64 \pm 4.24$		
T (yr)	2023.848 ± 0.012		
e	0.3147 ± 0.0013		
a (mas):	8.5614 ± 0.0116		
i	97.192 ± 0.034		
Ω ($^\circ$)	117.914 ± 0.027		
ω_{WR} ($^\circ$)	0.755 ± 0.552		
K_1 (km s^{-1})	25.75 ± 0.98		
γ (km s^{-1})	-12.70 ± 0.62		
χ^2	286.0		
χ^2_{red}	0.46		
Derived Quantities			
Quantity	Fit, $K_2 = 6.3$	Fit, $d=2.11$ kpc	Fit, $d=1.94$ kpc
M_{WR} (M_\odot)	2.69 ± 2.38	12.69 ± 8.60	8.42 ± 2.99
M_{O} (M_\odot)	11.34 ± 3.00	20.18 ± 3.33	17.00 ± 1.35
a_1 (AU)	10.84 ± 0.41	11.11 ± 0.42	11.11 ± 0.42
a_2 (AU)	2.57 ± 1.64	6.99 ± 1.51	5.50 ± 0.72
d (pc)	1566 ± 198	2114 ± 160	1941 ± 71
Parallax (mas)	0.639 ± 0.081	0.473 ± 0.038	0.515 ± 0.018
Reference (d)	Derived	Rate & Crowther (2020)	Bailer-Jones et al. (2021)

