Post-common-envelope binaries: A planetary nebula perspective

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AGENCIA
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Unión Europea
Fondo Europeo
de desarrollo Regional
"Una manera de hacer Europa"

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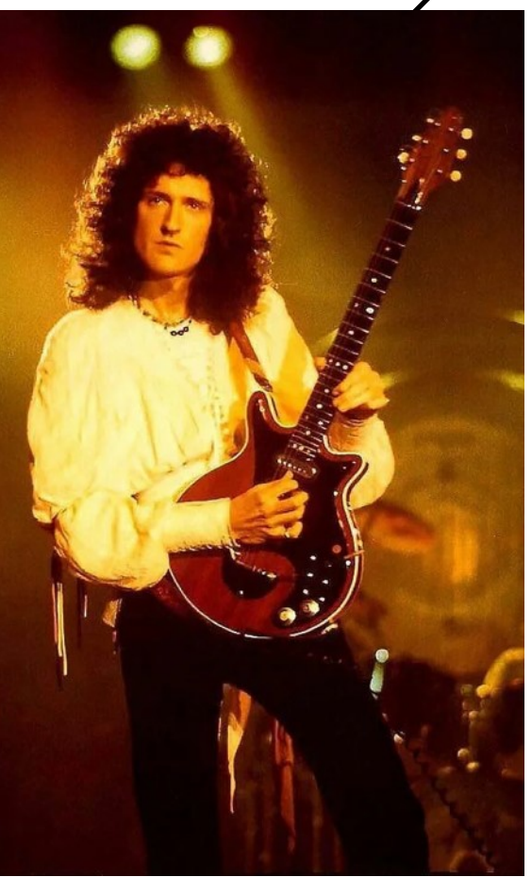
astrogen.aas.org



Nušl, František

Braddick, Henry John James
1932, University of Cambridge

Kopal, Zdeněk
1937, Charles University

Ring, James "Jim"
1959, Victoria University of Manchester

Chapman, Sydney
1914, Victoria University of Manchester

Meaburn, John
1965, Victoria University of Manchester

Kahn, Franz Daniel
1950, University of Oxford

Lloyd, Myfanwy
1992, Victoria University of Manchester

O'Brien, Timothy John "Tim"
1990, Victoria University of Manchester

Jones, David
2011, University of Manchester

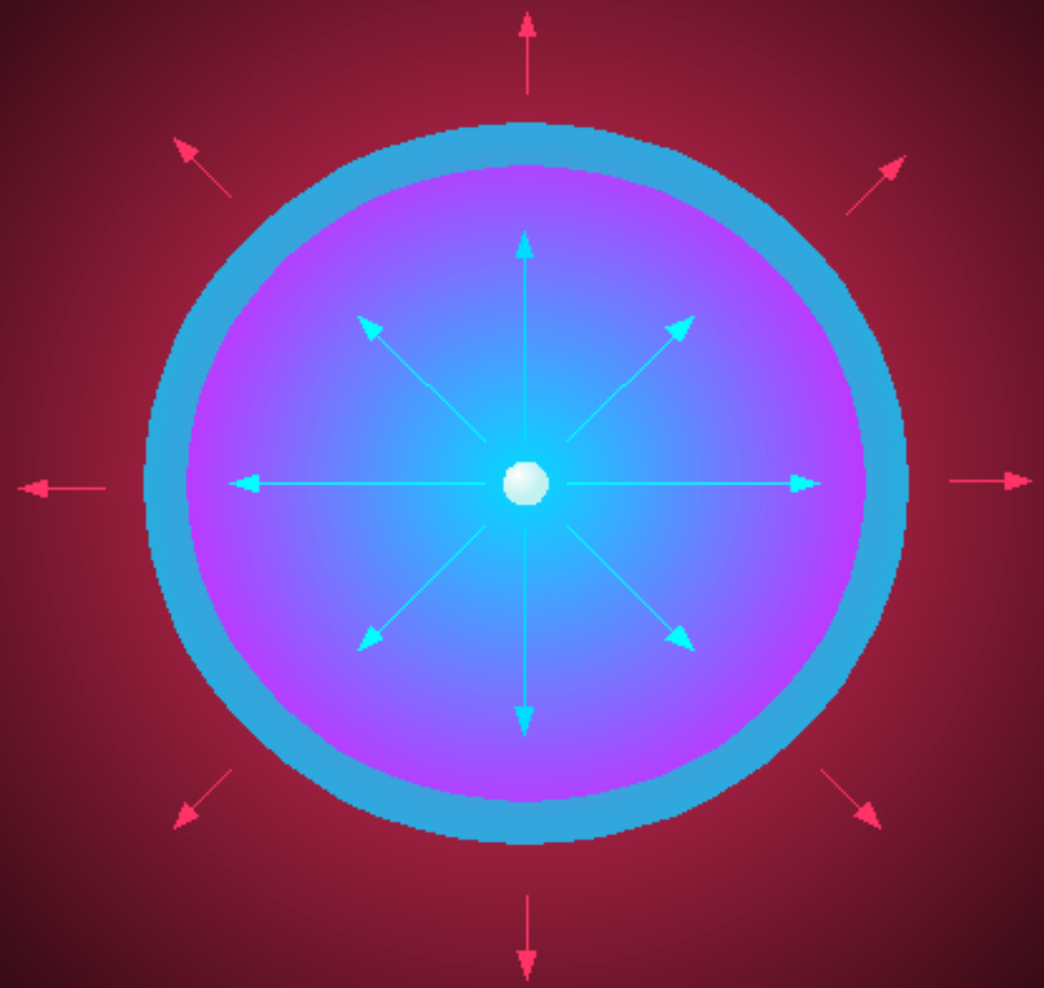
Tyndall, Amy A
2014, University of Manchester

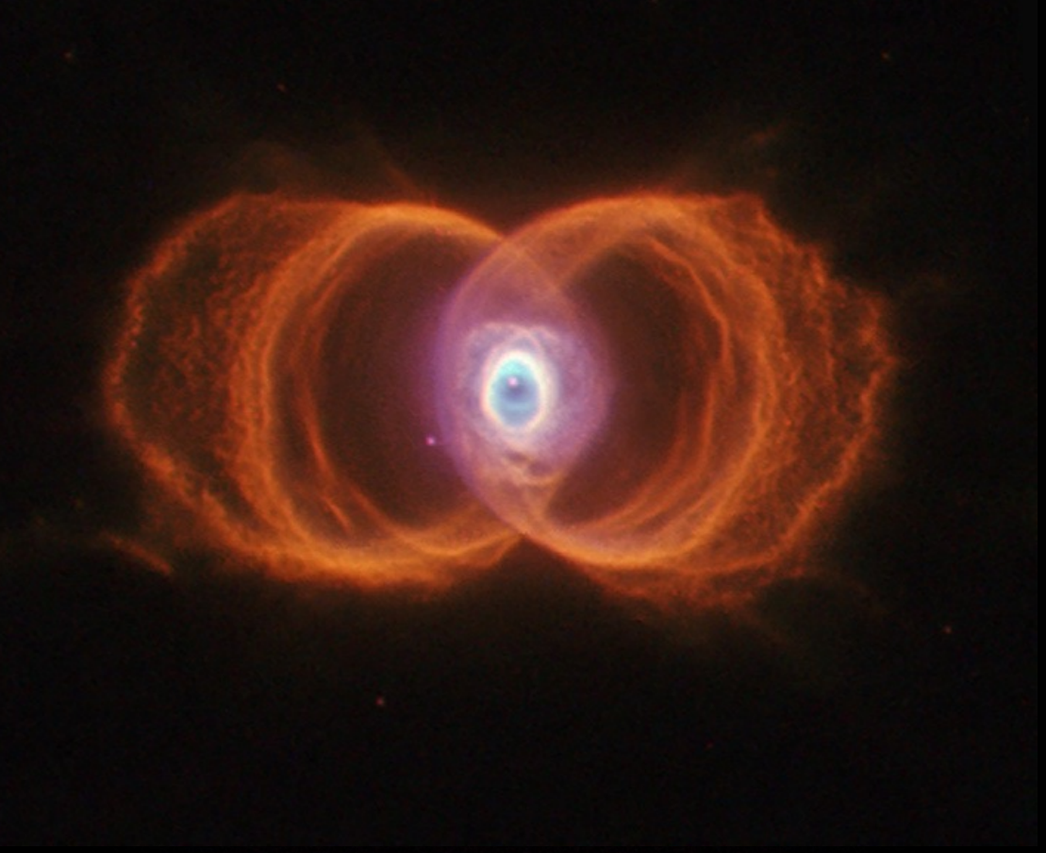
Sowicka, Paulina
2024, Nicolaus Copernicus Astronomical Center, Polish Academy of Sciences

