Long-term CHARA observations of Binary Cepheids

Alexandre Gallenne

Universidad de Tarapacá

Chile

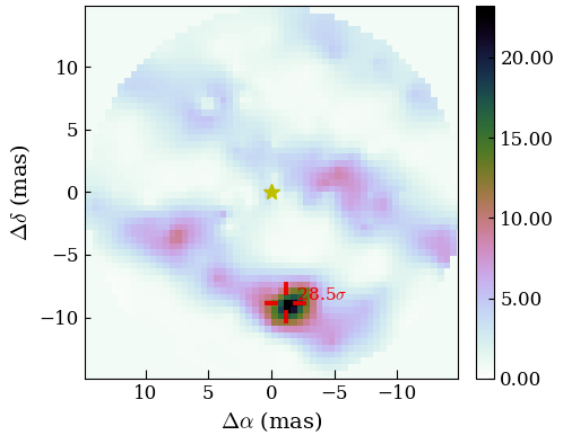
- Cepheids are important standard candles for the extragalactic distance scale
- When in a binary system (> 80%), we should be able to:
  - Have an independent distance measurement: test Gaia and P-L relations
  - Measure the dynamical mass: test evolutionary models

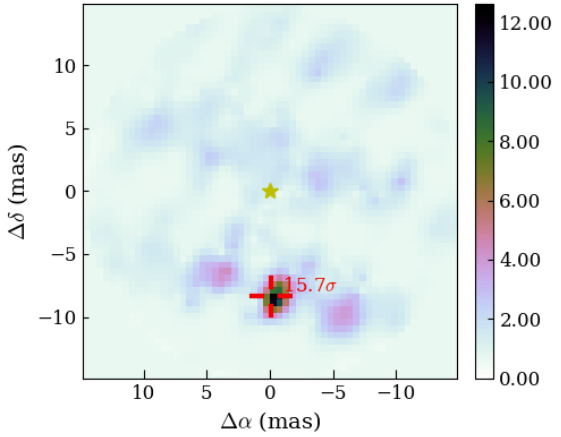
- Challenging targets because we need to detect the companions both spectrally and spatially:
  - Companions are mostly early-type main-sequence → high contrast
  - Lines are usually broad and blended
  - Orbits are within 50mas

