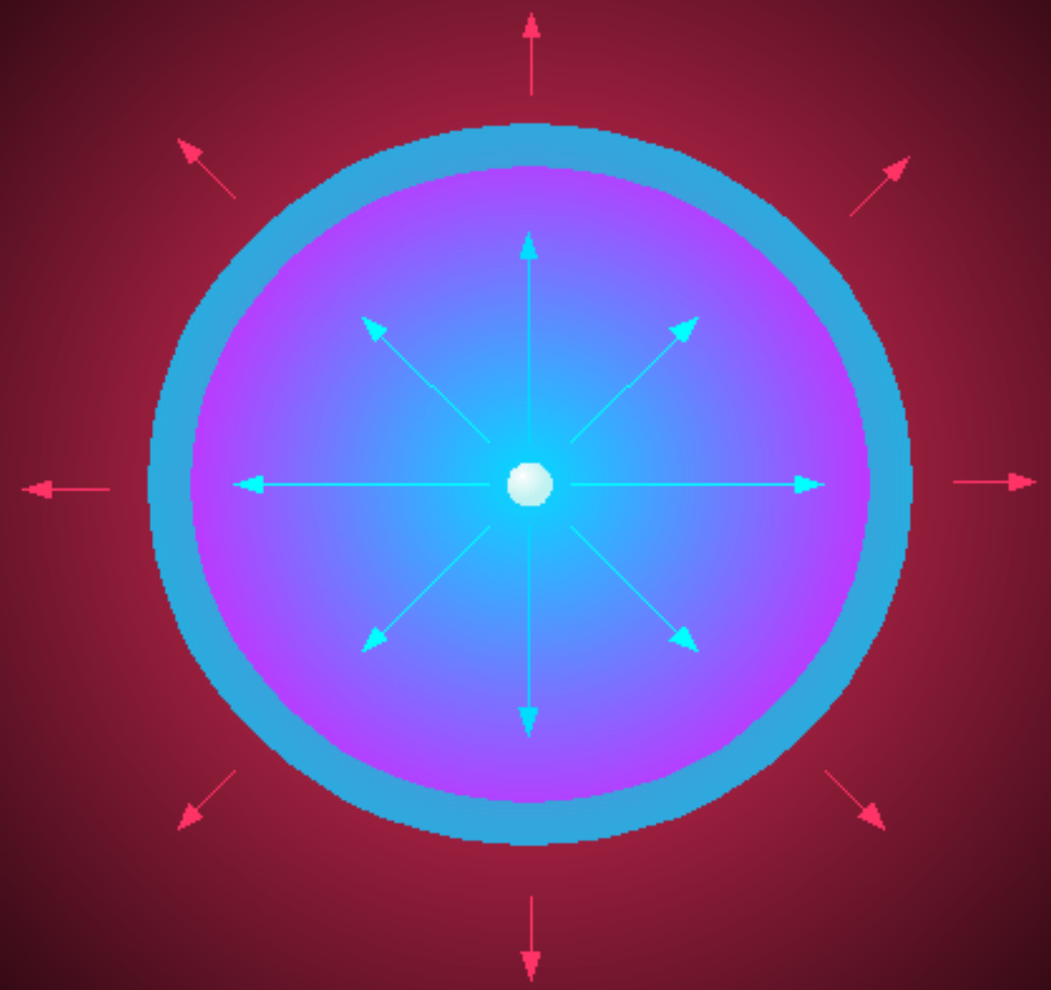
Long-period binary central stars of planetary nebulae

DAVID JONES

PLANETARY NEBULA

Ejected envelope

Ionising nucleus (pre-WD)

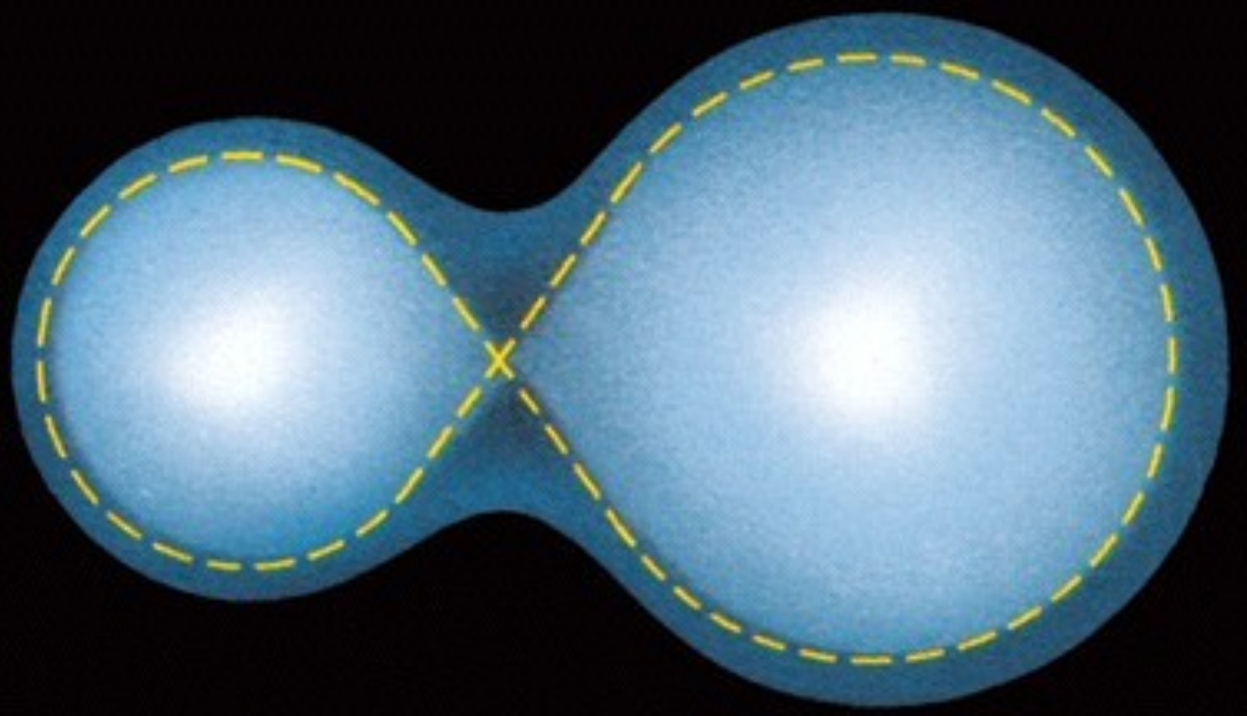


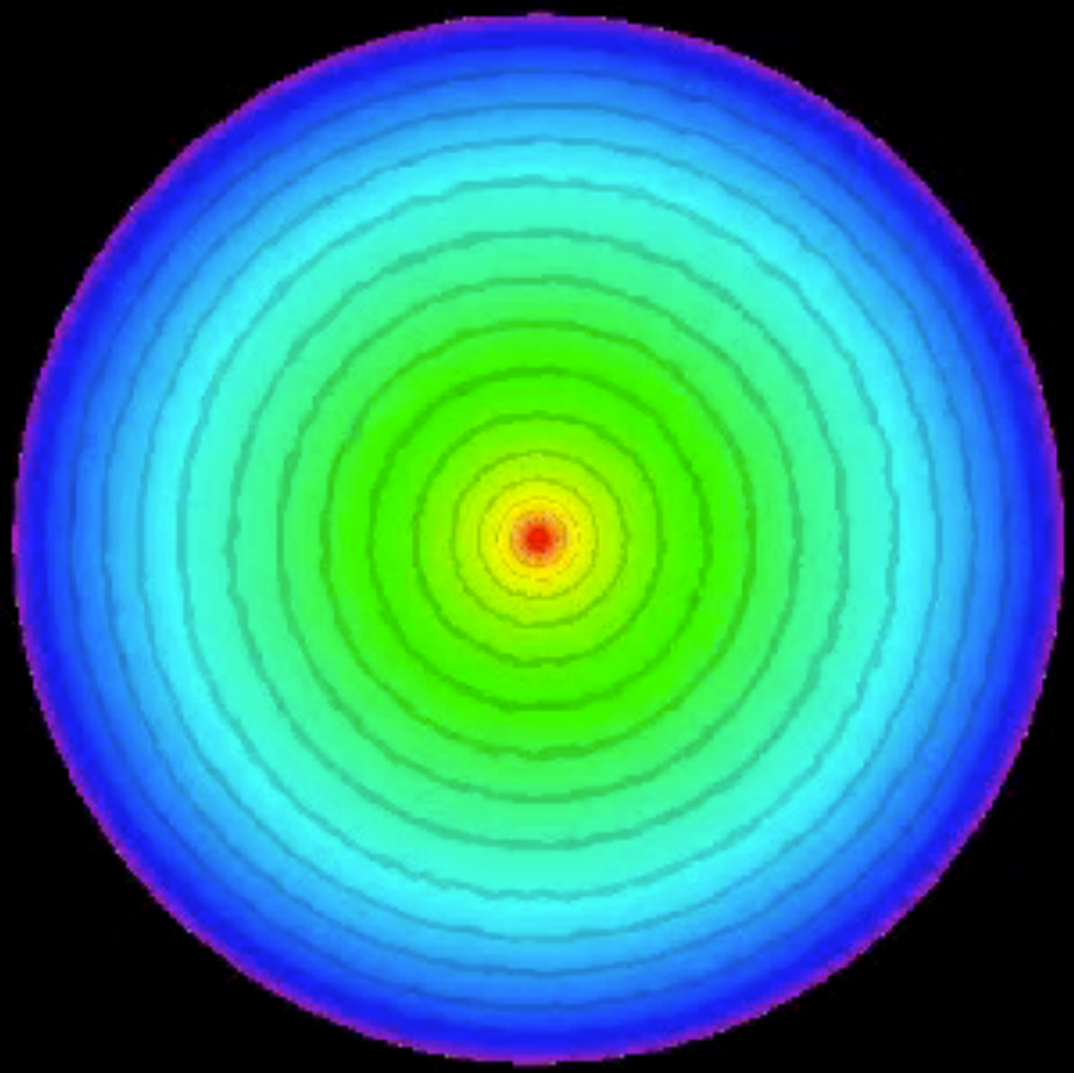
HOW DO YOU MAKE AN HOURGLASS?

- Rapid rotation?
- Magnetic fields?
- ¡Binaries!