PLANETARY NEBULA

Ejected envelope

Ionising nucleus (pre-WD)

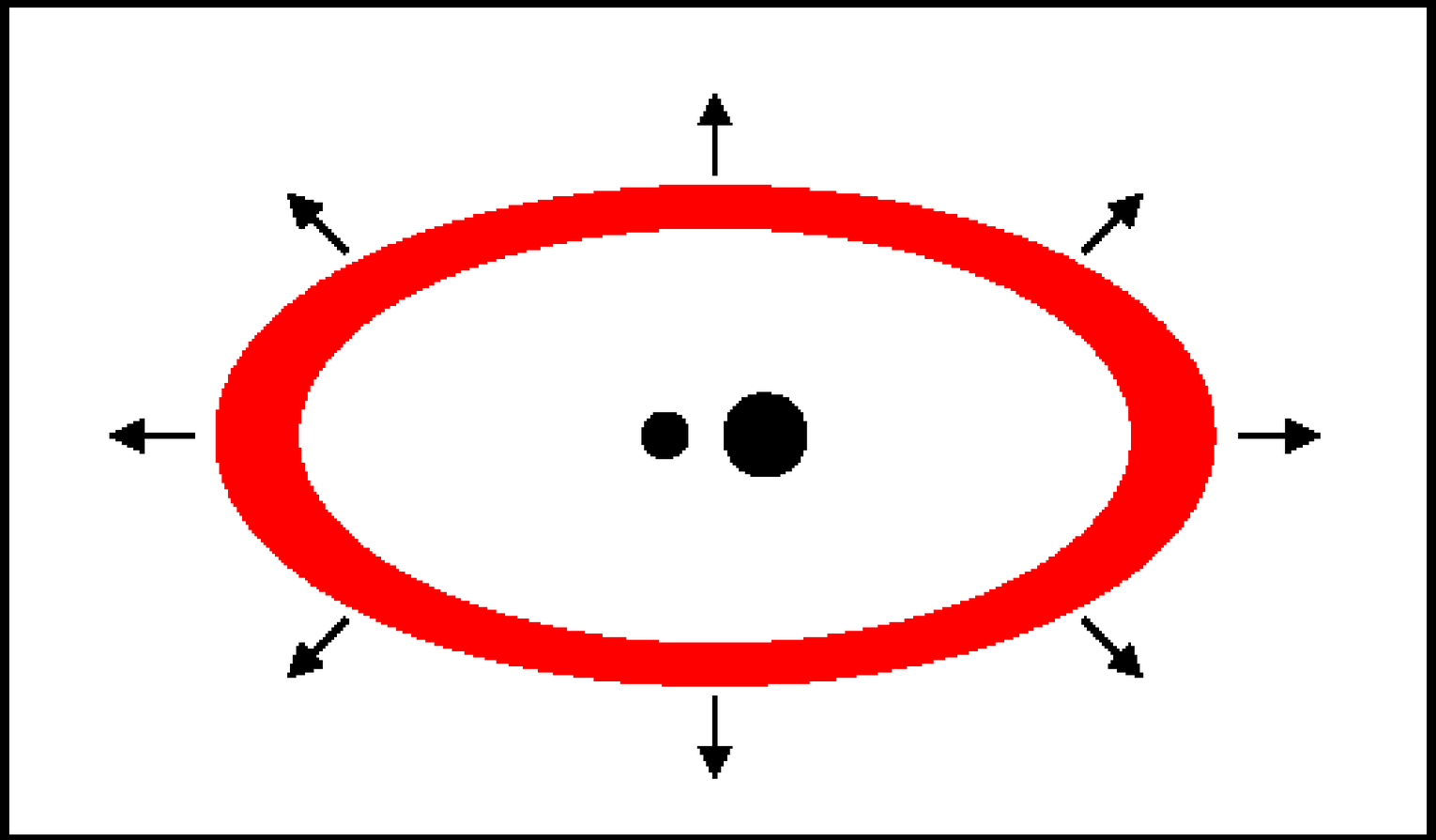




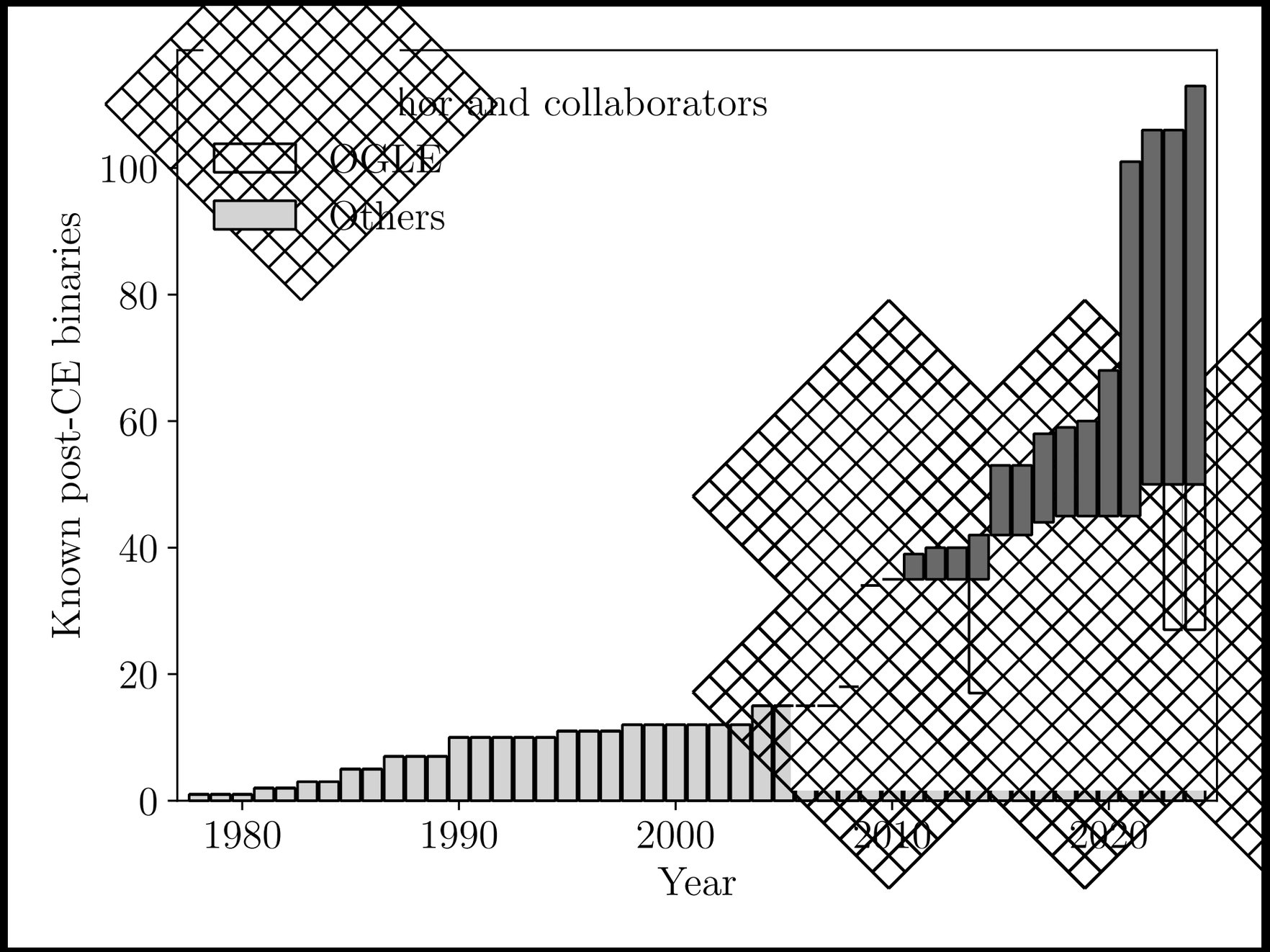
HOW DO YOU MAKE AN HOURGLASS?