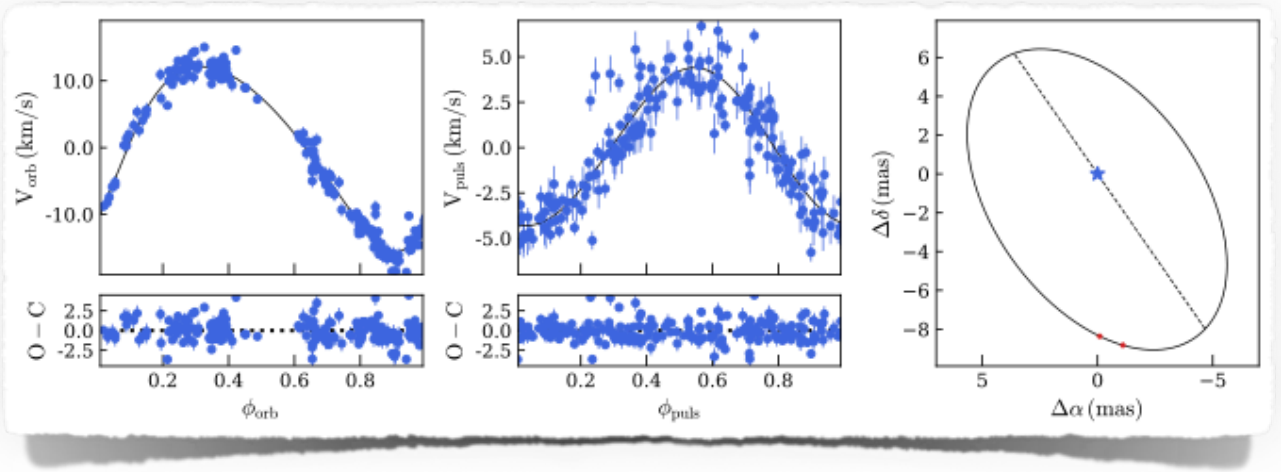
UV spectroscopy necessary

Long-baseline interferometry needed

- First binary Cepheid observed with MIRC in 2012: V1334 Cyg



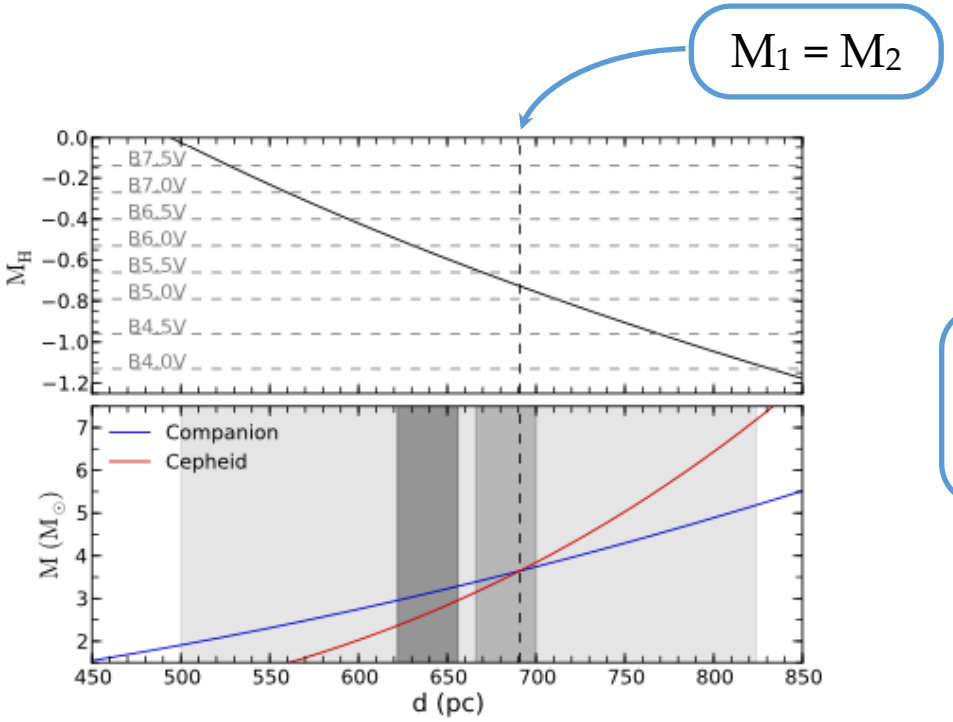




Gallenne et al. (2013)

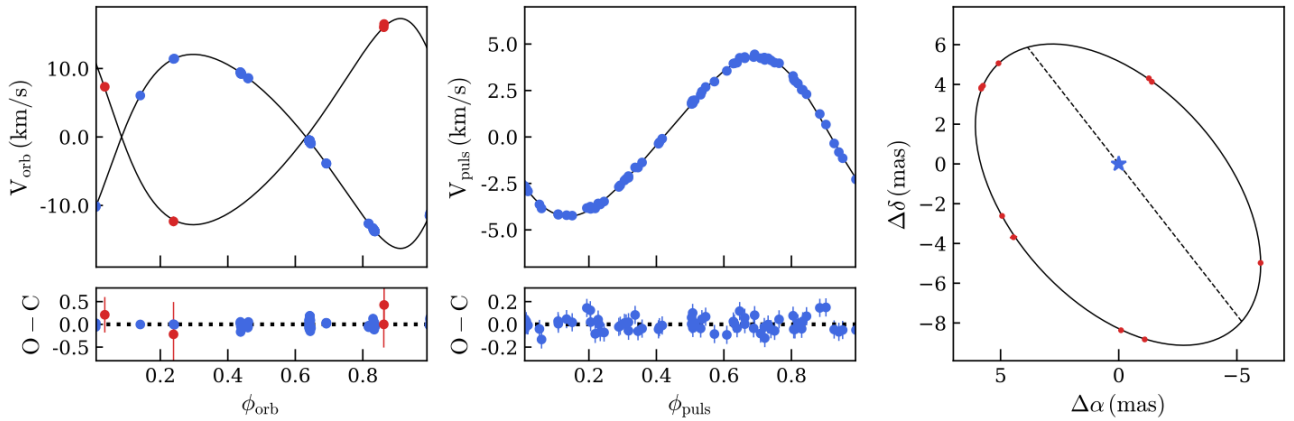
- SB1 system: masses and distance are degenerate parameters