COMMON ENVELOPE

BINARY EVOLUTION

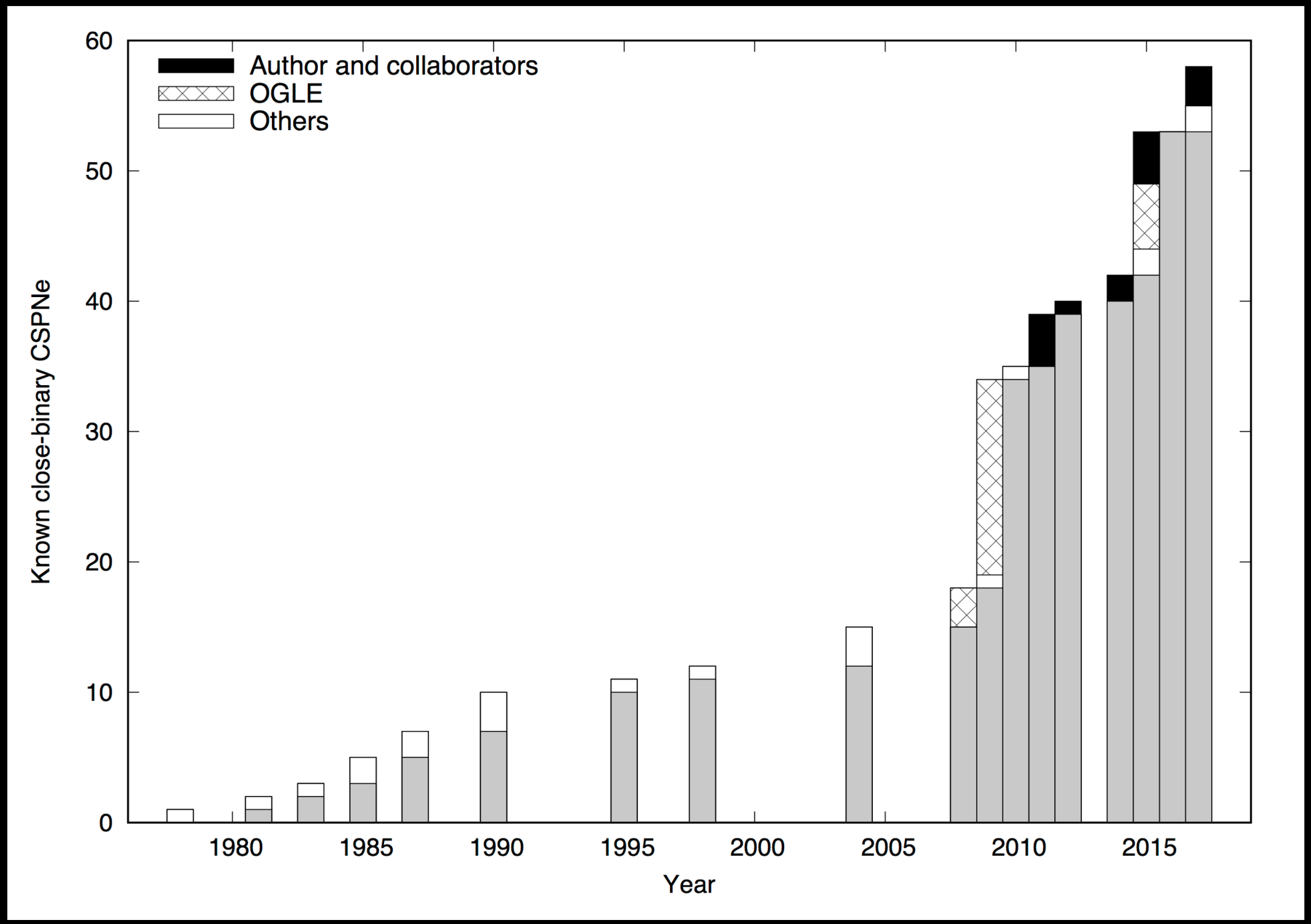




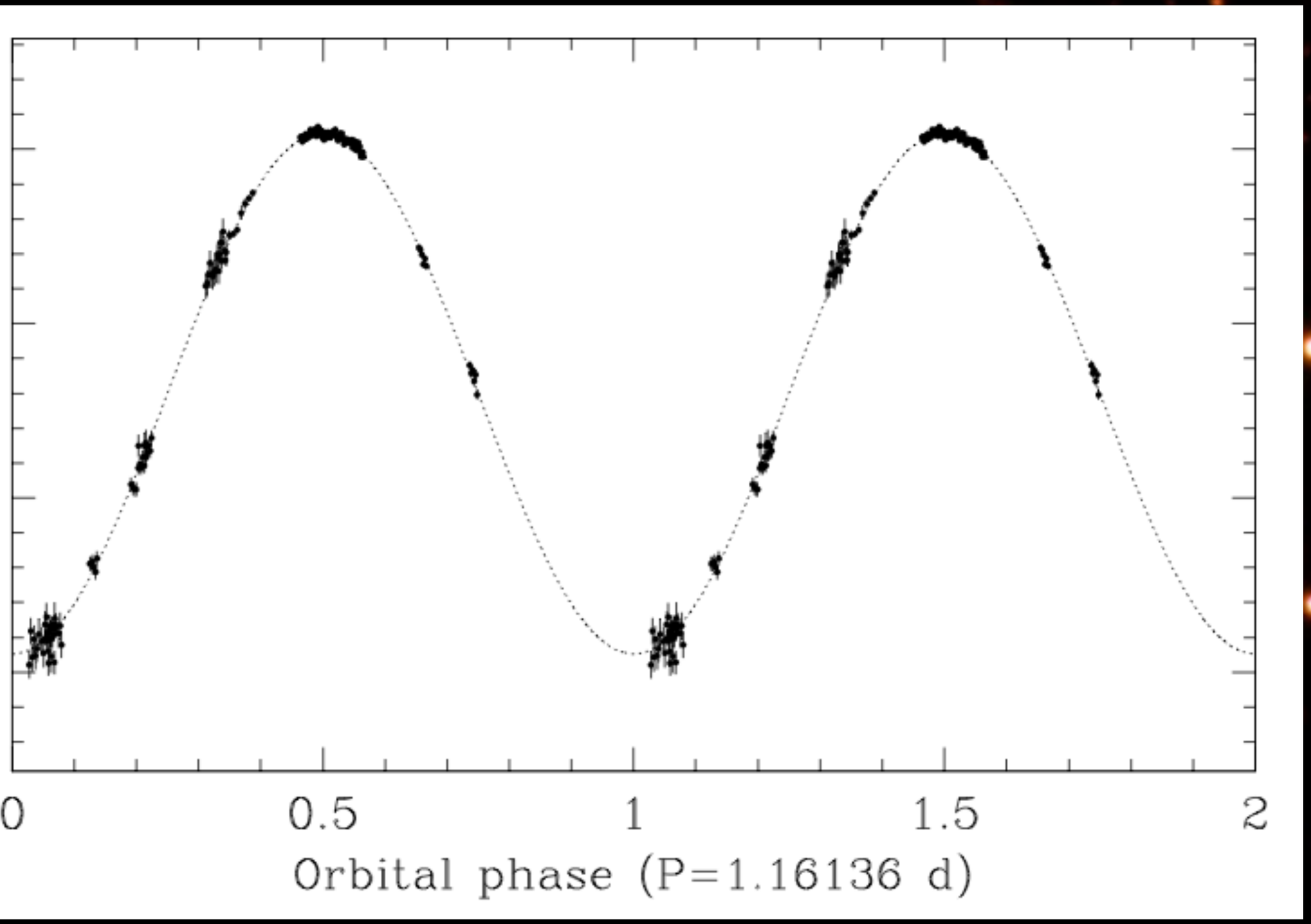
Initial separation

Passy et al. (2012, ApJ, 744, 52)

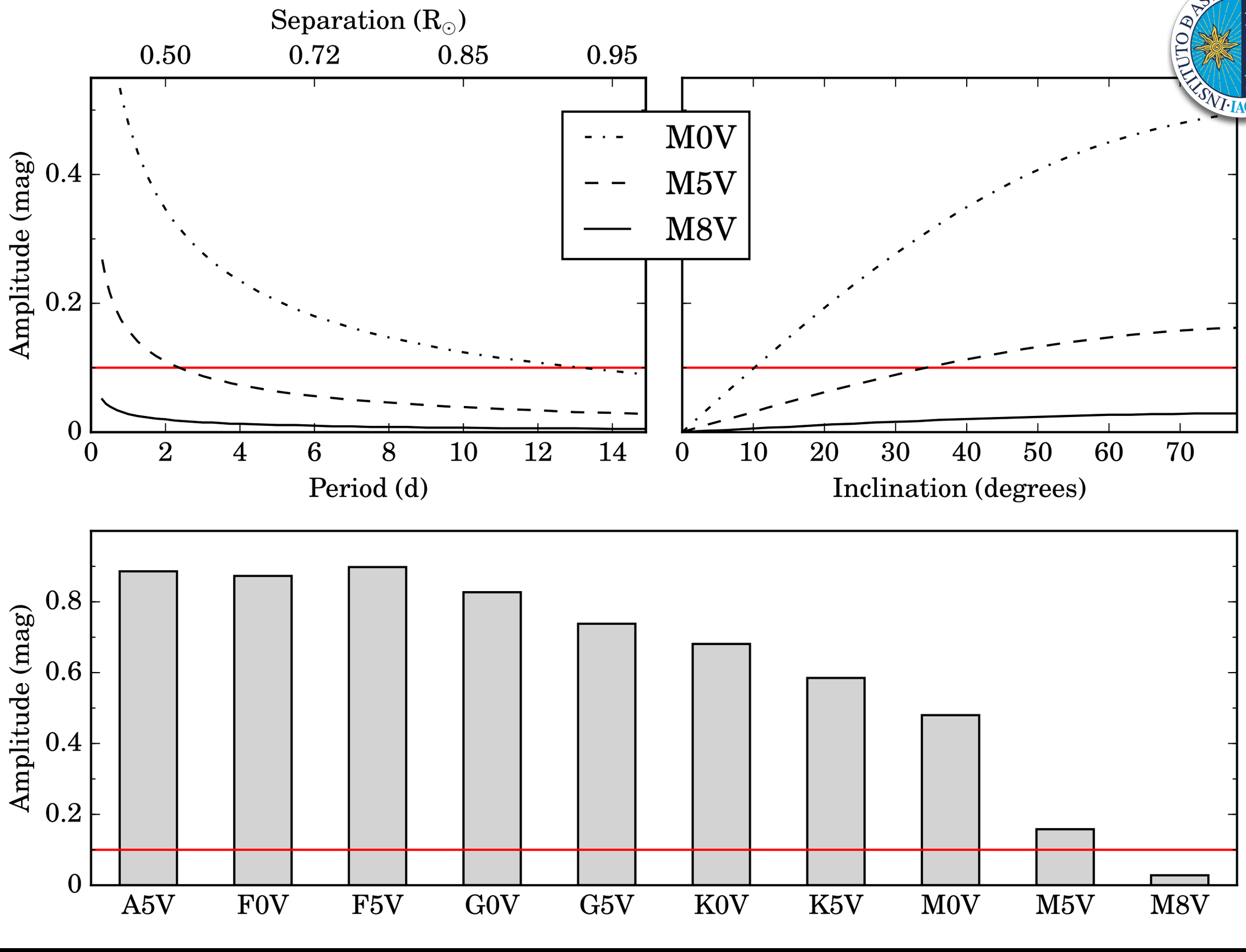
WHERE ARE THEY ALL THEN?



HOW DO YOU DETECT A BINARY?



Corradi et al. (2011, MNRAS, 410, 1349)

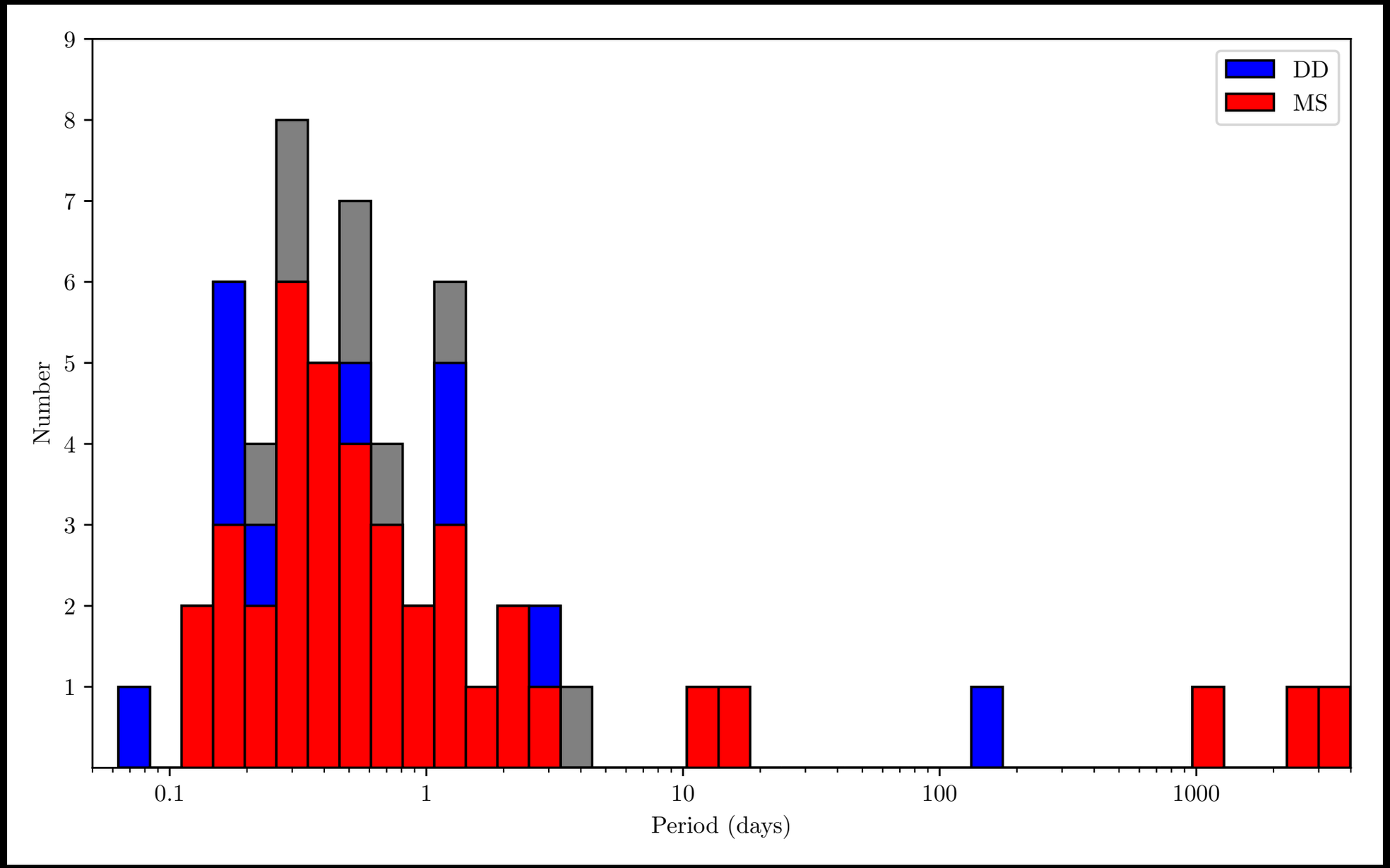


Jones & Boffin (2017, Nature Astronomy, 1, 117)

True binary fraction?

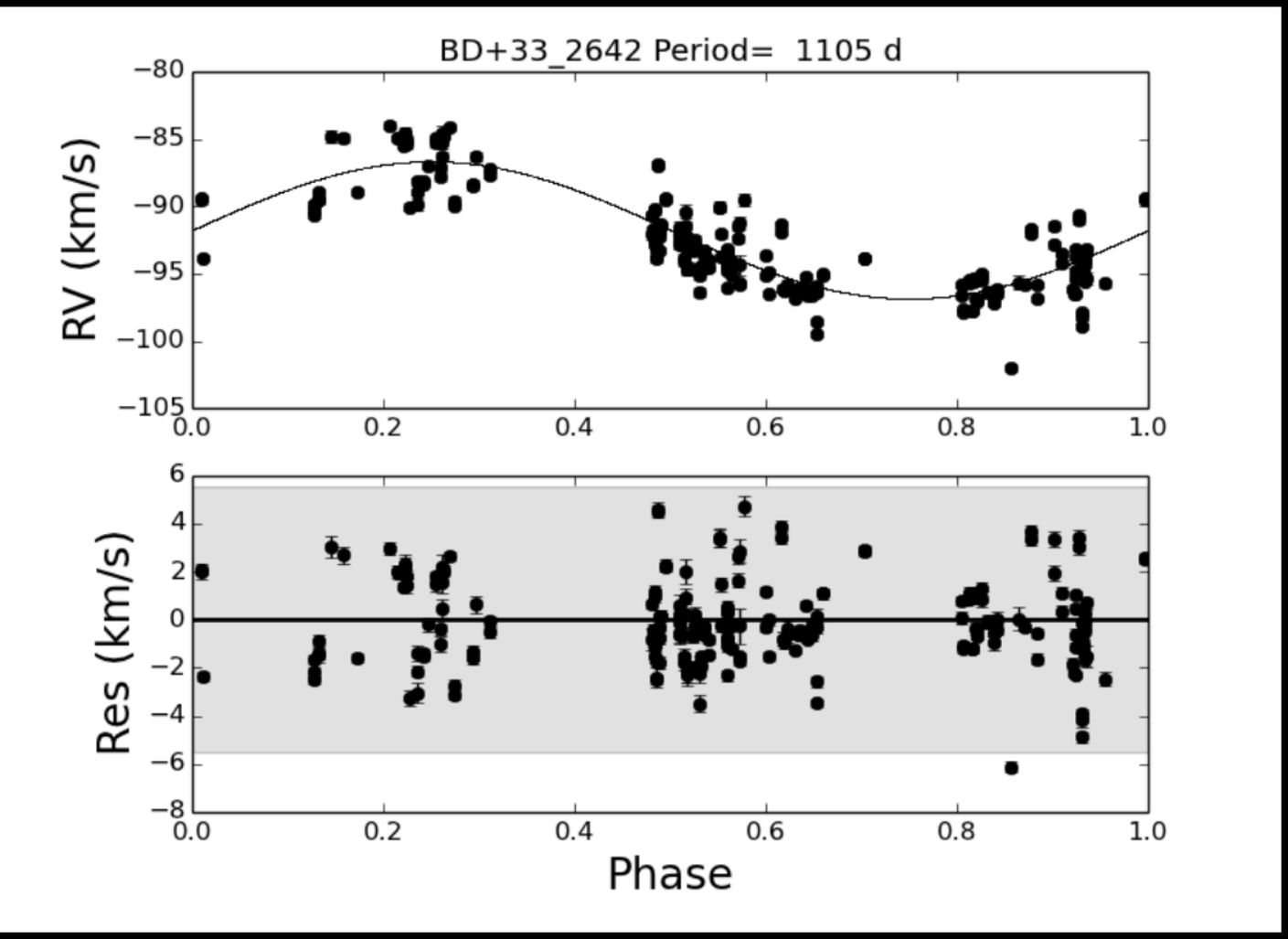
- (Photometrically) detectable fraction ~20% (Miszalski et al. 2009, A&A, 496, 813)

- Maybe as high as 80% based on other methodologies (de Marco et al. 2004, ApJ, 602, 93; Douchin et al. 2015, MNRAS, 448, 3132)



Missing long and intermediate periods?