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

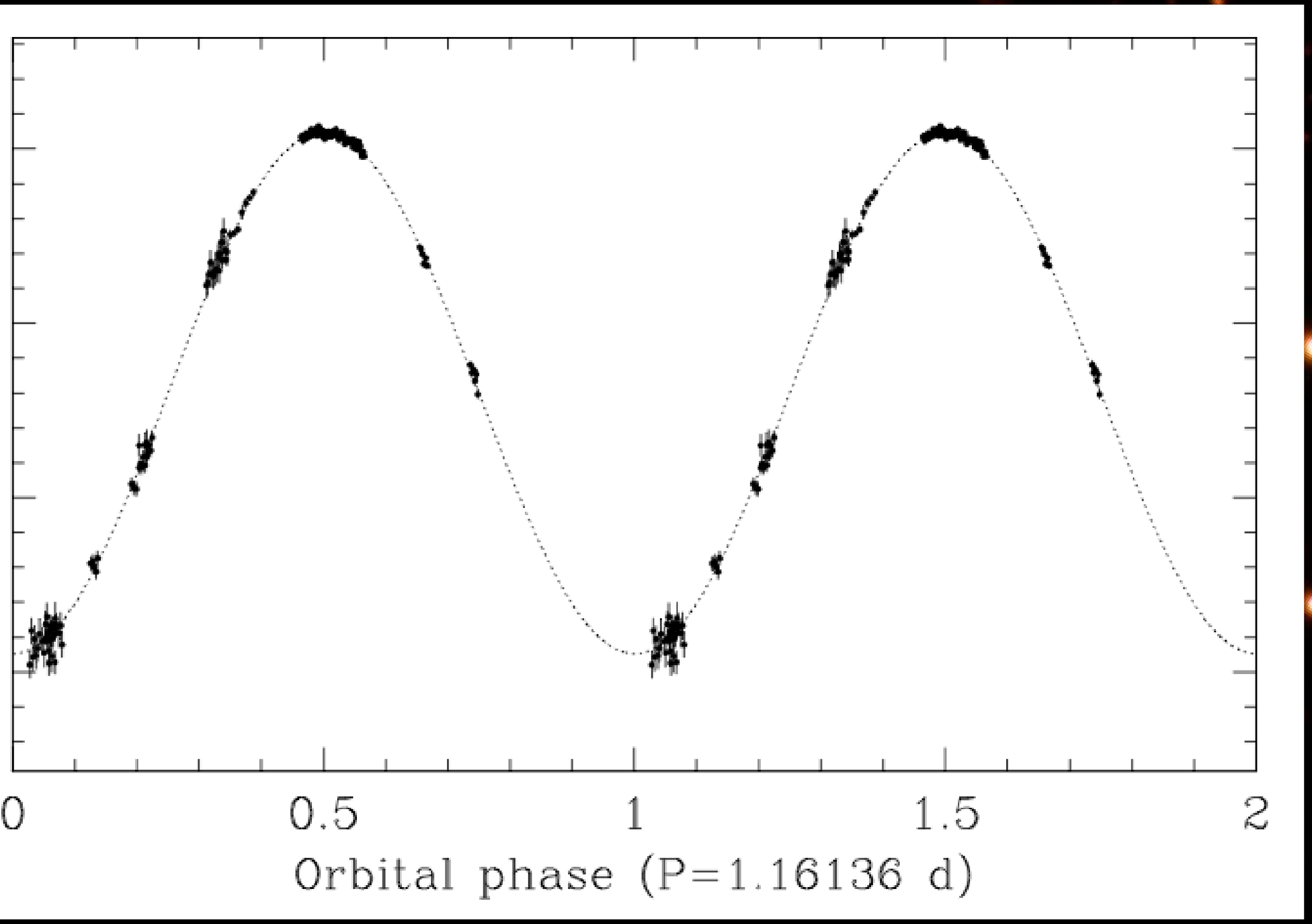
From CE to PN



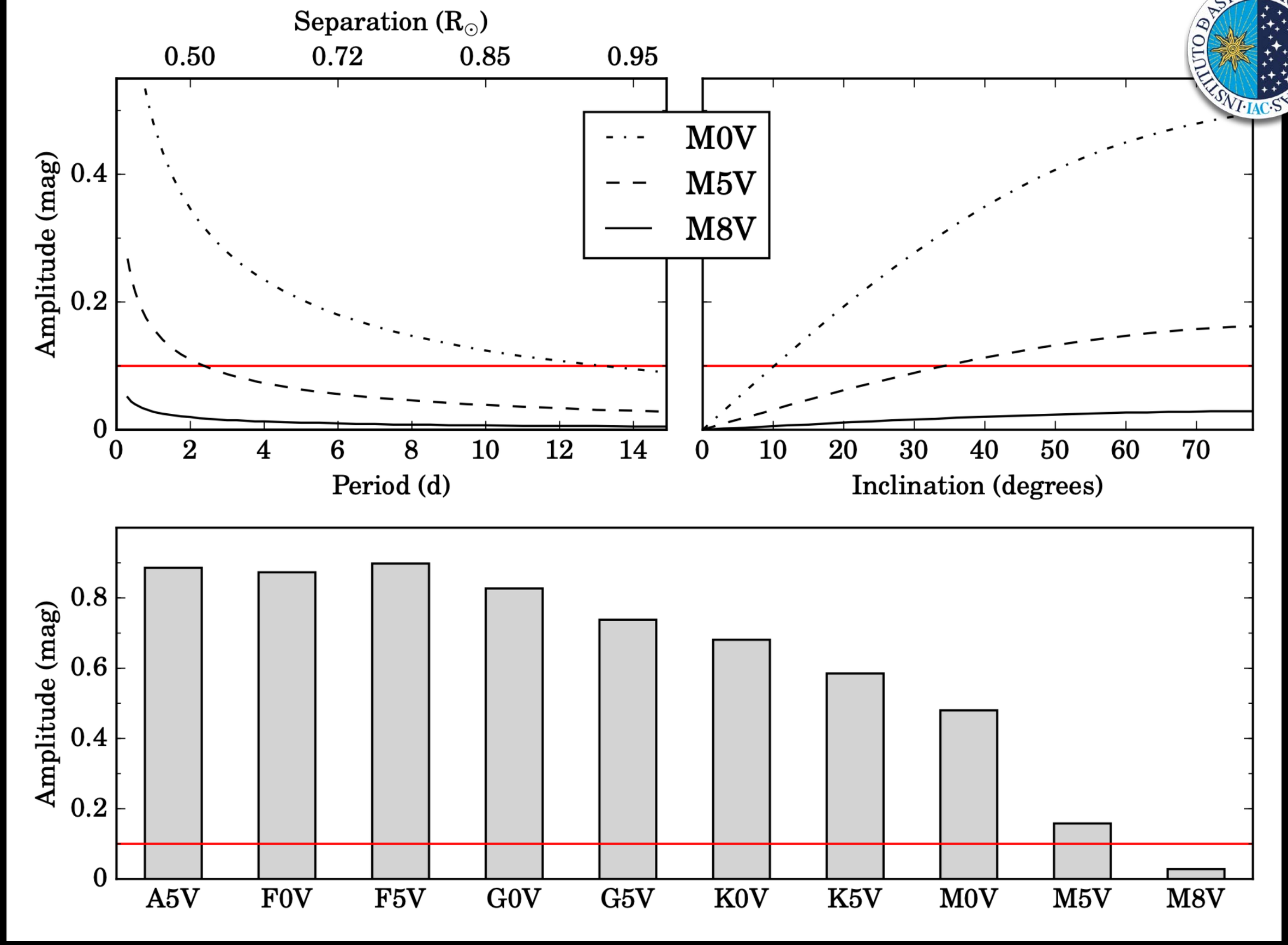
WHERE ARE THEY ALL THEN?



HOW DO YOU DETECT A BINARY?



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

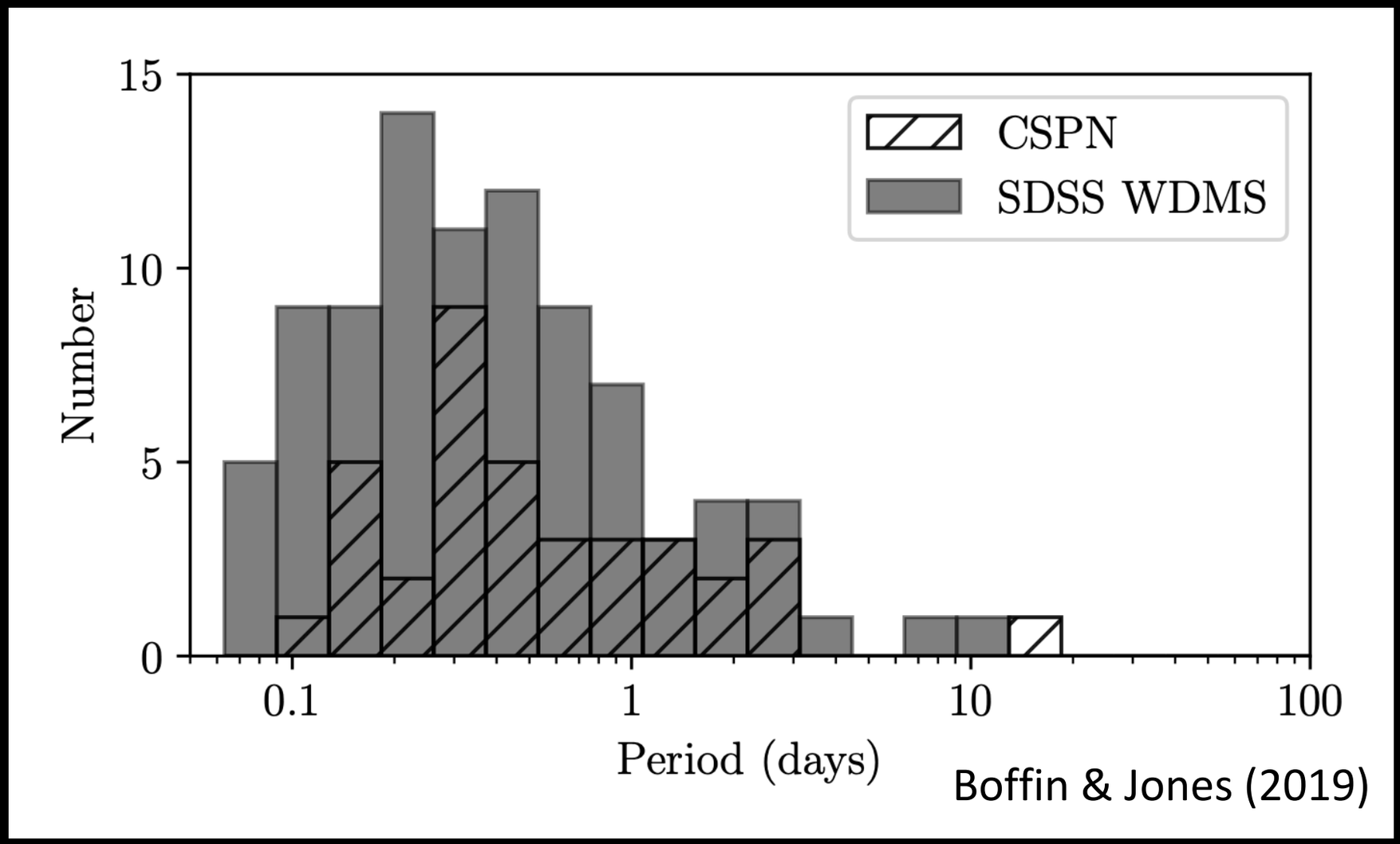


Jones & Boffin (2017, Nature Astronomy, 1, 117)

True binary fraction?

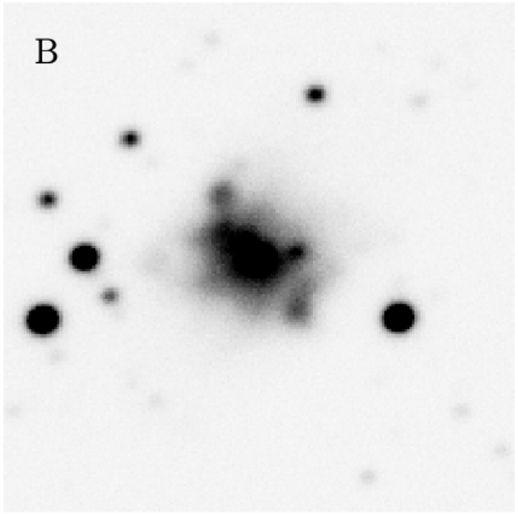
- (Photometrically) detectable (post-CE) fraction ~20% (Miszalski et al. 2009, Chornay et al. 2021, Jacoby et al. 2021)
  - Do (observable) PNe form “more easily” via CE than from single stars? (Only 1/6th of eligible stars form a PN? Moe & De Marco 2006)
- Maybe as high as 80% based on other methodologies (De Marco et al. 2004; Douchin et al. 2015), but these also include long period systems.
  - ~50% of CSPNe are not consistent with single star evolutionary tracks (Weidmann et al. 2020)