	Spectroscopy only (Evans 2000)	This work
Orbit		
P_{orb} (days)	1937.5 ± 2.1	1938.6 ± 1.2
T_p (HJD)	2 443 607 ± 14	2 443 616.1 ± 7.3
e	0.197 ± 0.009	0.190 ± 0.013
K_1 (km s^{-1})	14.1 ± 0.1	13.86 ± 0.17
v_γ (km s^{-1})	−1.8 ± 0.1	−1.9 ± 0.1
ω (°)	226.3 ± 2.9	228.7 ± 1.6
Ω (°)	–	206.3 ± 9.4
a (mas)	–	8.54 ± 0.51
i (°)	–	124.7 ± 1.8
m_H	–	8.47 ± 0.15
Pulsation		
P_{puls} (days)	3.33251 ± 0.00001	3.33250 ± 0.00002
T_0^a (HJD)	2 440 124.5330	2 440 124.5330
A_1	–	4.35 ± 0.15
A_2	–	1.81 ± 0.11
B_1	–	0.08 ± 0.06
B_2	–	2.72 ± 1.30



$d \geq 690pc$
$M_2 \geq 3.6M_\odot$

- I monitored the orbit with various instruments



New HST/STIS RV2

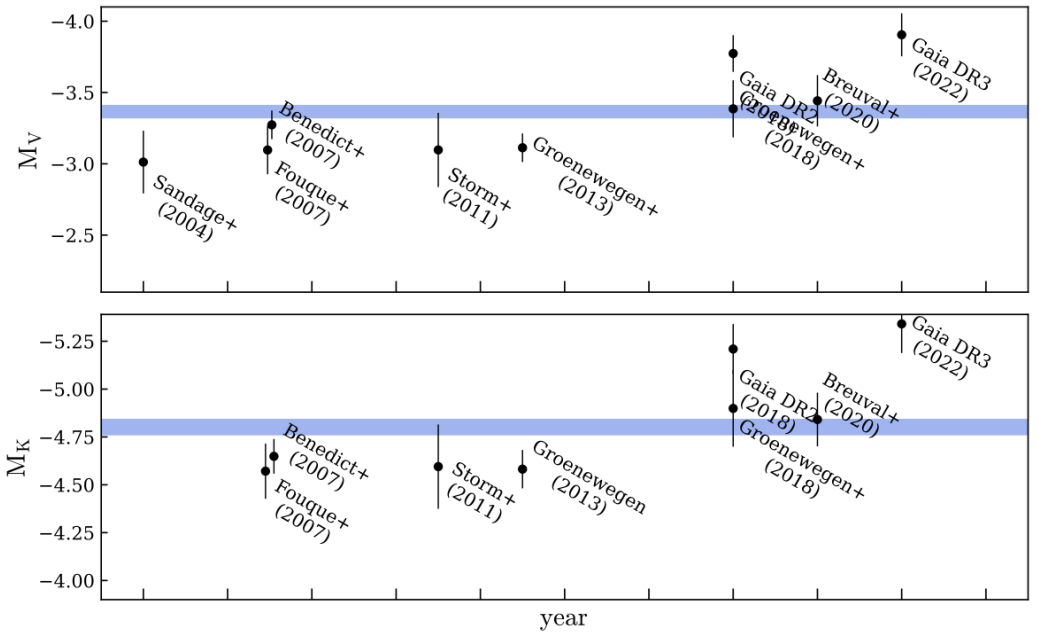
New ground-based RV1

MIRC astrometry

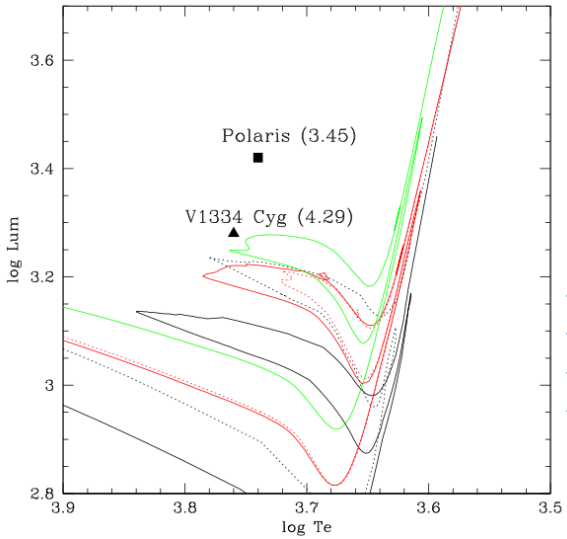
Gallenne et al. (2018)

➡ Accurate & precise distance of a Cepheid (1%)
➡ Accurate & precise mass of a Galactic Cepheid (3%)

- Comparison with Gaia and P-L relations:



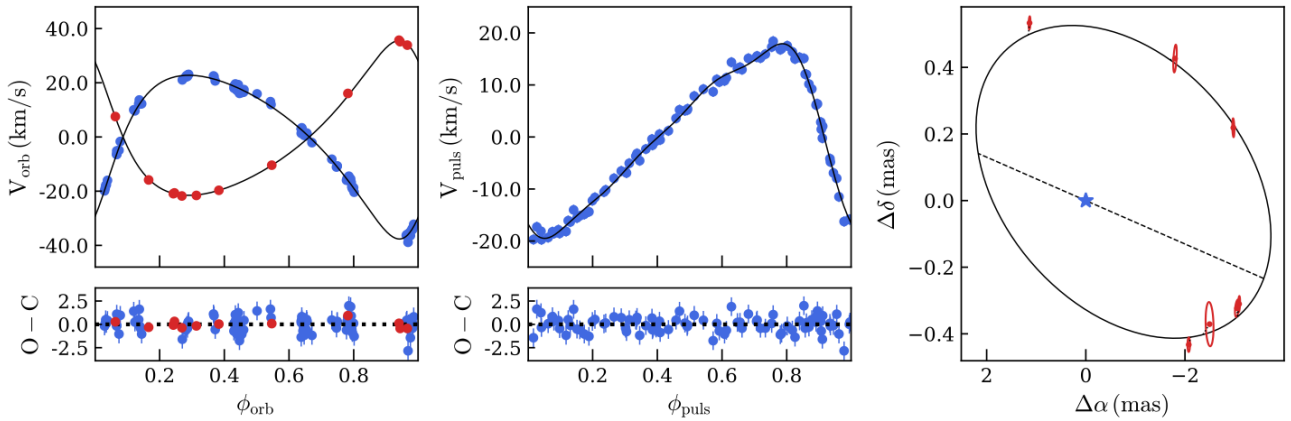
- Comparison with prediction from evolutionary models:



- **Black**: 5M⊙ Geneva models
- Red: 5M⊙ MIST models
- Green: 5M⊙ PARSEC models
- Dotted lines include significant rotation

➡ Dynamical mass smaller than the predicted mass: mass loss, binary merger, evolutionary model?