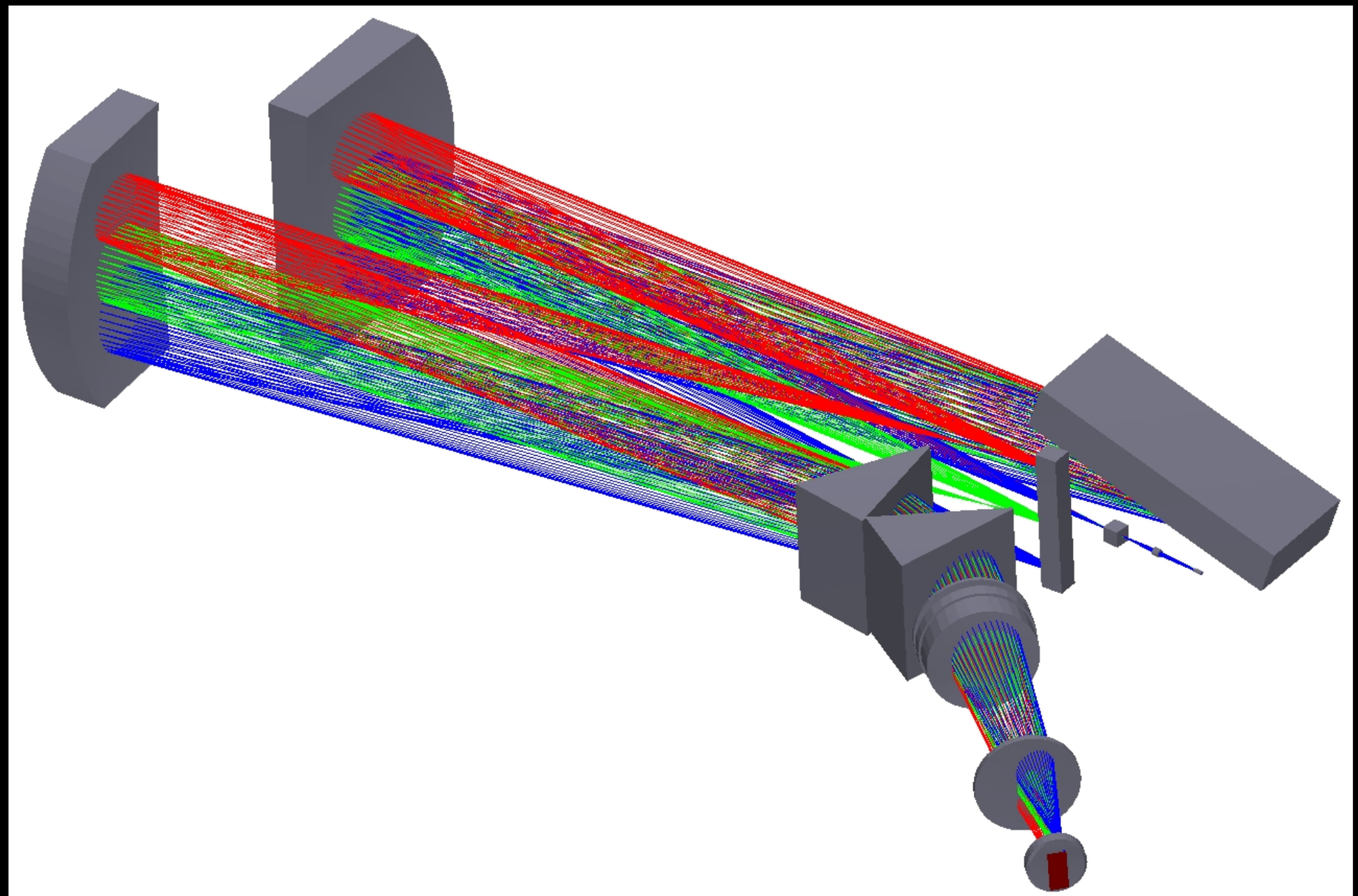
Long periods: Radial Velocities



Van Winckel et al. (2014, A&A, 563, L10)
Jones et al. (2017, A&A, 600, L9)

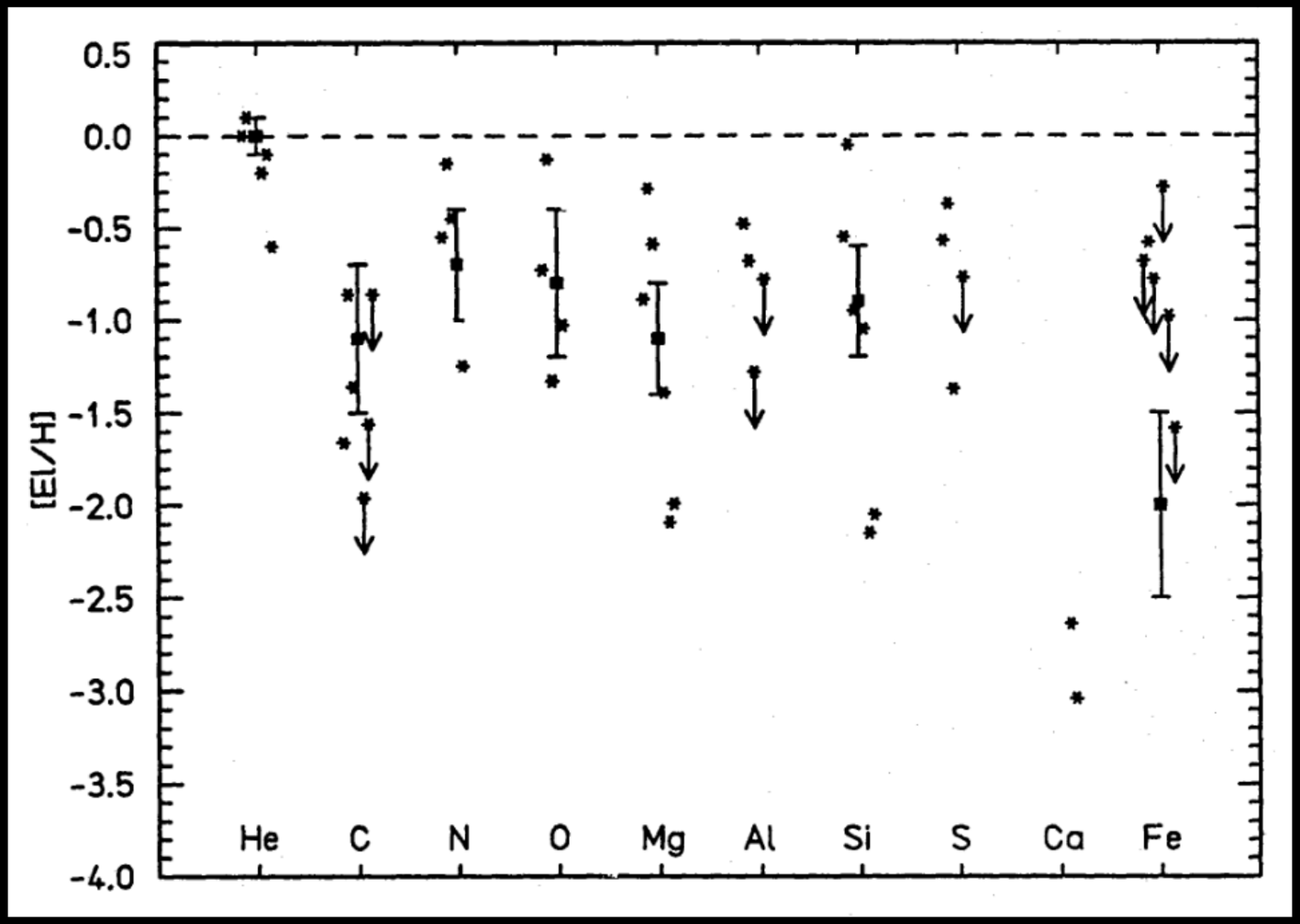
- Extremely difficult - everything is variable on some level (e.g De Marco et al. 2004)
- Needs high-resolution, high-stability spectrograph and lots of data!

Mercator-HERMES



- Pressure and temperature controlled
- Wide spectral range (377-900nm)
- High efficiency
- High resolution (Raskin et al. 2011, A&A, 526, 69)