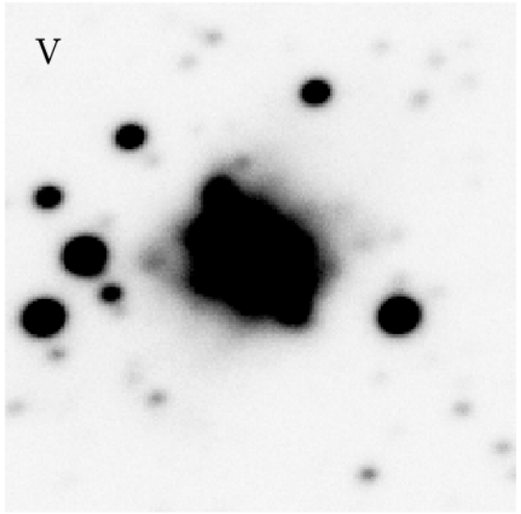
Period distribution

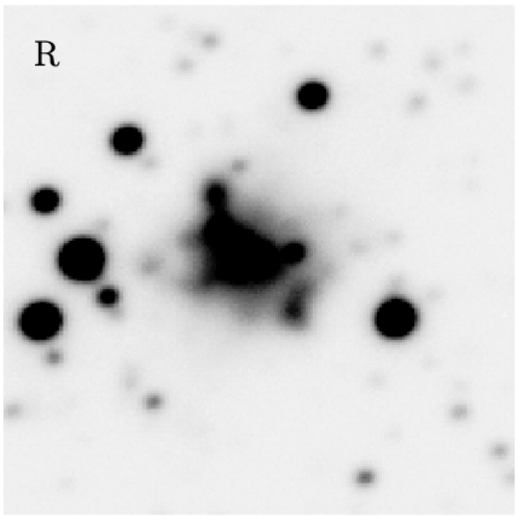


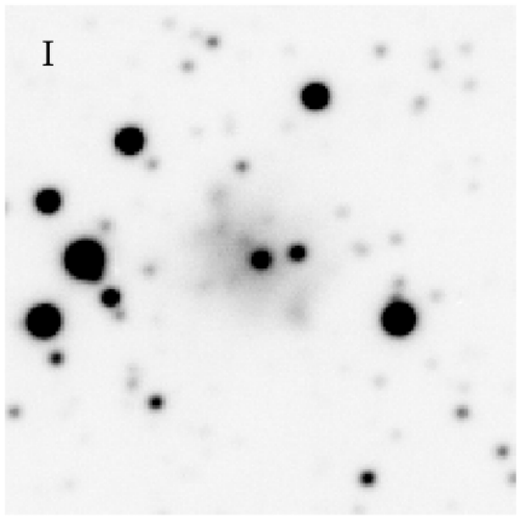
Boffin & Jones (2019)