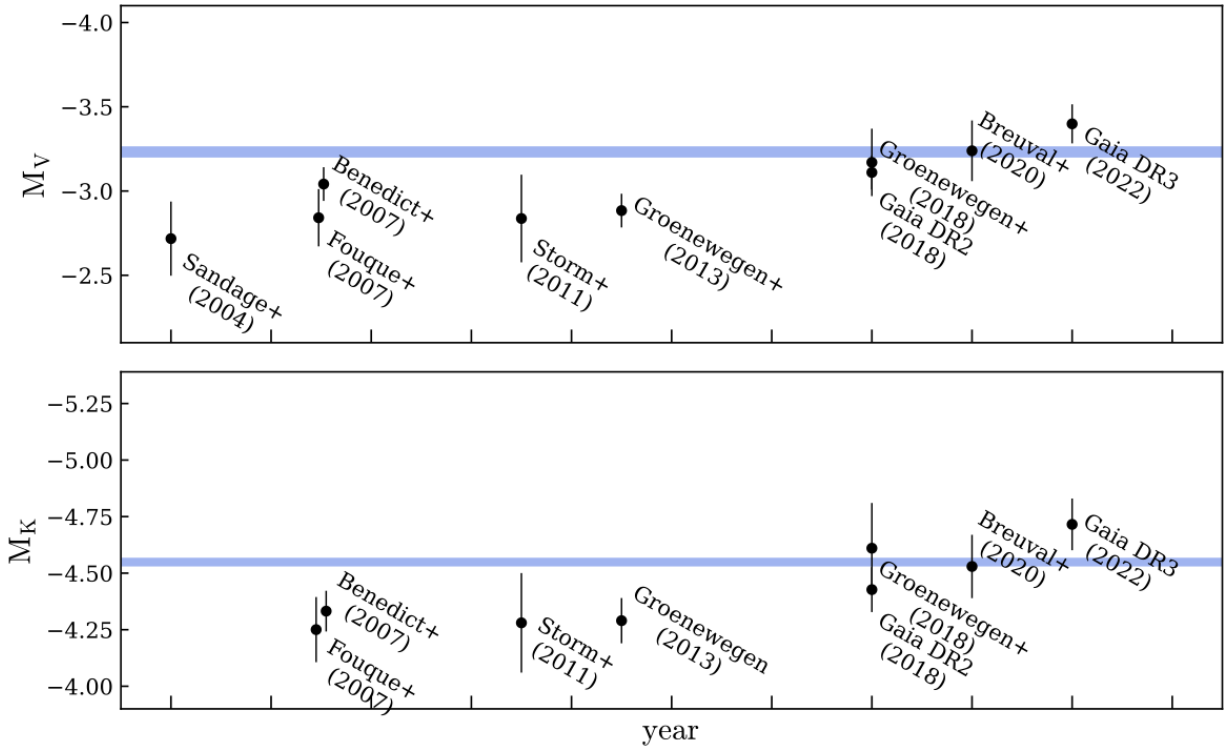
- New results for another Cepheids, SU Cyg:



Gallenne et al. (2025)

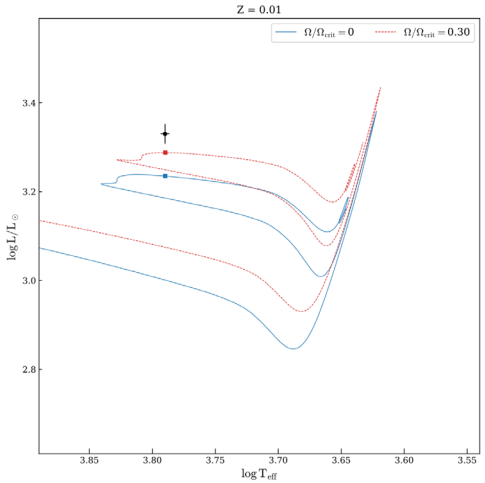
- Most accurate & precise distance of a Cepheid (0.5%)
- Most accurate & precise mass of a Galactic Cepheid (1%)