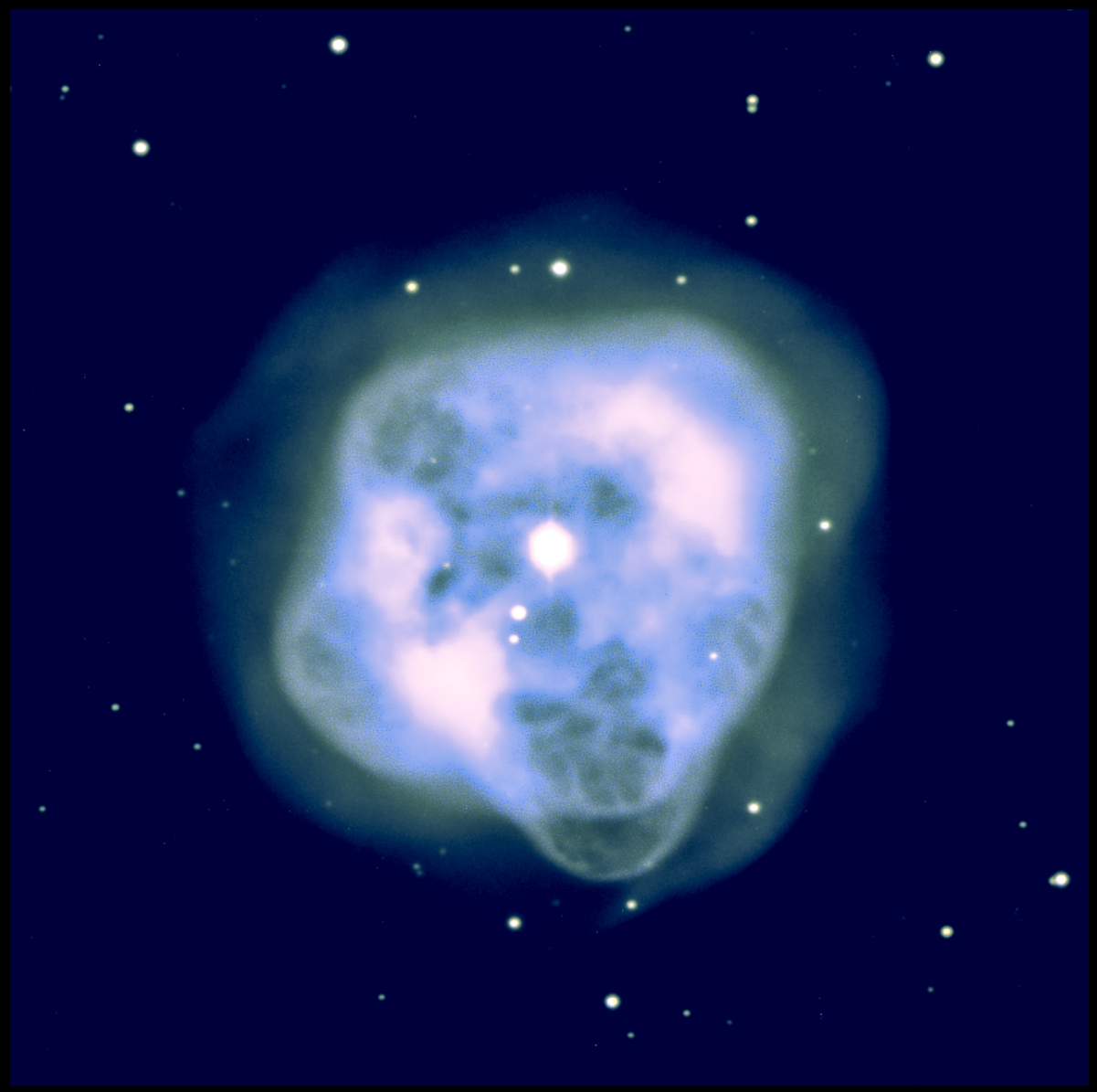
PNG052.7+50.7



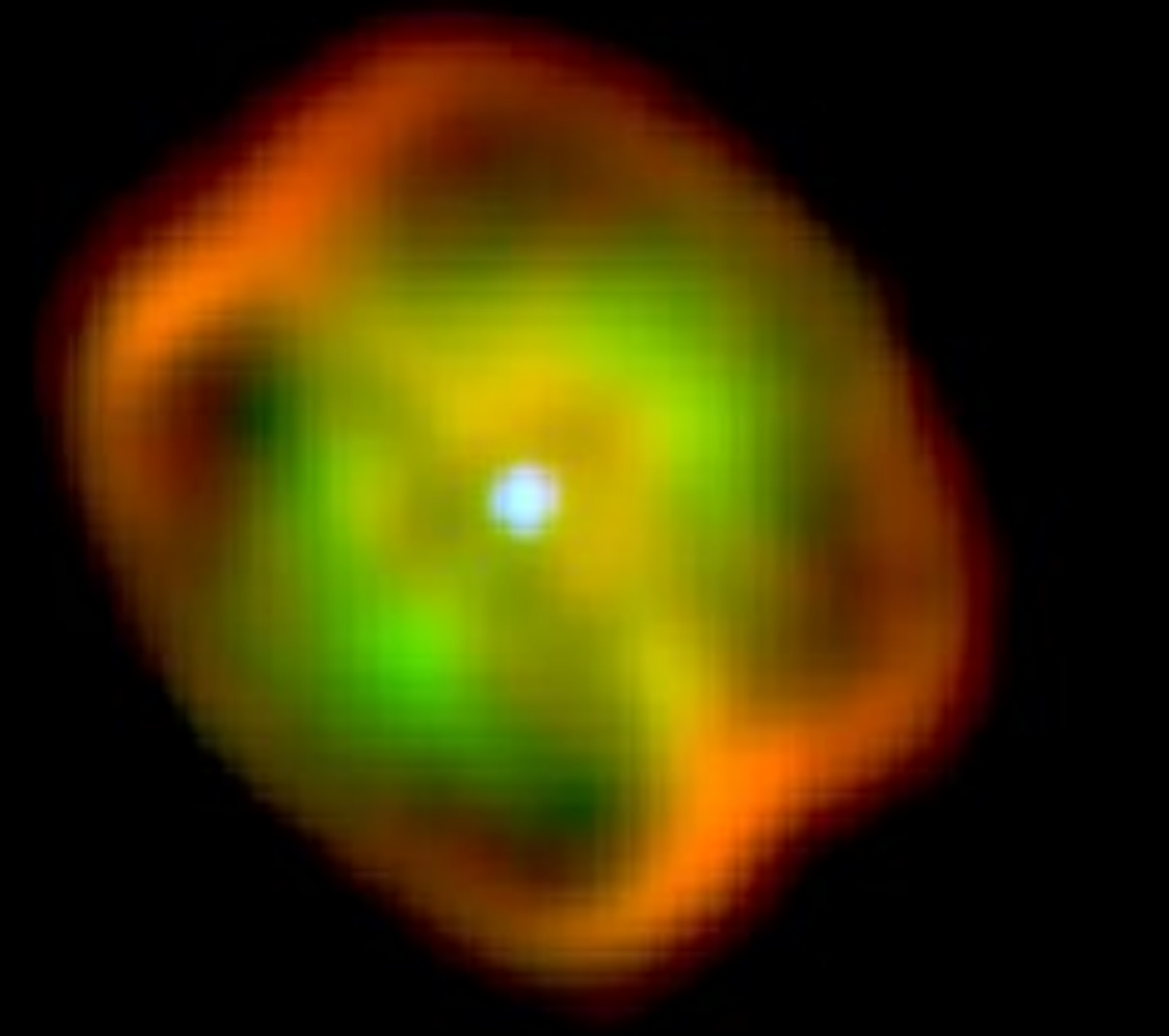
Napiwotzki, Heber & Köppen (1993, A&A, 292, 239)

- First discovered (Van Winckel et al. 2014)
- Zero eccentricity
- Abundances like a post-AGB star with circumbinary disc (Van Winckel 2003, ARA&A, 41, 391)

NGC1514

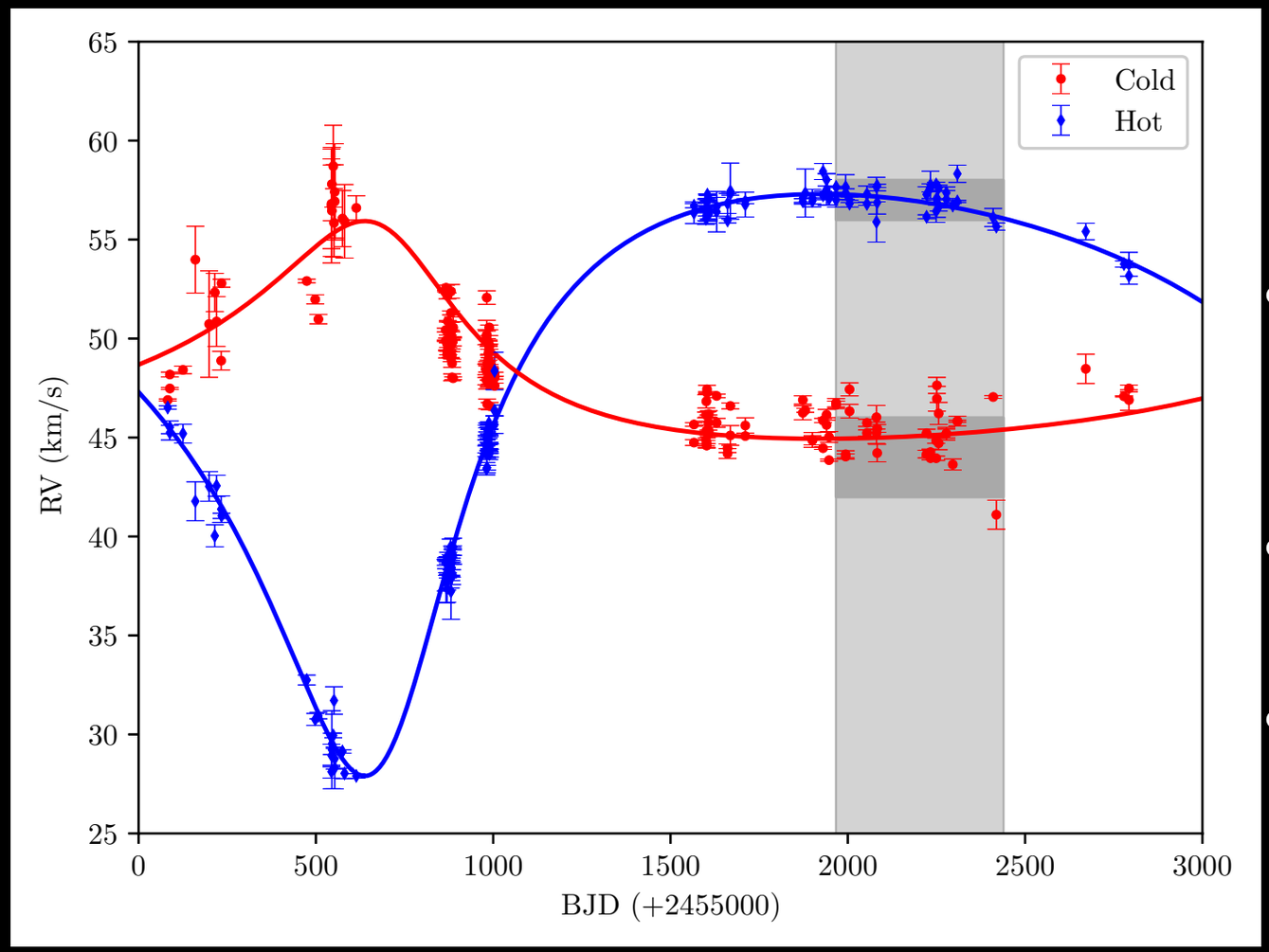


Jones et al. (2017, A&A, 600, L9)



Ressler et al. (2010, AJ, 140, 1882)

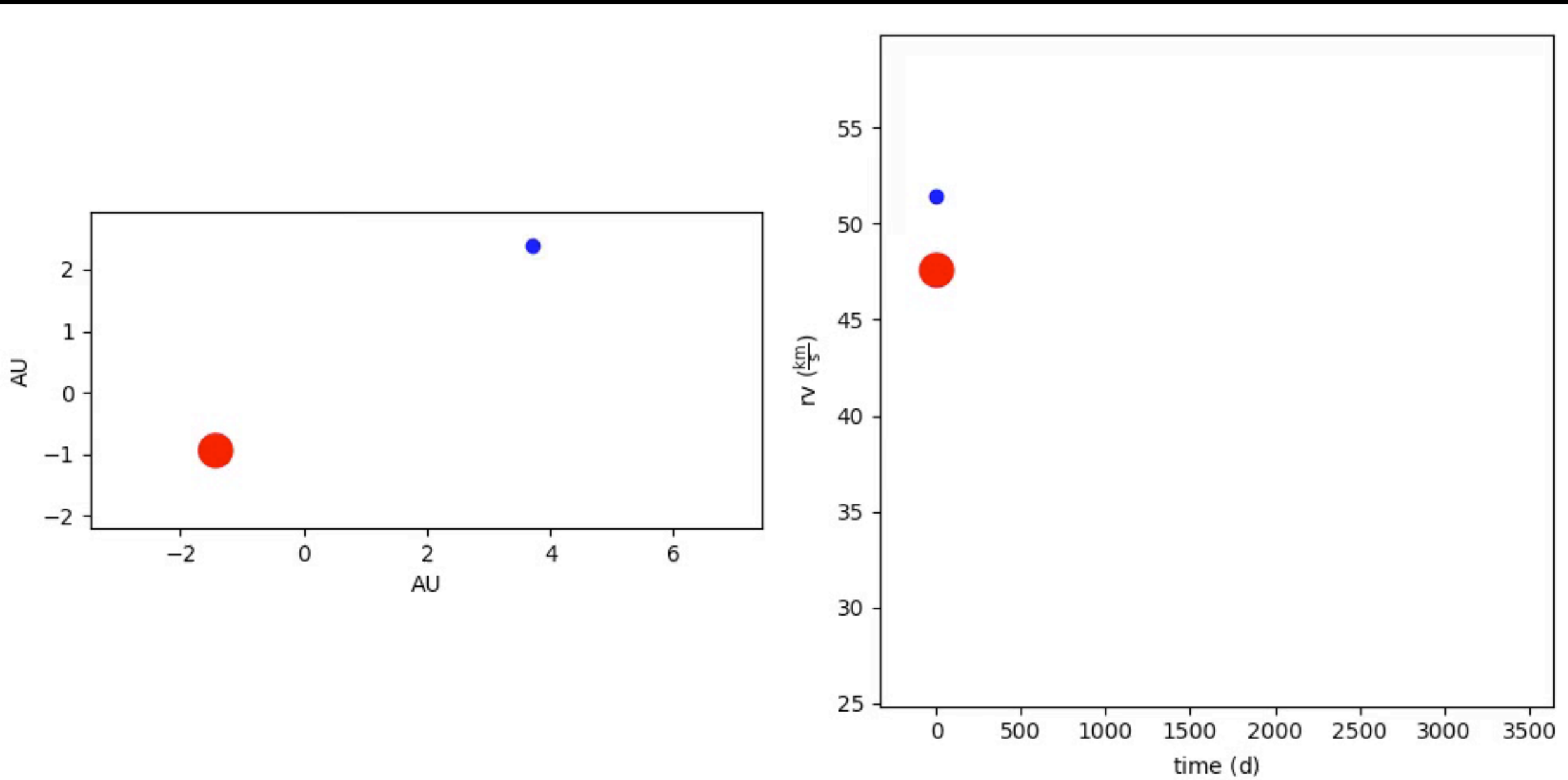
NGC1514



- Longest period central star known at ~9 years
- High eccentricity, e~0.5
- Previous study concluded that the two stars are unrelated!