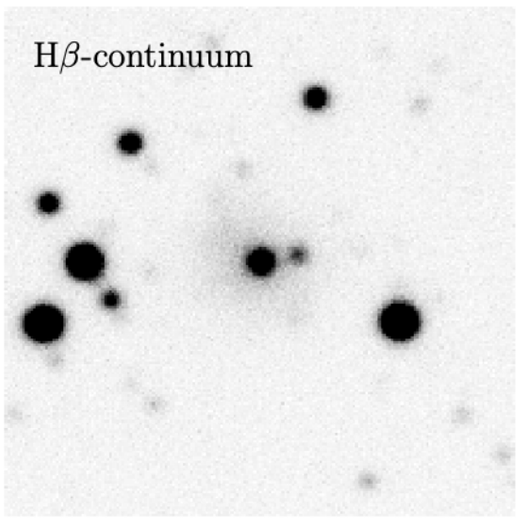
Consistent with general WDMS population



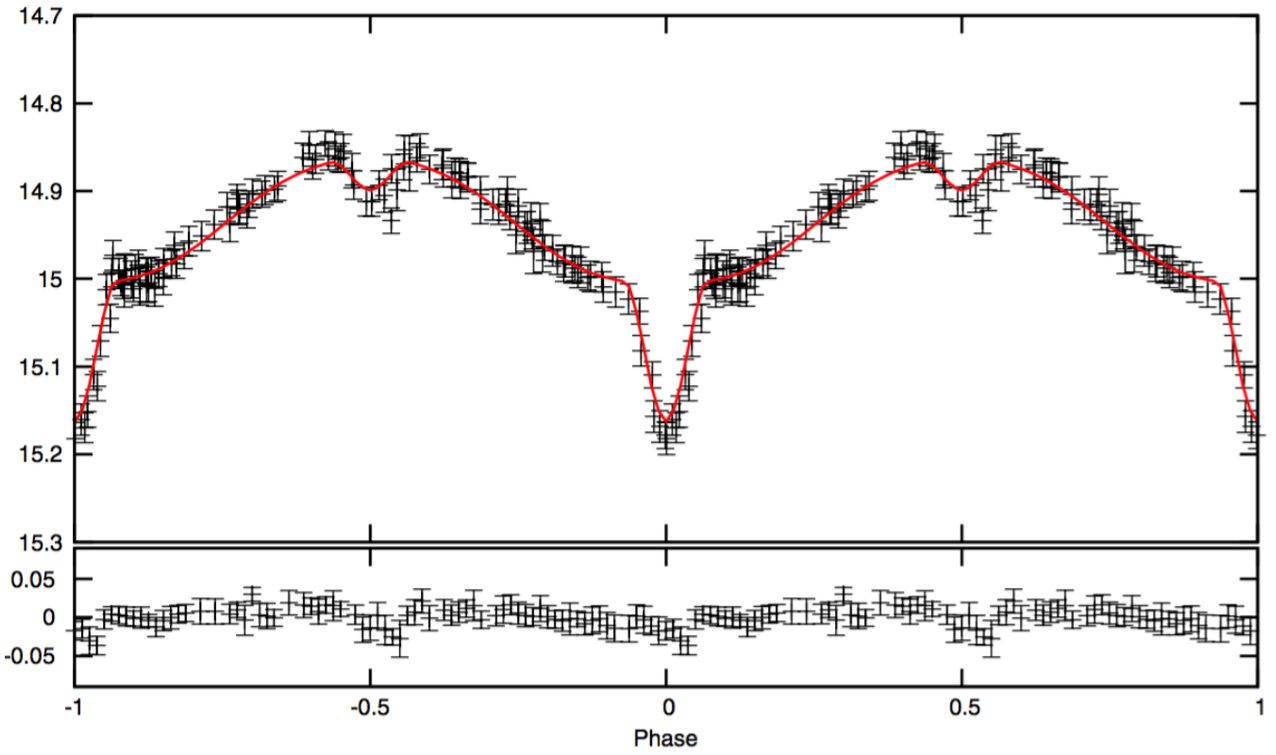


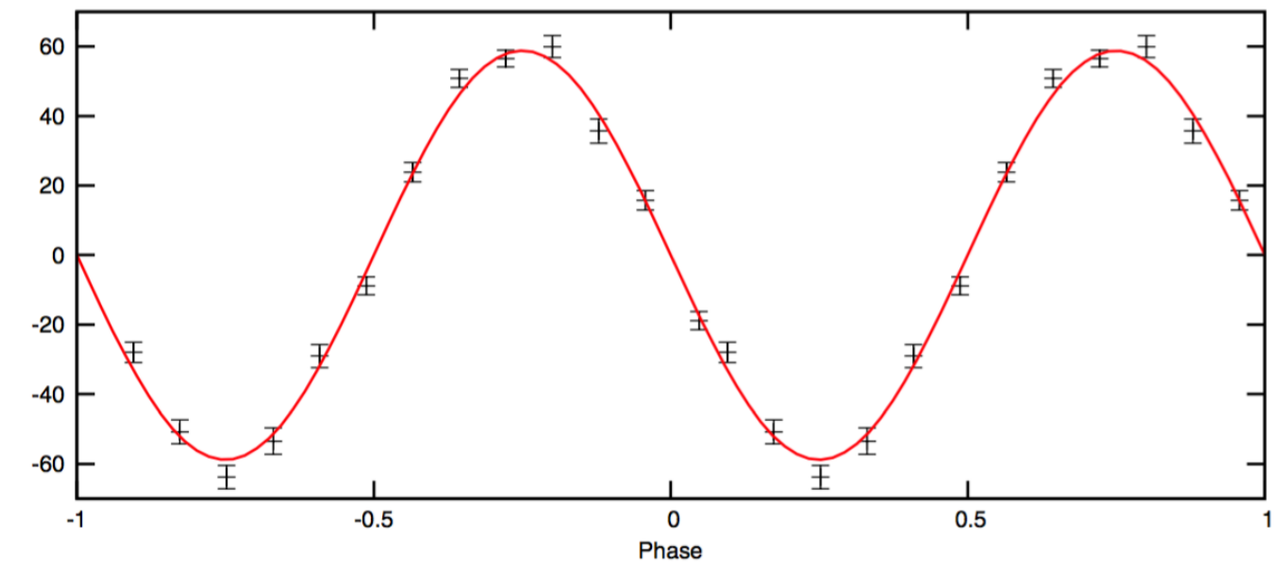






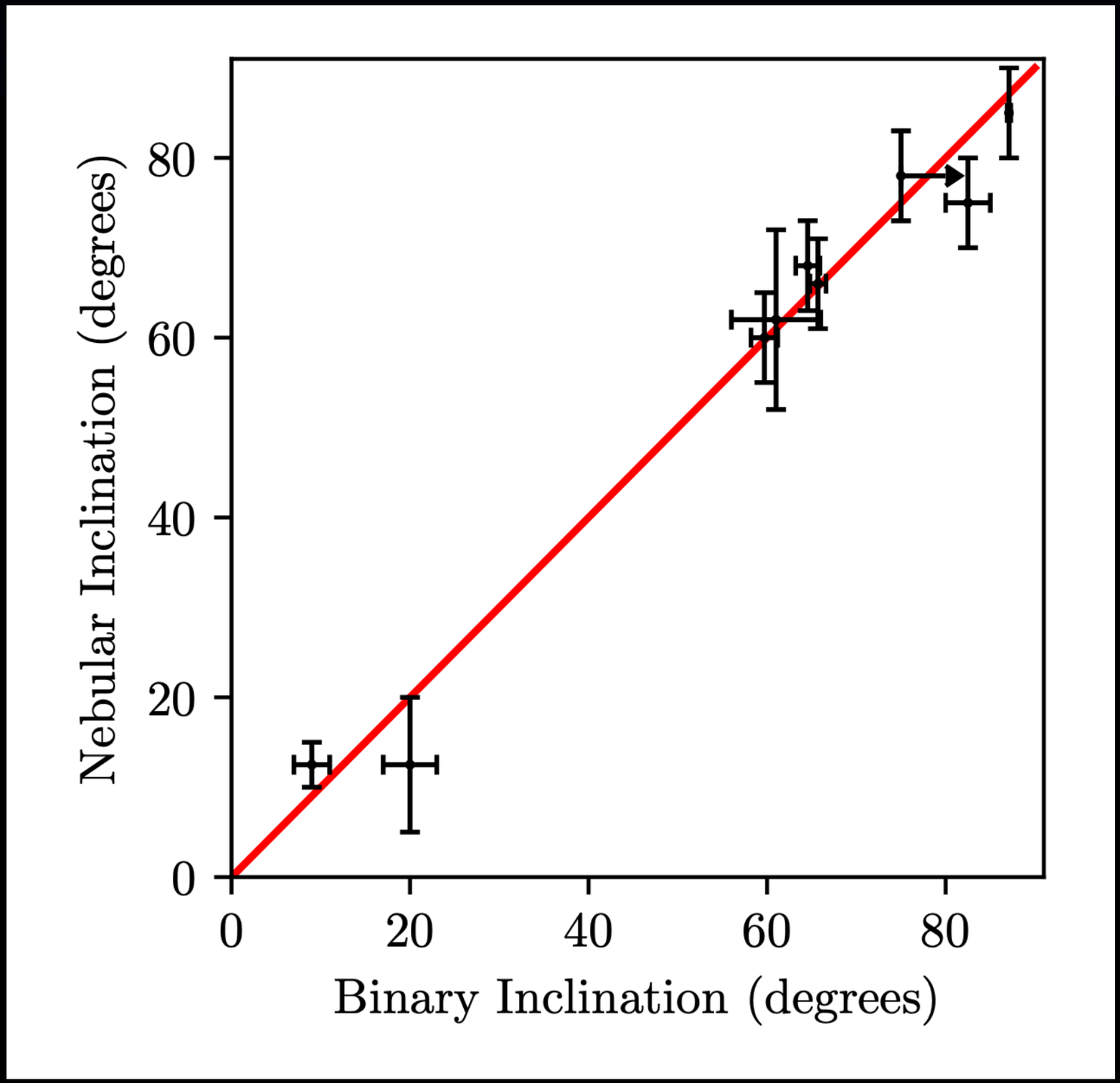
Simultaneous light & RV curve modelling





Jones et al. (2015, A&A, 580, 19)

Less than one in a million chance…



Munday, Jones et al. (2020, MNRAS, 498, 6005)

Inflated secondaries
Evidence of mass transfer!

Abell 46

Hen 2-155

Every*

well constrained main-sequence secondary is inflated!

Jones et al. (2015)