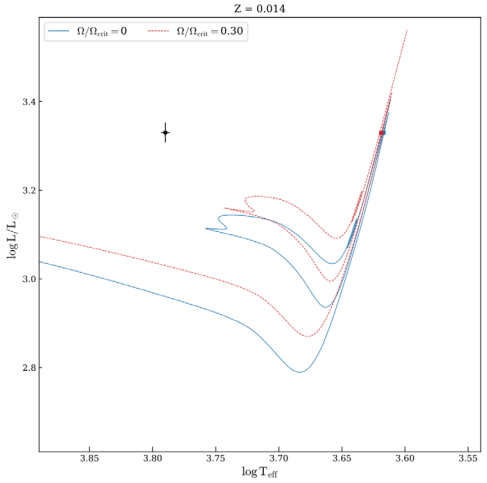
- Comparison with Gaia and P-L relations:

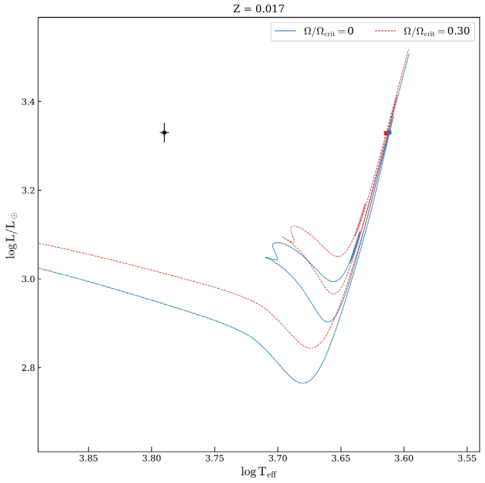


- Comparison with prediction from evolutionary models:

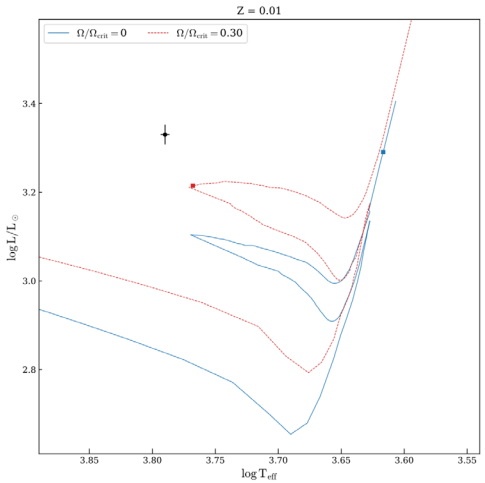
PARSEC

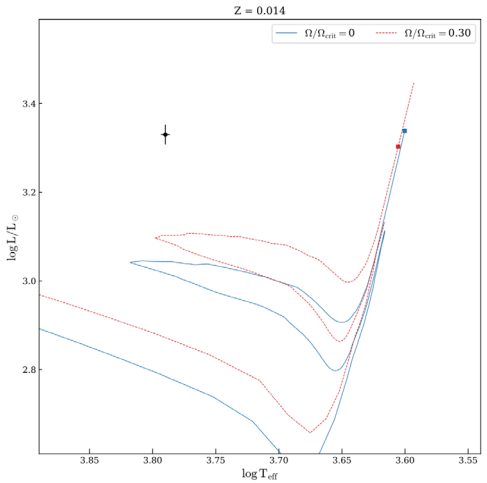


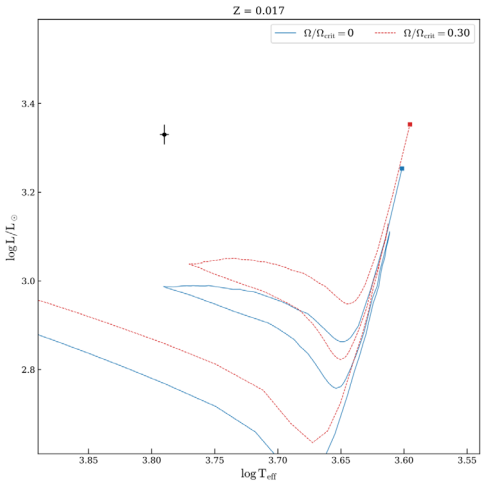




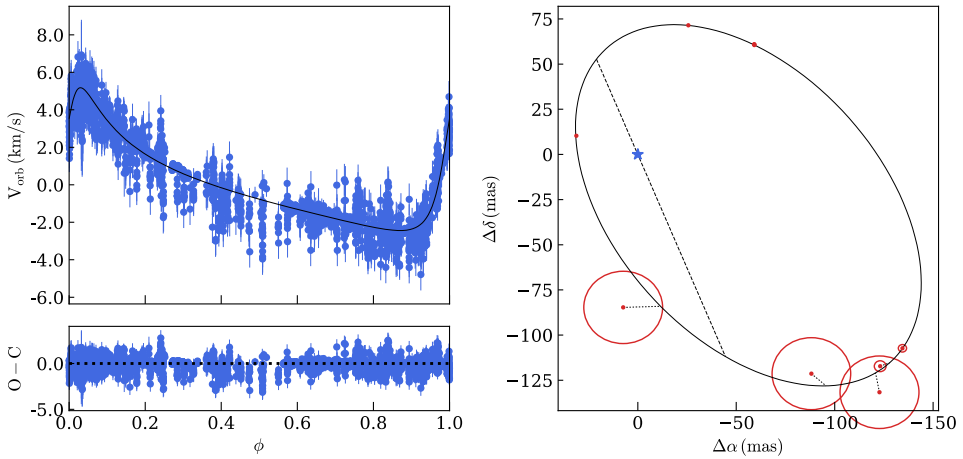
GENEVA







- Other published SB1 systems, assumed distances to obtain the Cepheid masses:

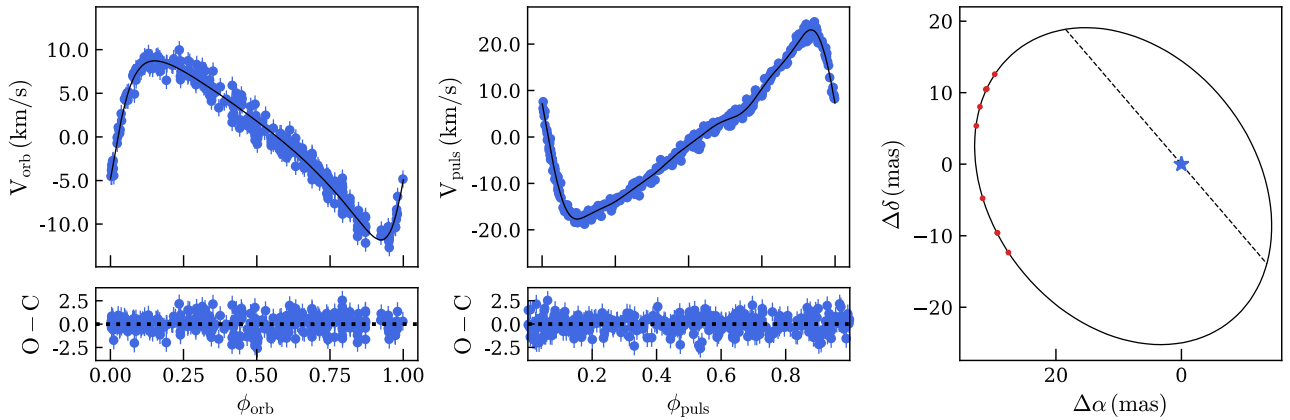


Polaris

Evans et al. (2024a)

AW Per

Evans et al. (2024b)



Conclusions

- LBI efficient in detecting bright companions of Cepheids
- But still challenging due to the high contrast
- Next step of this project is SPICA with a more favourable observing wavelength

- PhD student starting in October: Combination of Gaia epoch astrometry, interferometry & RVs
- Large survey of southern bright Cepheids requested with GRAVITY
- Final goals:
  - Obtain precise and accurate mass of several Cepheids
  - Improve the accuracy of the Gaia parallax
  - Obtain an unbiased P-L relation

Thank you