Jones et al. (2017, A&A, 600, L9)

NGC1514

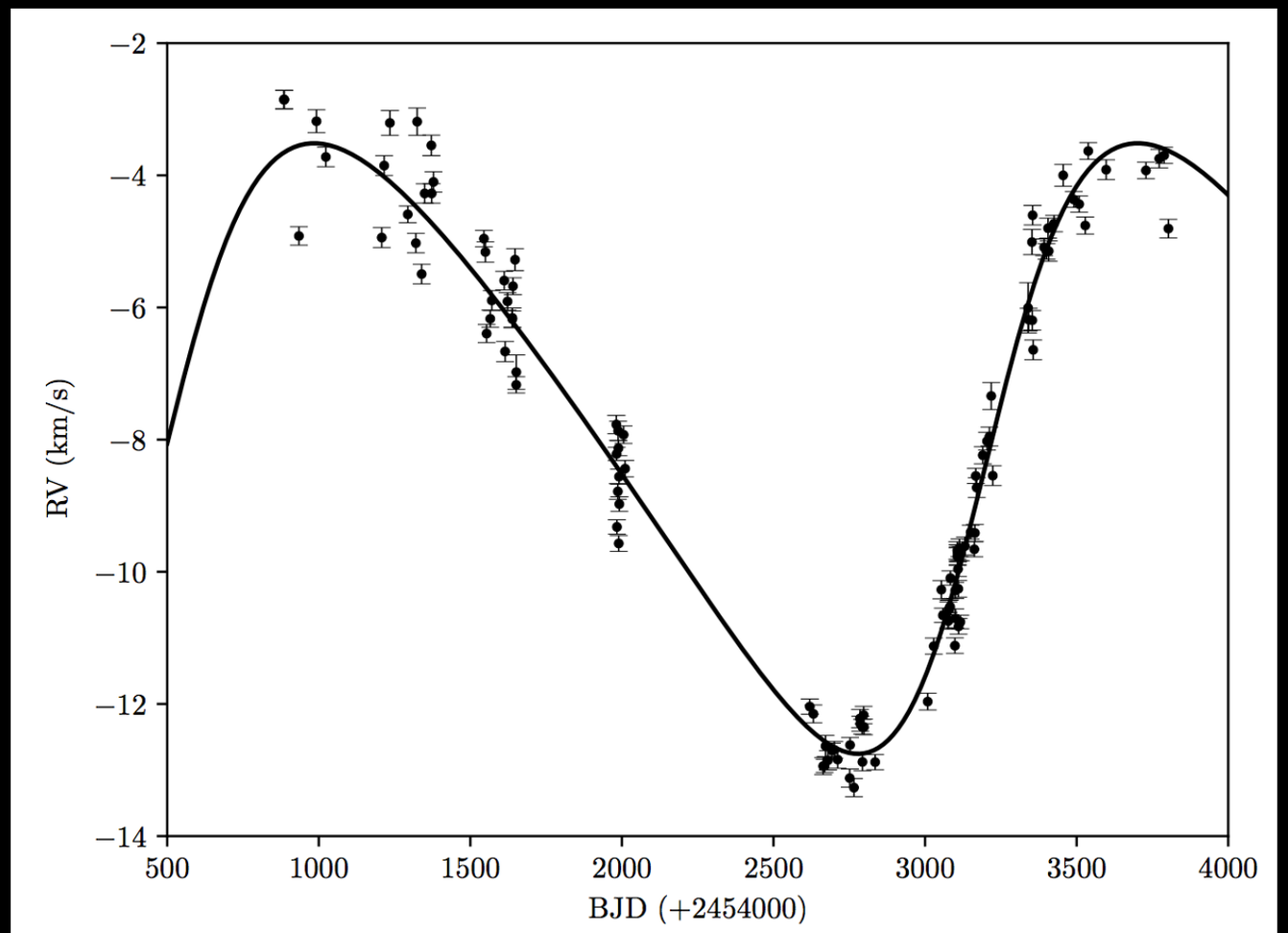


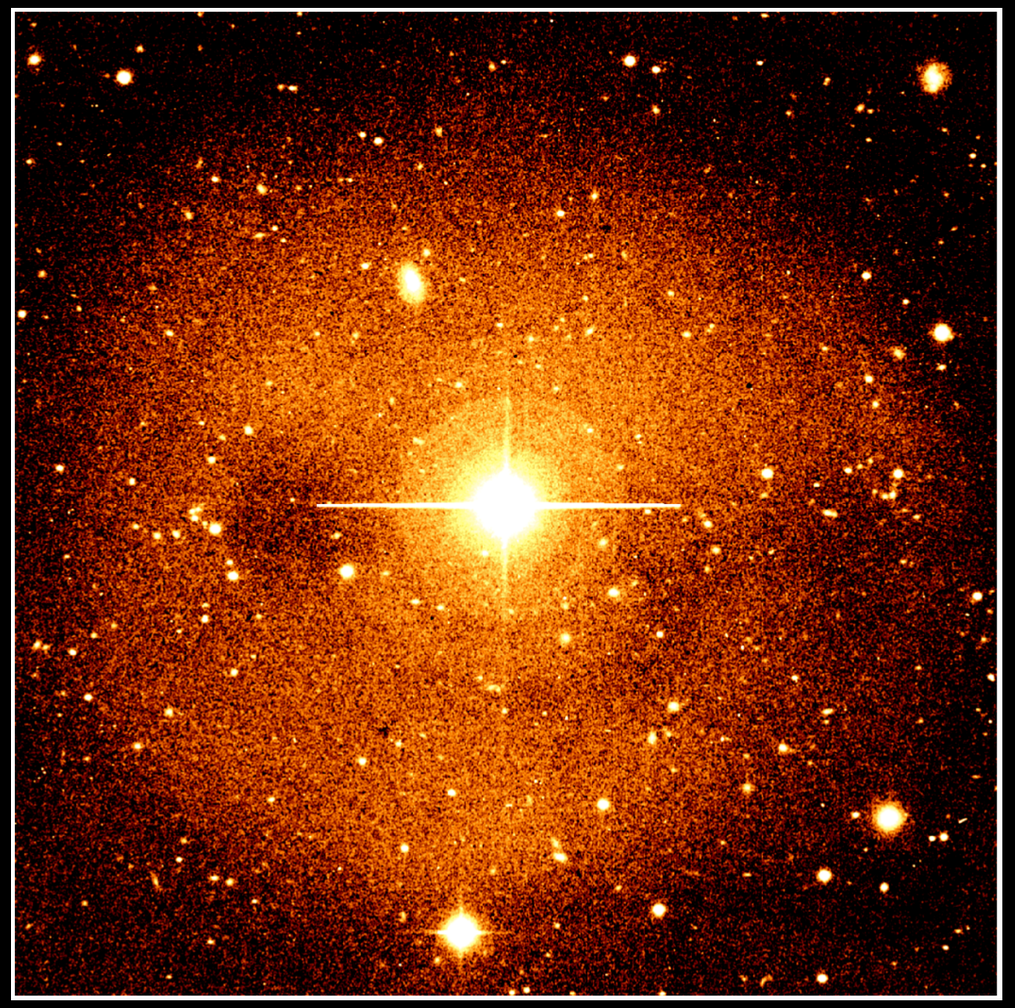
Jones et al. (2017, A&A, 600, L9)

NGC1514

Telecanarias - 4 Mayo 2017

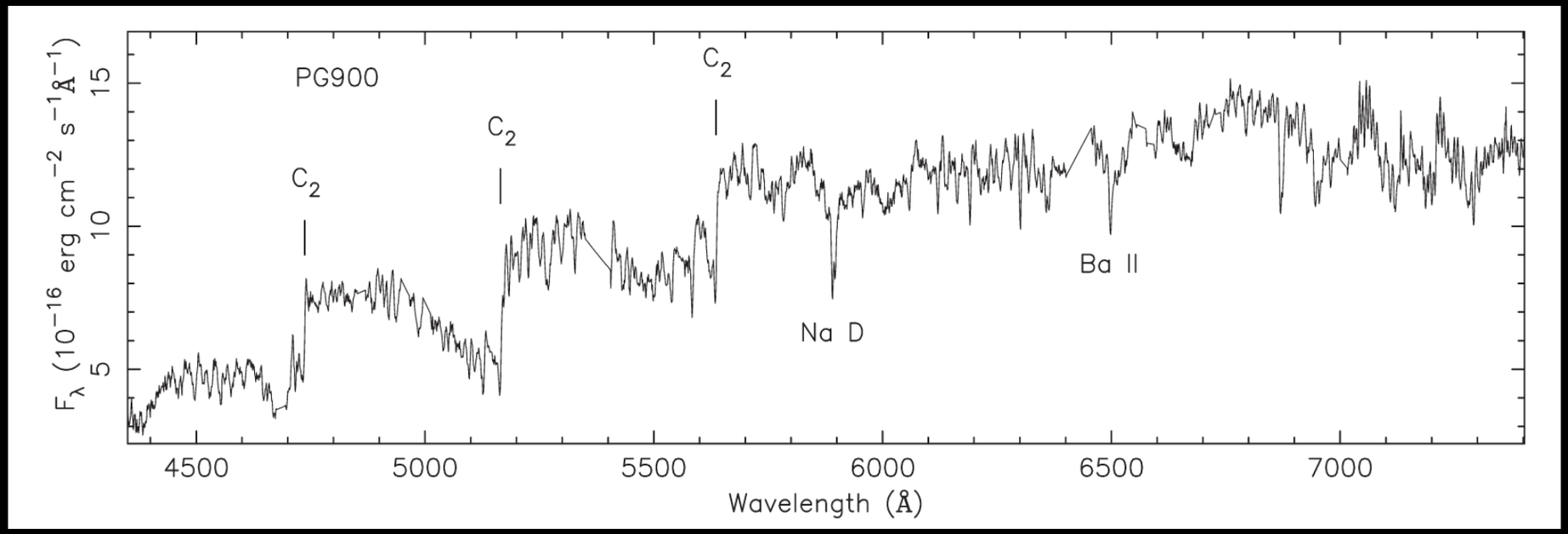
LoTr 5





Jones et al. (2017, A&A, 600, L9)
Aller et al. (in prep)

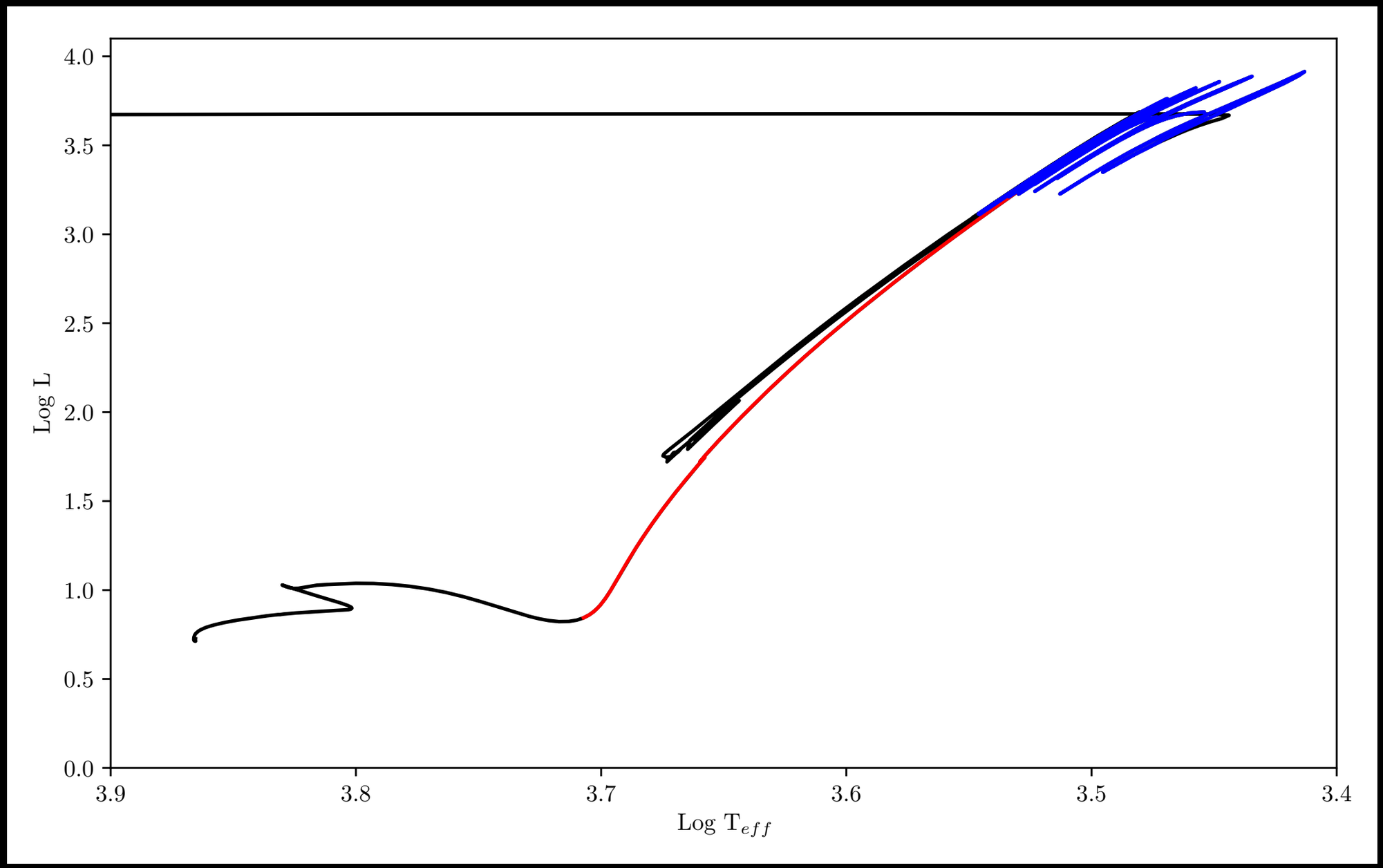
Barium stars



Miszalski et al. (2012, MNRAS, 419, 39)
Miszalski et al. (2013, MNRAS, 436, 3068)
Tyndall et al. (2013, MNRAS, 436, 2082)