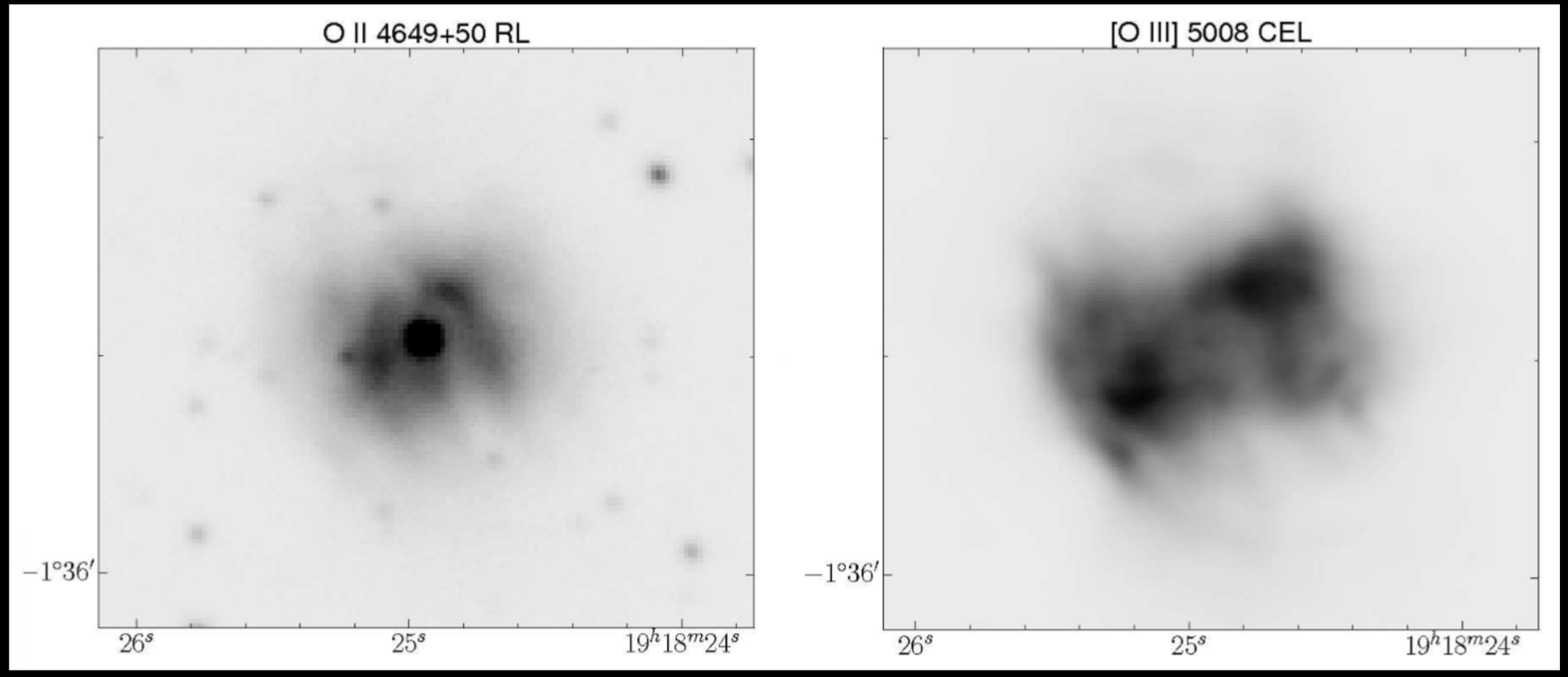
*Except where they are already Roche lobe filling!

Jones et al. (2019, MNRAS, 582 , L75)

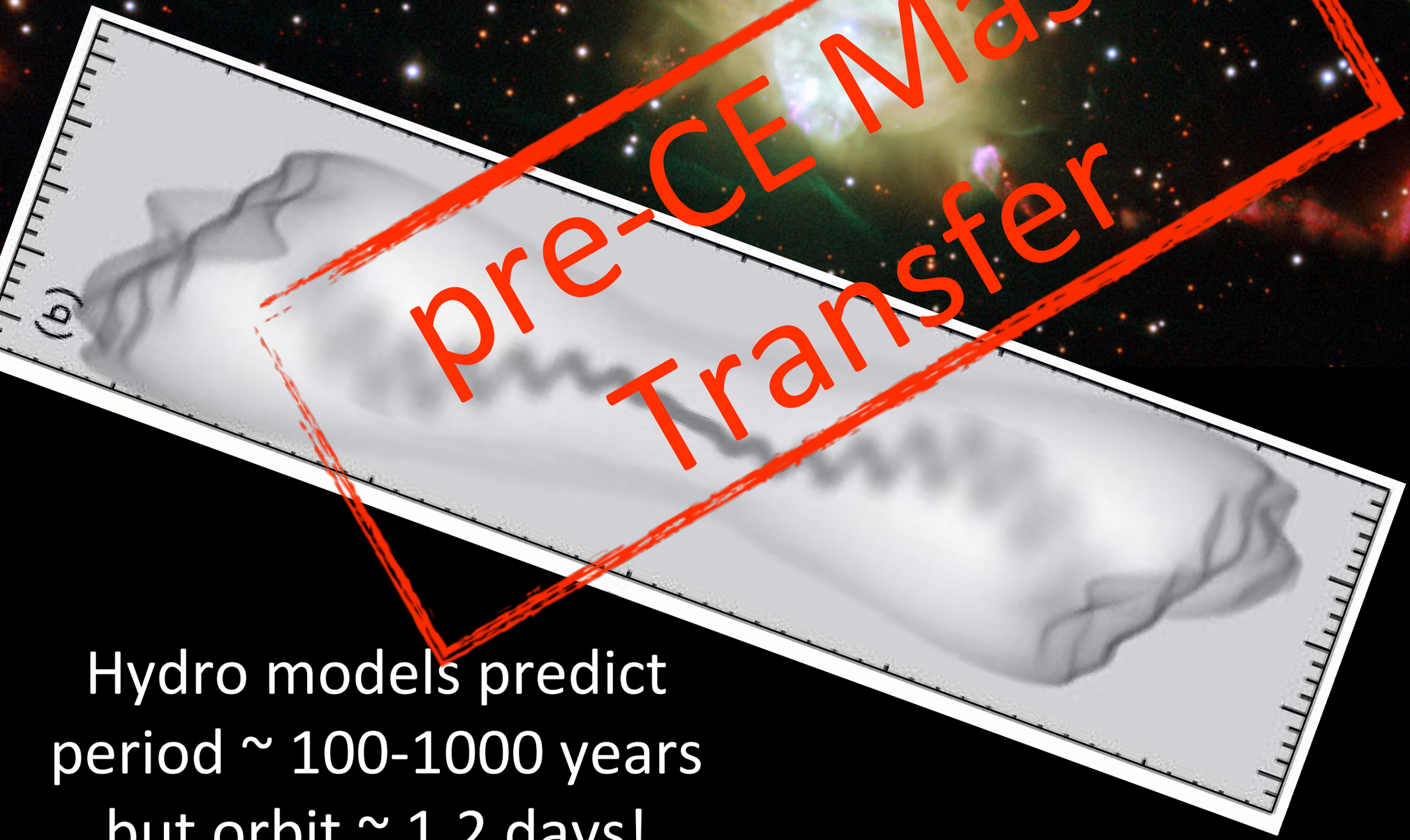
Wesson et al. (2008)

Nova-like anomalous abundances

- Short period post-CE PNe often have extreme abundance discrepancies
- Looks like a nebula within the nebula, that has nova-like abundances (metal-enriched).



Corradi et al. (2015), Jones et al. (2016), García-Rojas et al. (2016), Wesson et al. (2018)



pre-CE Mass Transfer

Hydro models predict
period ~ 100-1000 years
but orbit ~ 1.2 days!