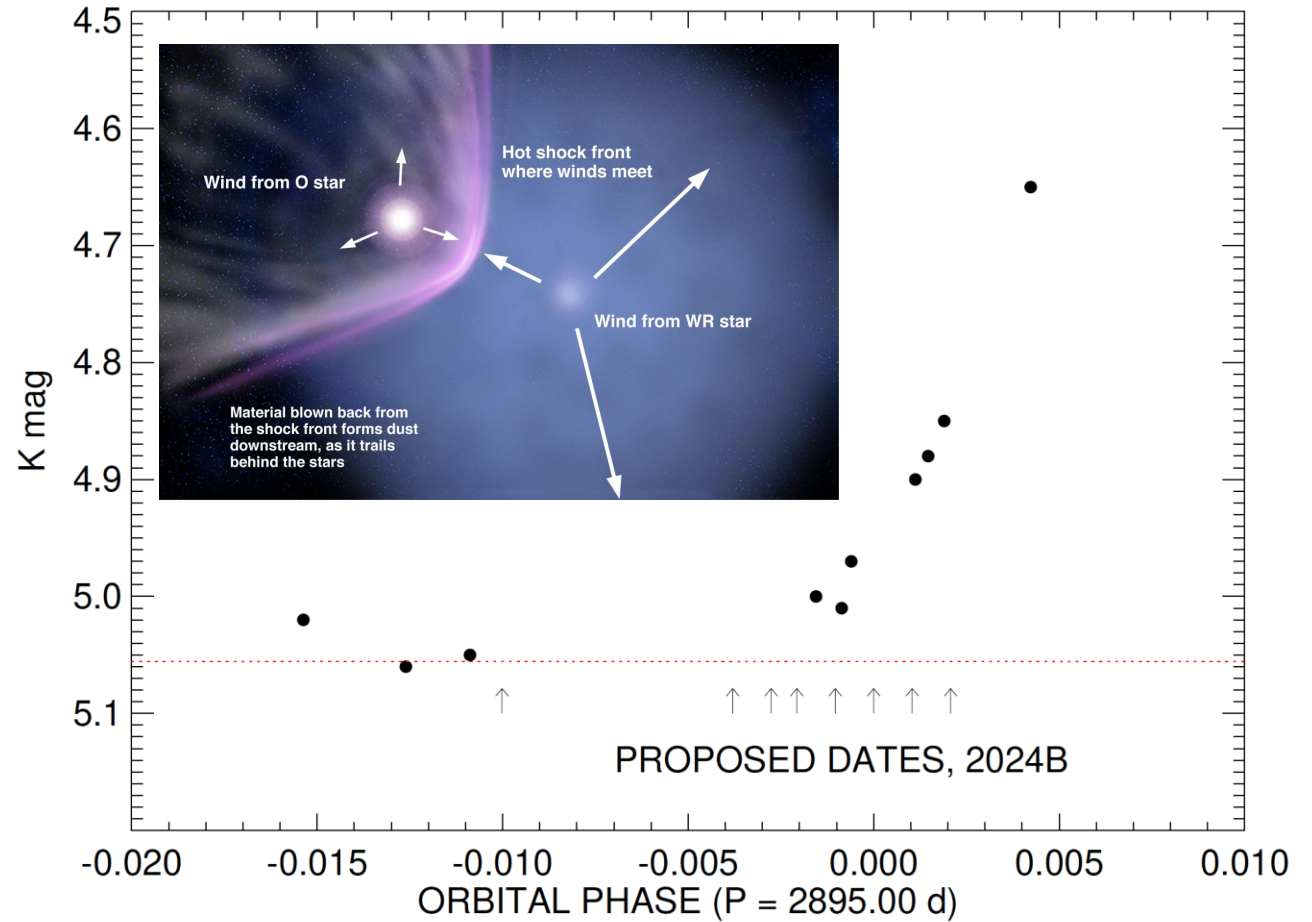
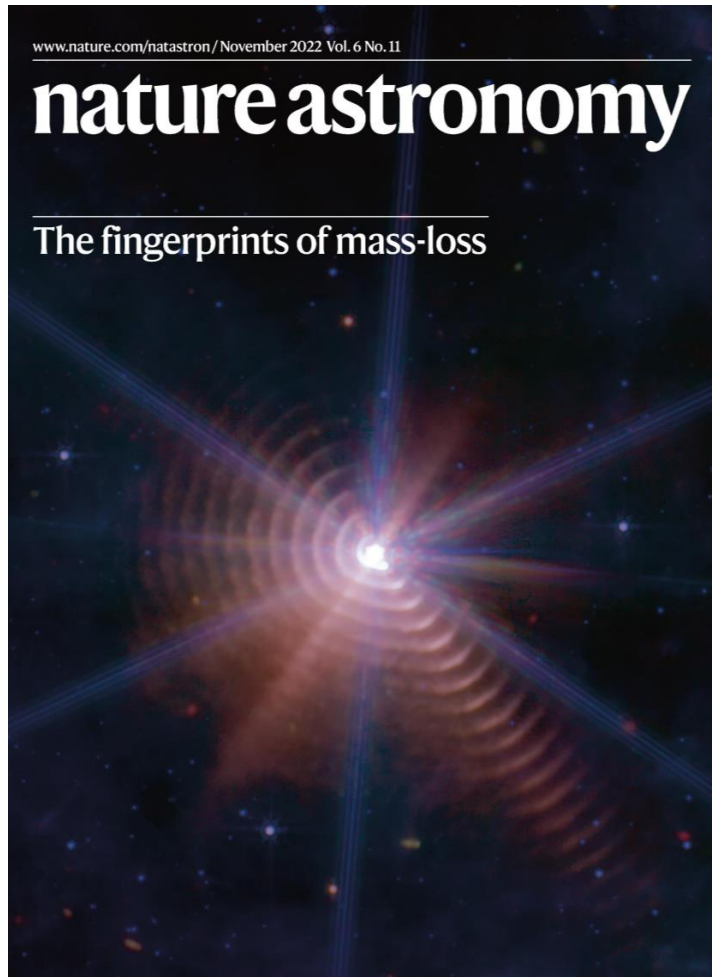


Other cool aspects of WR 137



WR 138 (hopefully finish in next several months)





Hopeful new NOIRLab program for 2024B