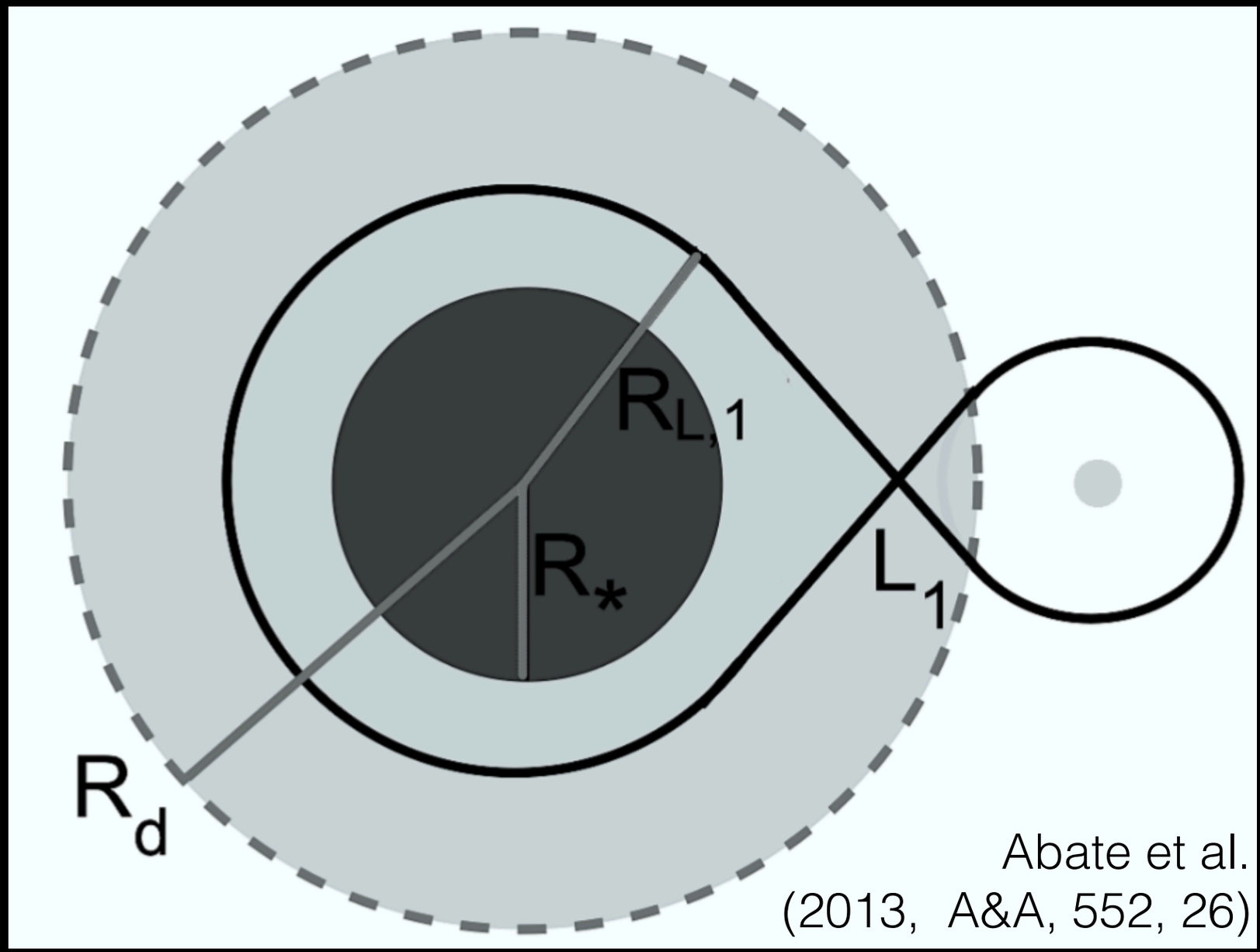
- G-K type giants that have strong absorption lines of s-process elements
  - Not evolved enough to be self-enriched
  - Chemically polluted by the nebular progenitor

Dredge-up



- First Dredge Up: C/O drops (rather C/N drops)
- Third Dredge Up: C/O rises, s-process elements to surface

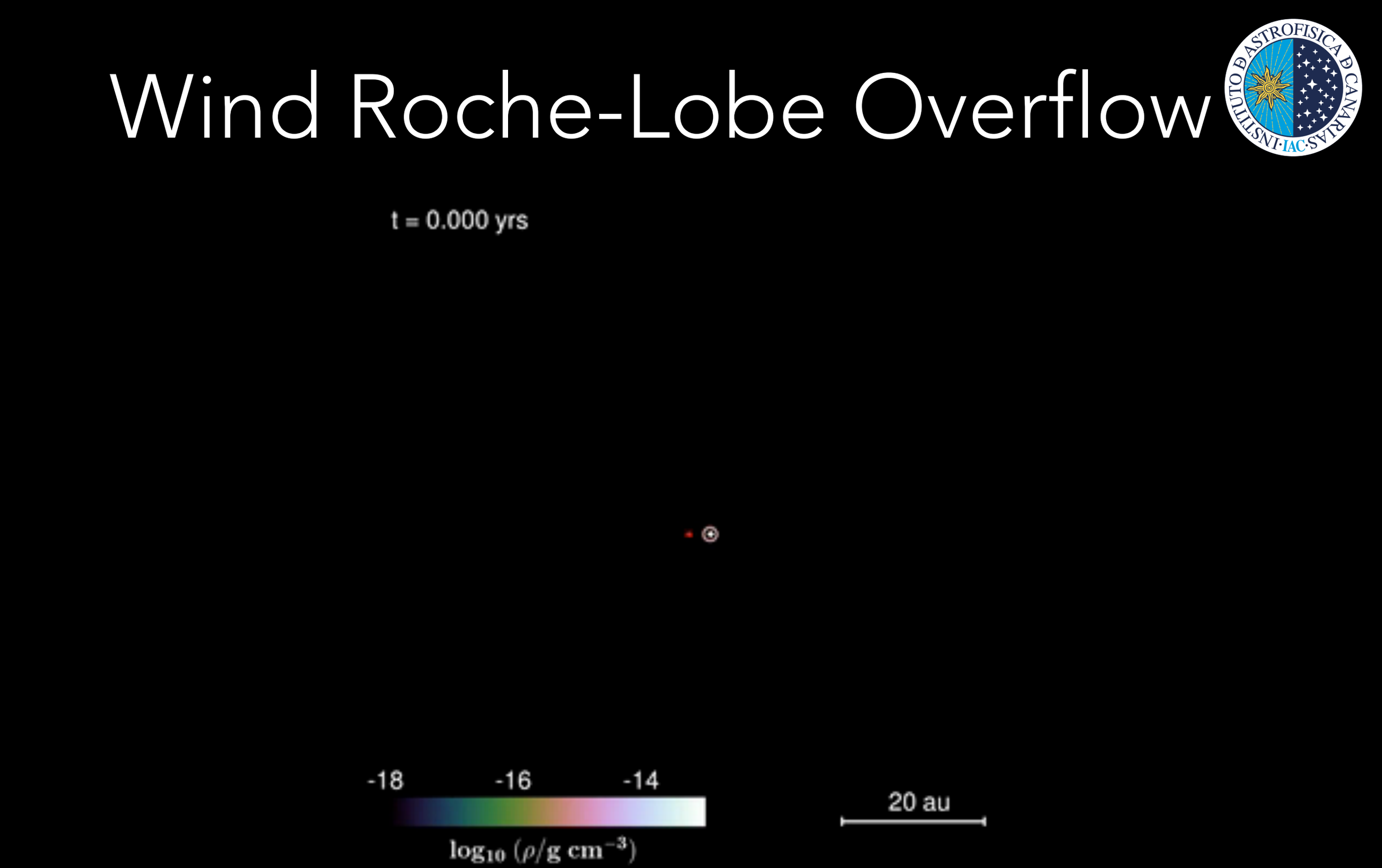
Wind Roche-Lobe Overflow



Abate et al.
(2013, A&A, 552, 26)

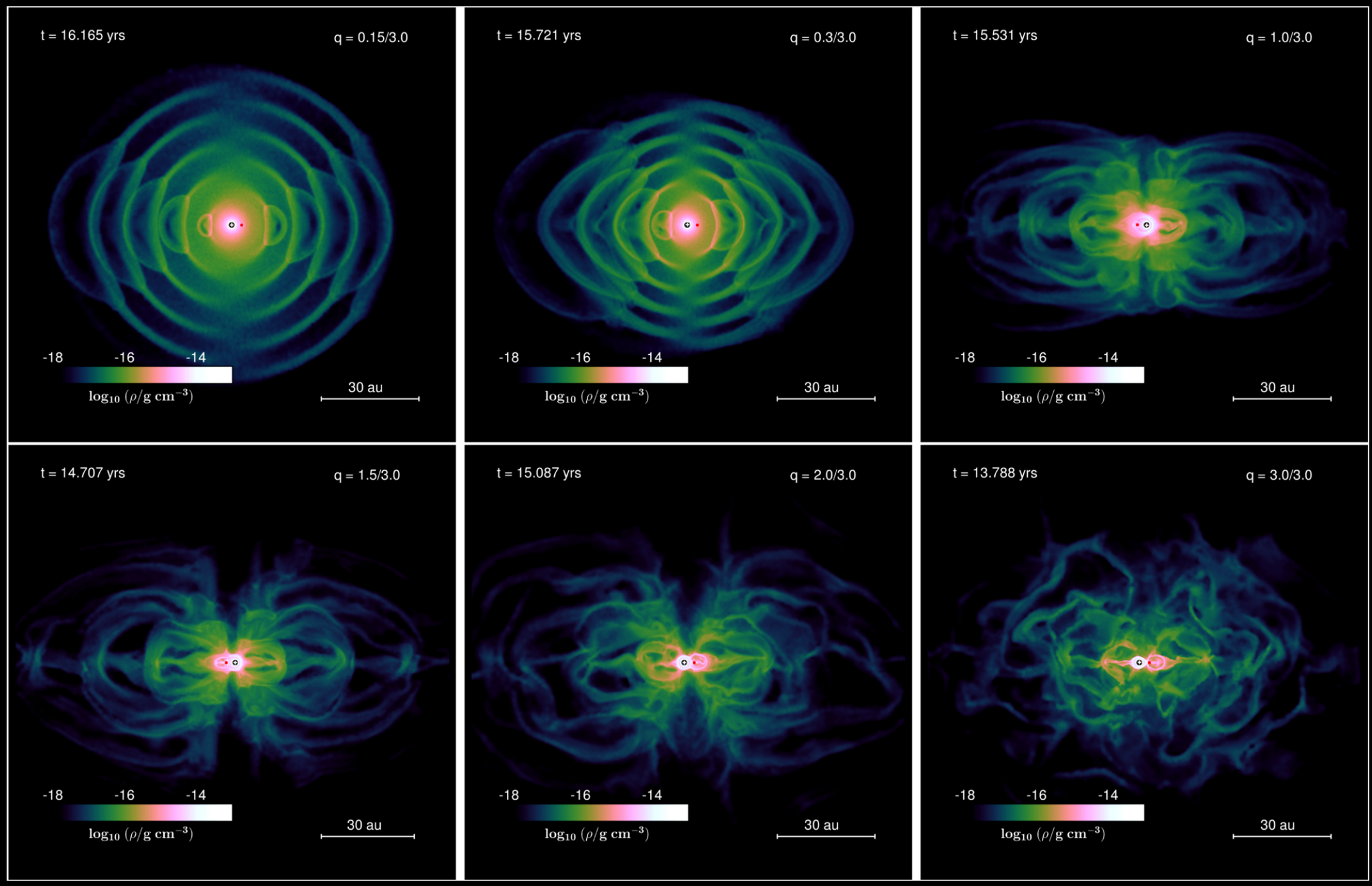
- Wind rather than star fills Roche lobe
- Accretion rate 100x Bondi-Hoyle-Lyttleton rate!

Wind Roche-Lobe Overflow



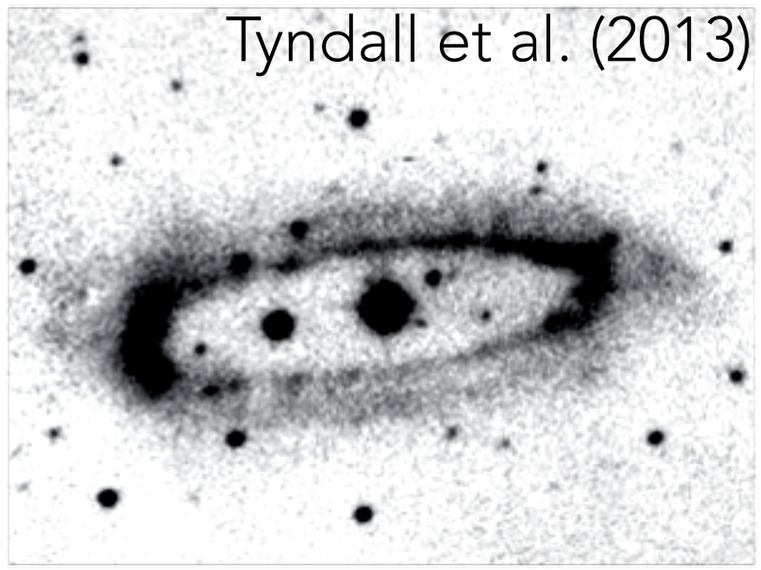
Liu et al. (2017, ApJ, 846, 117)

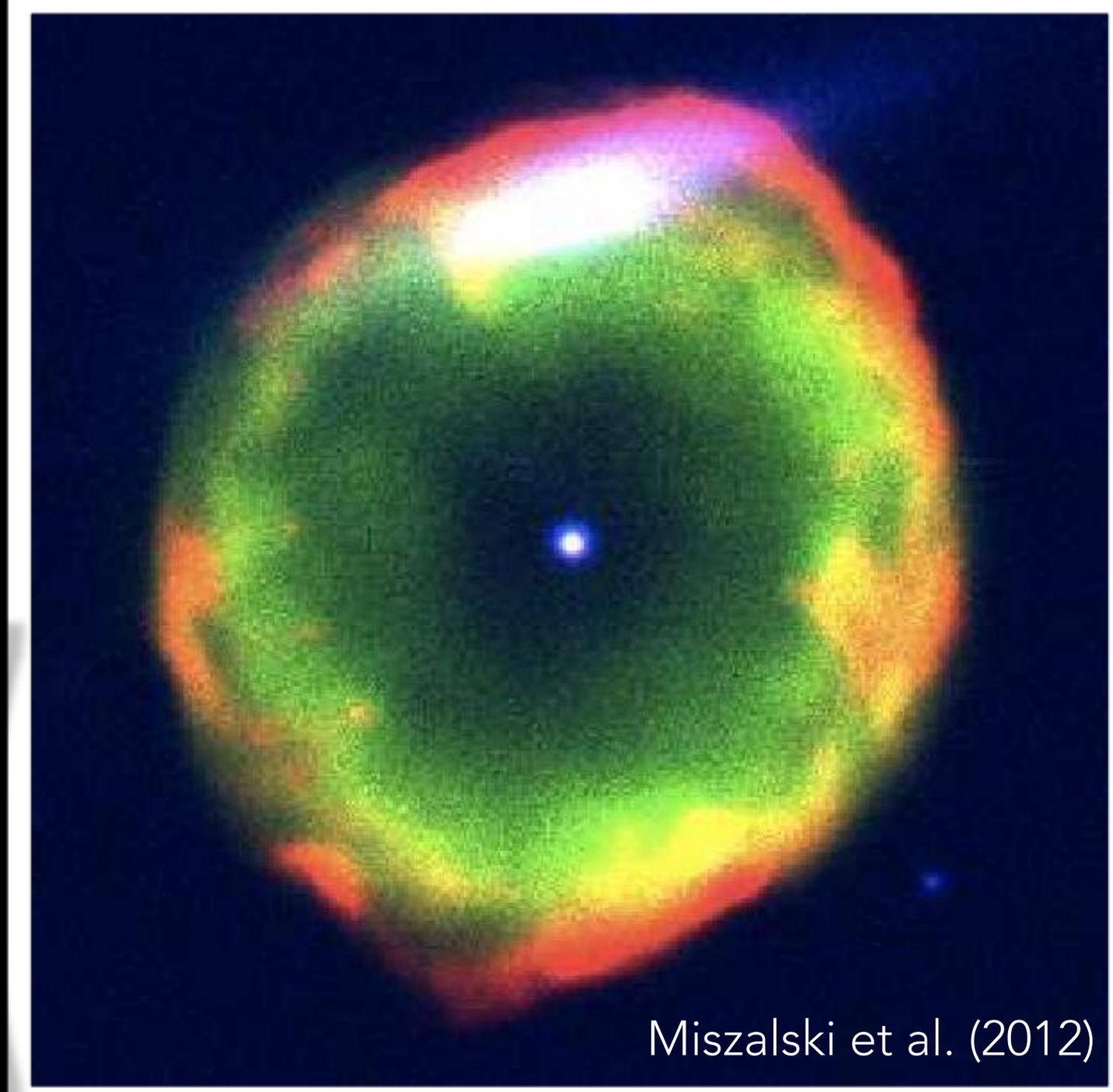
Wind Roche-Lobe Overflow



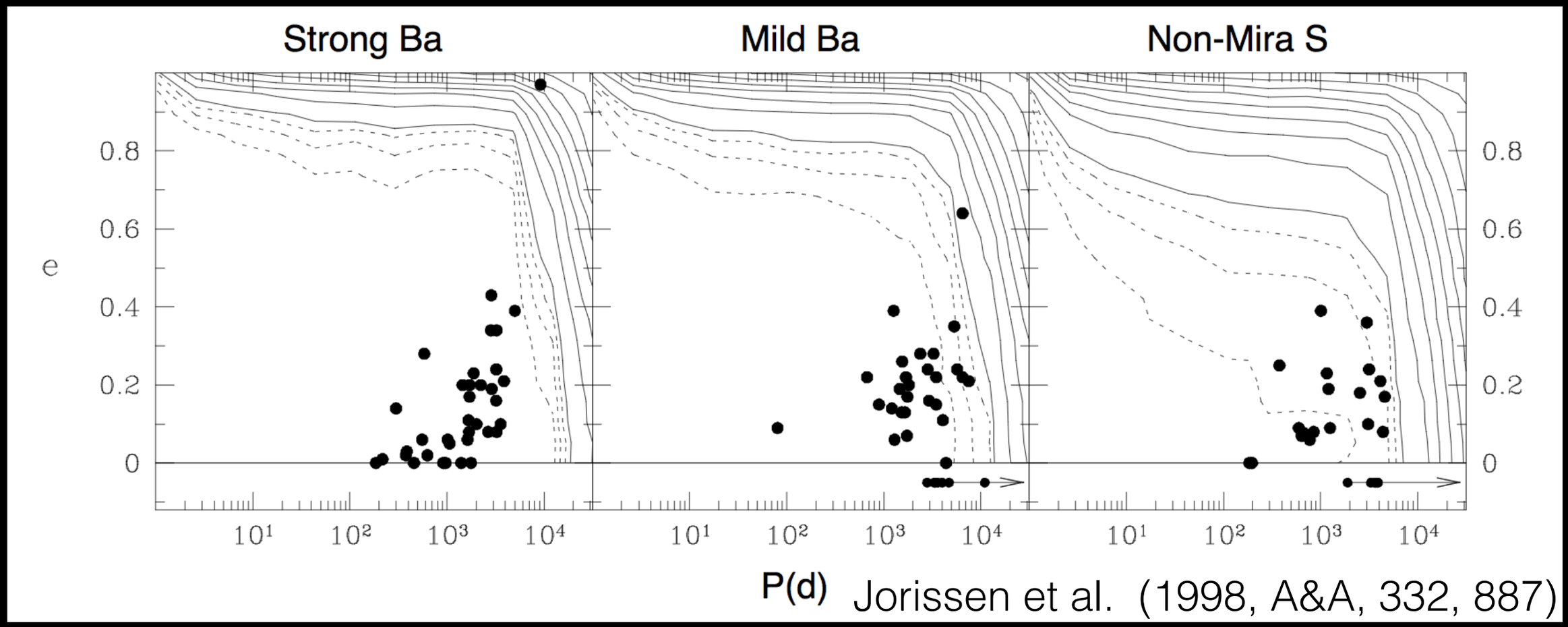
Liu et al. (2017, ApJ, 846, 117)

The Lord of the (Ba-)rings





Orbital periods?

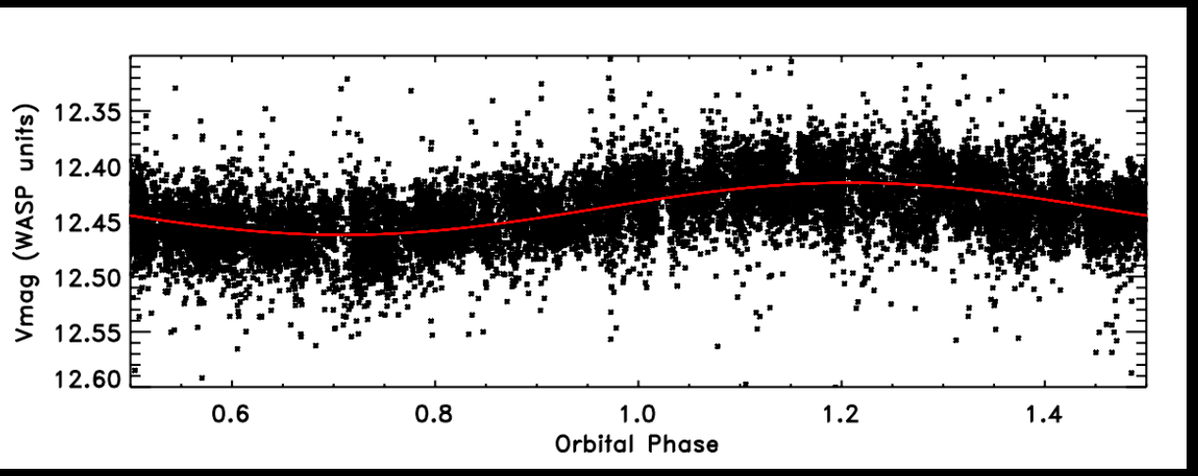


Jorissen et al. (1998, A&A, 332, 887)

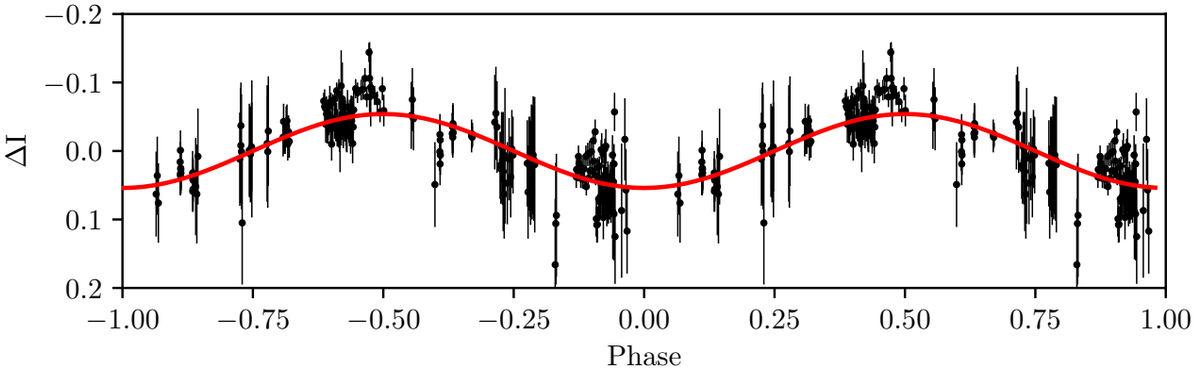
- No known periods for PN Ba stars…
- Field Ba stars have P~100-3000 days
- Too faint for Mercator-HERMES

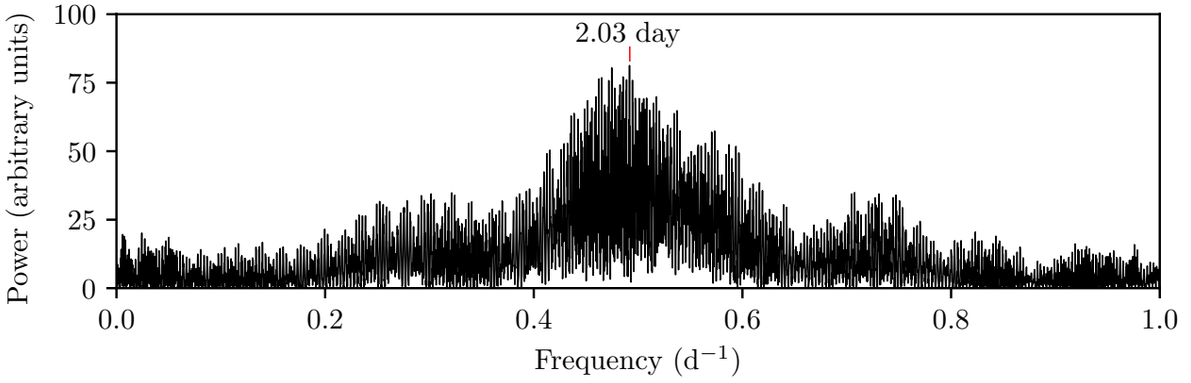
- But not for VLT-UVES, so watch this space!

Rotational periods?

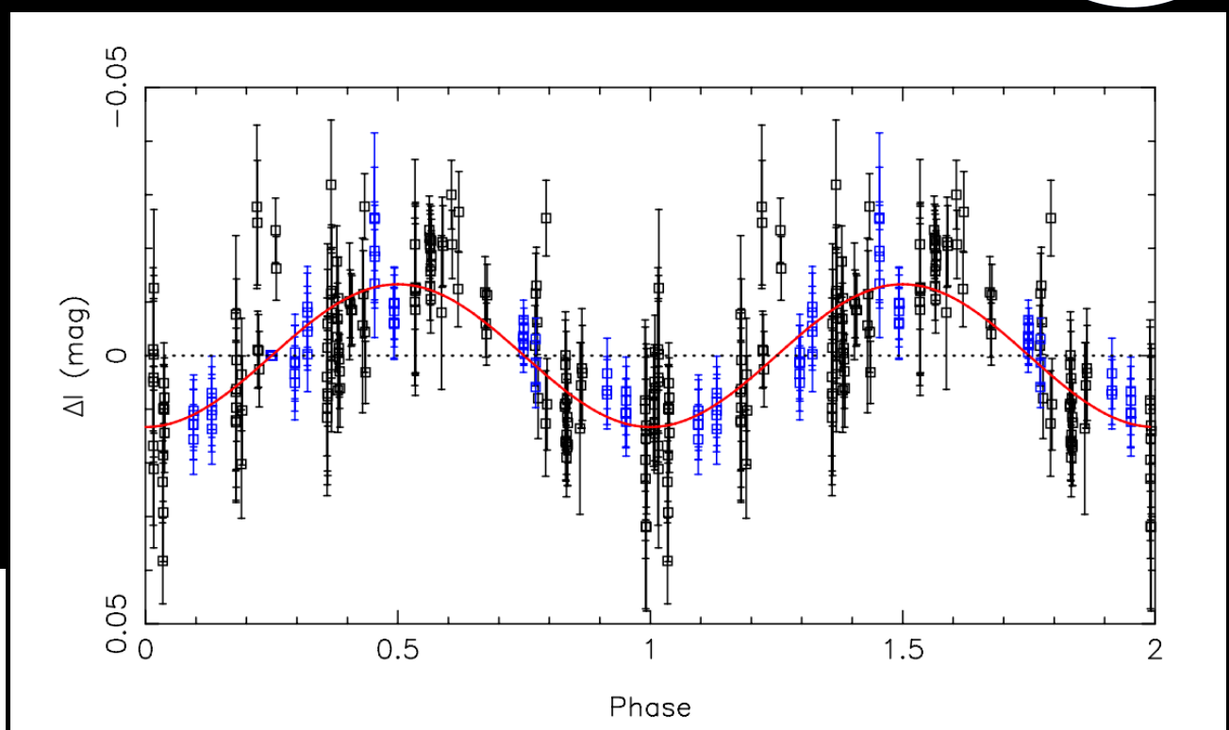


LoTr 1, P~6.4d (Tyndall et al. 2013)





A 70, P~2d (Brown et al. in prep)

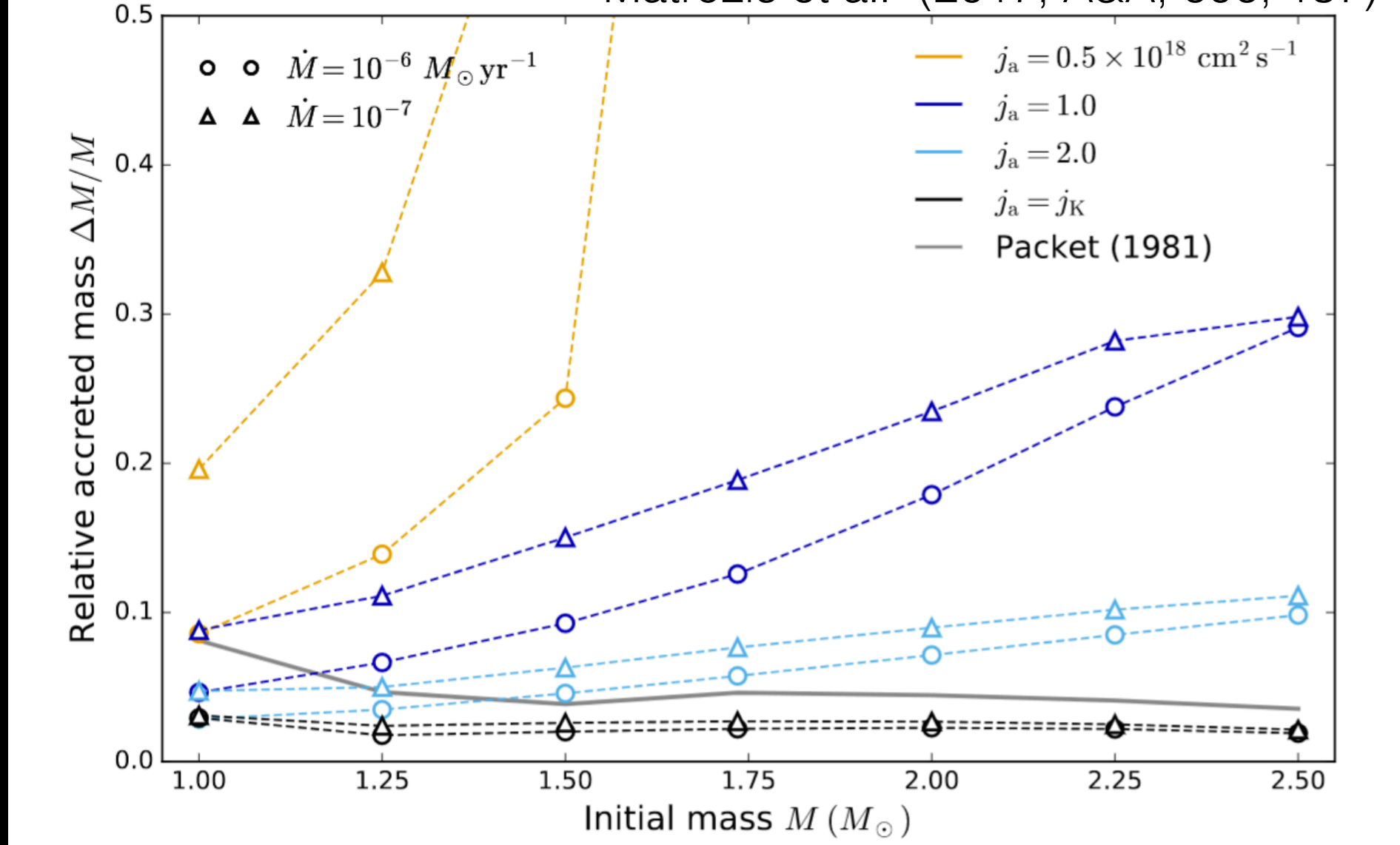


Hen 2-39, P~5.5d (Miszalski et al. 2013)

- Periods of a few days
- Highly spun-up!
- Accreted angular momentum

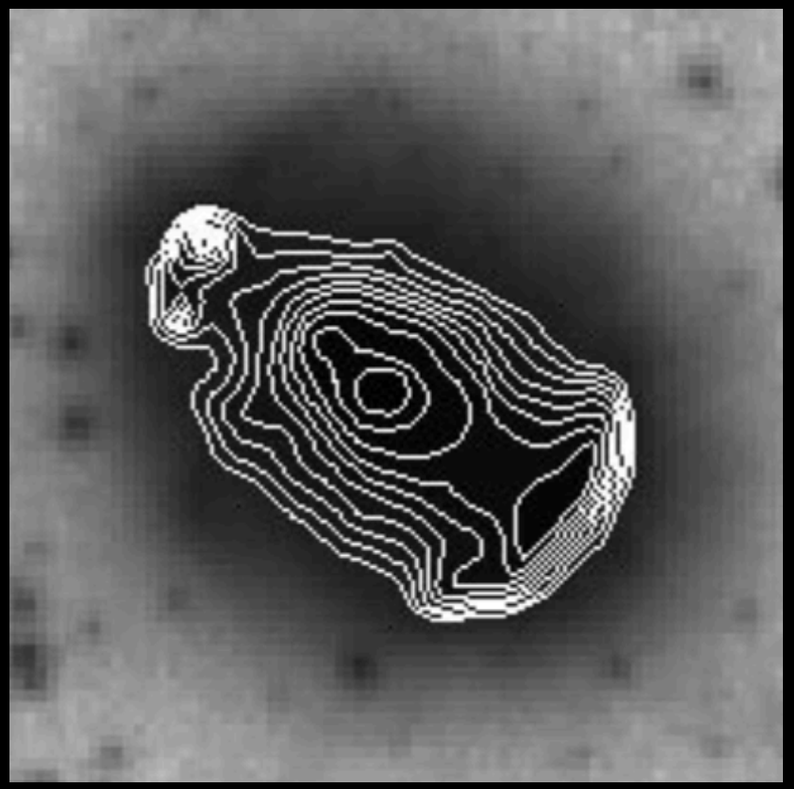
Rotational periods?

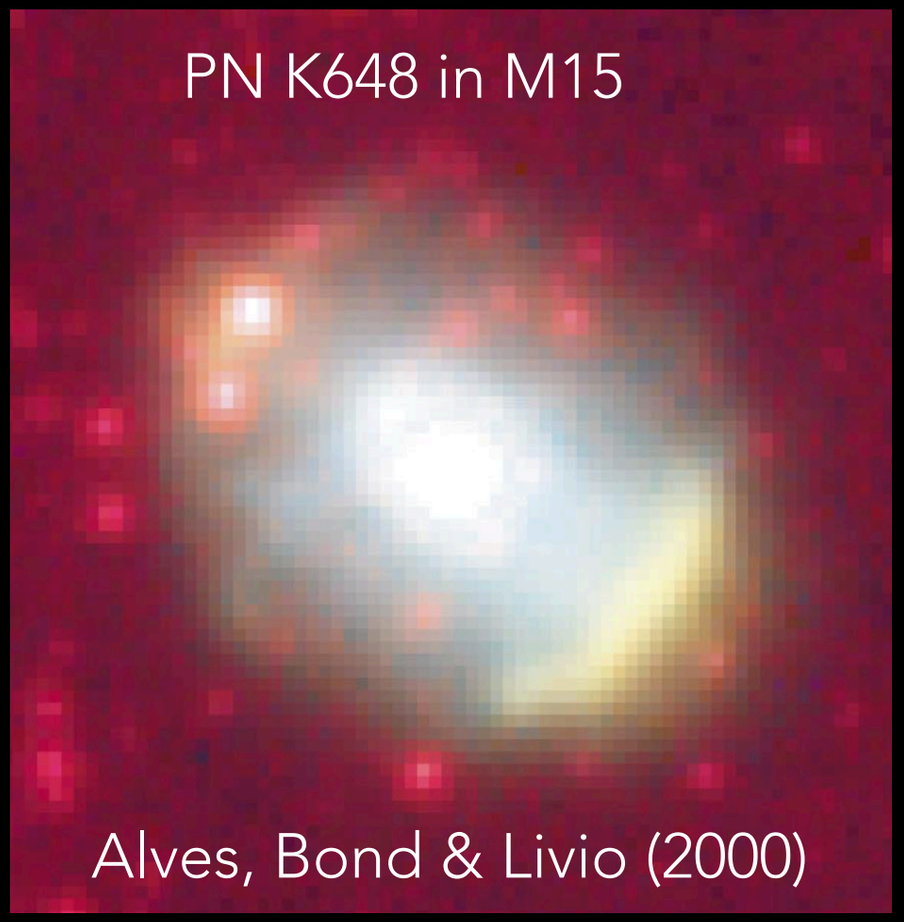
Matrozis et al. (2017, A&A, 606, 137)

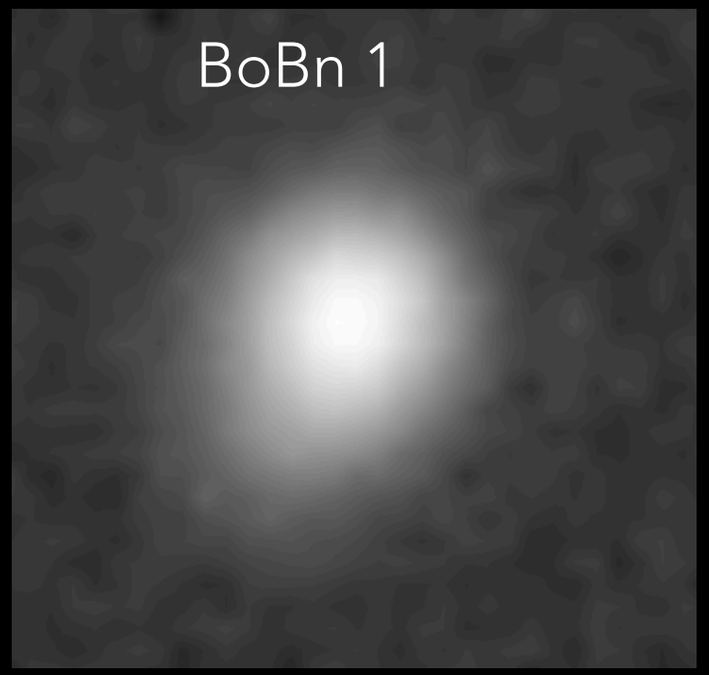


- Very few estimates of mass transferred
- But, probably very (too?) high!
- e.g. 0.5 $M_\odot$ on to 1.5 $M_\odot$ star (Miszalski et al. 2013)

CEMP stars





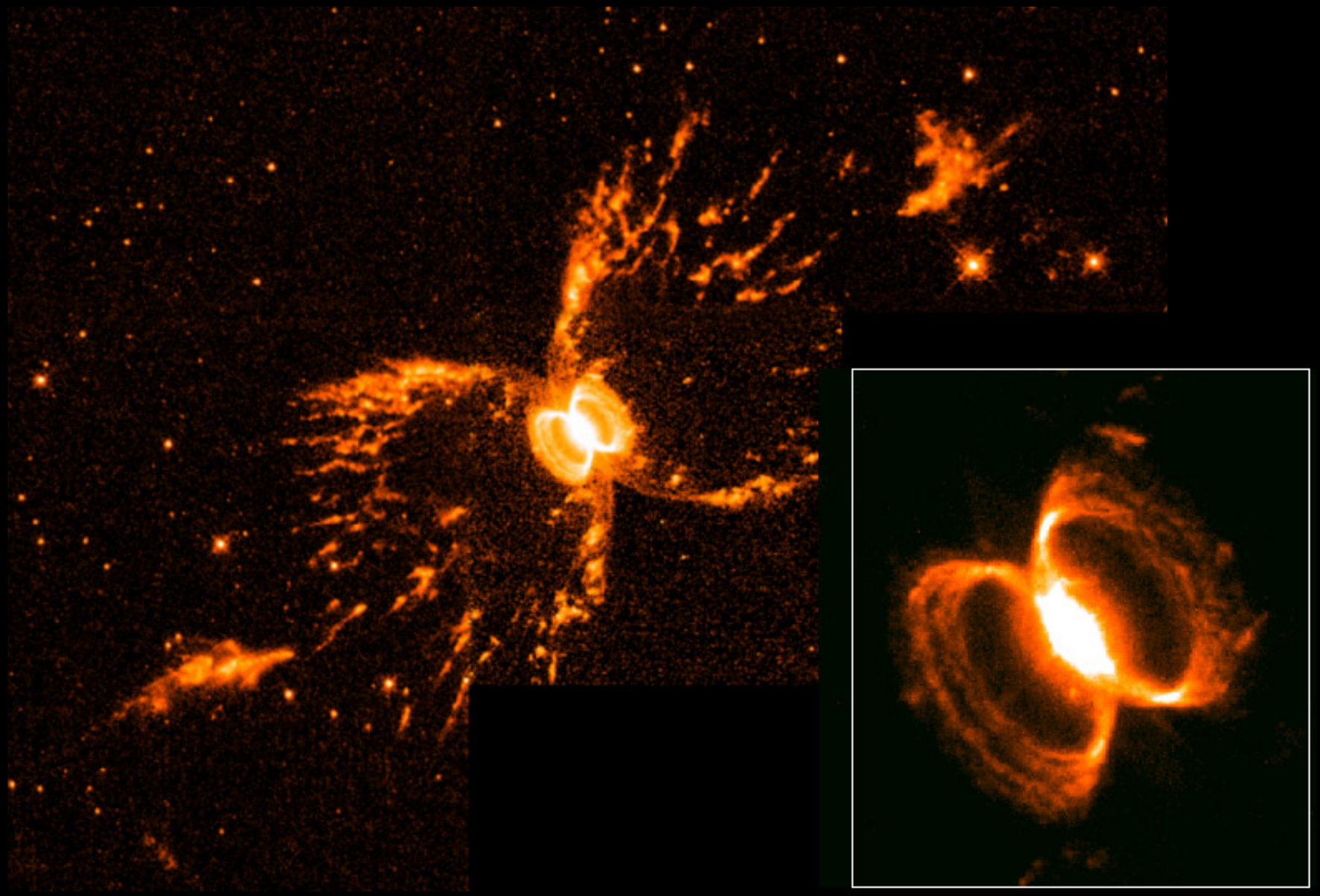


Otsuka et al. (2010)

- Expected to form like Ba stars
- Population II rather than Pop I

- Handful of PNe show similar abundances
- Also elevated core masses
- Maybe even nebular rings?

D-type Symbiotics



Santander-García et al. (2008, A&A, 485, 117)

Summary

- Binaries are responsible for shaping (some/most/all) PNe

- Even wide binaries play an important role
  - Difficulties in detection so hard to constrain

- Barium stars in PNe are critical for understanding WRLOF physics

A detailed study of the barium central stars of the planetary nebulae Abell 70 and Henize 2-39

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COMING SOON!