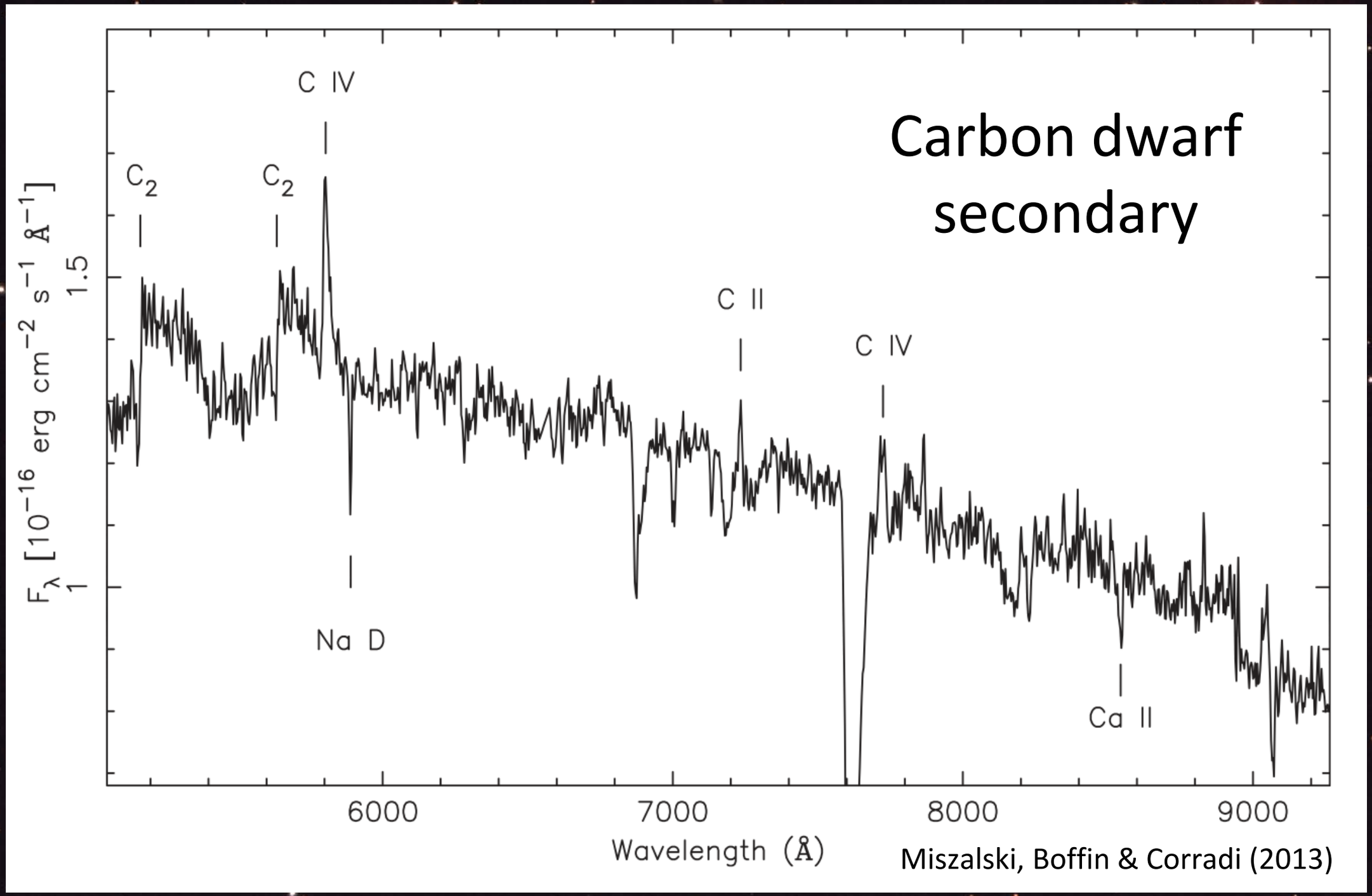
Boffin et al. (2012, Science, 338, 773)

Jets were formed before orbital shrinkage!

PN	Neb. age (yrs)	Jet age (yrs)
Fg 1	2000	2500-7000
Necklace	1100	2400
ETHOS 1	900	1800
Abell 63	3500	5200

Jones (2014, APN6 proc.)

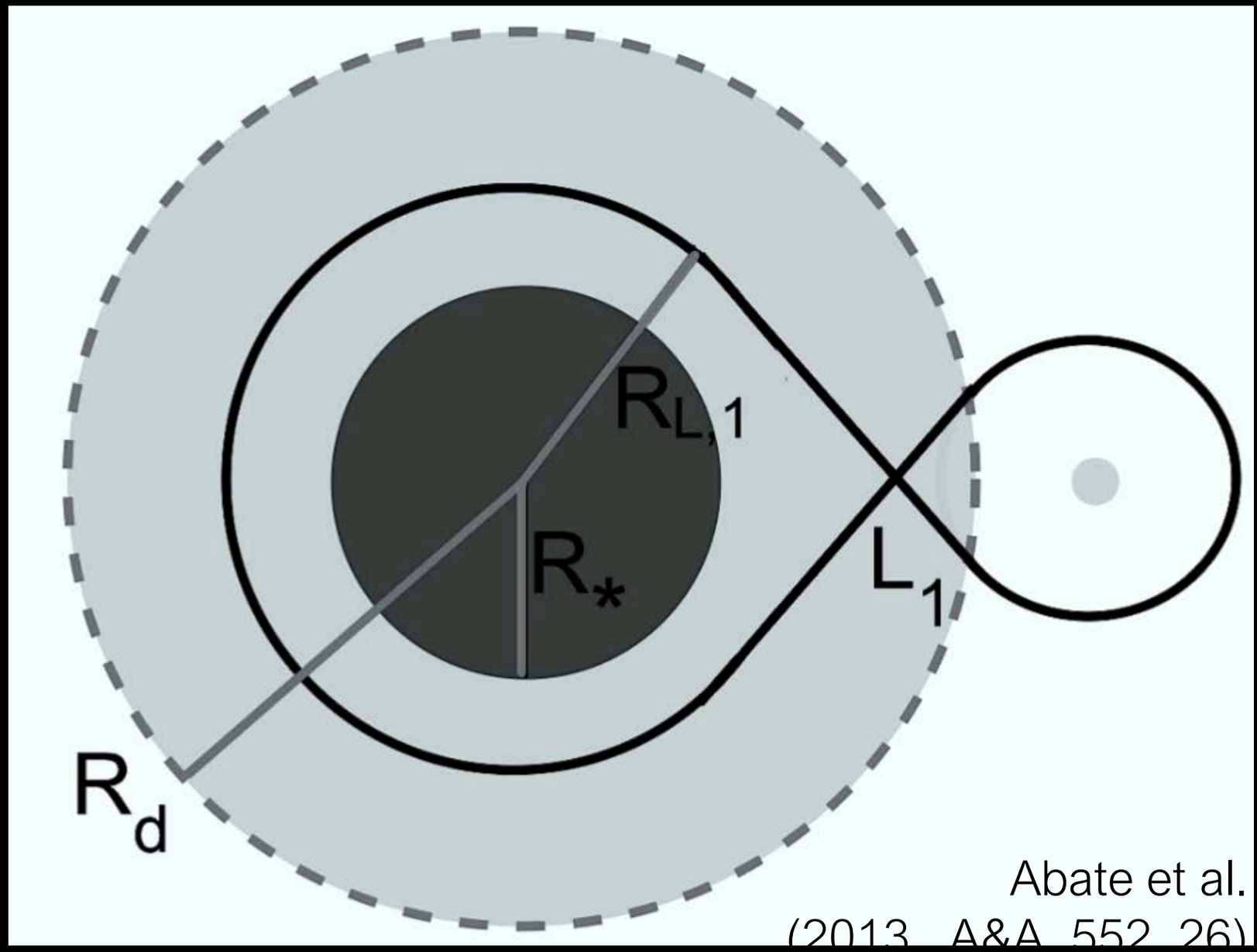
More evidence of mass transfer!



Carbon dwarf secondary

Miszalski, Boffin & Corradi (2013)

Wind Roche-Lobe Overflow

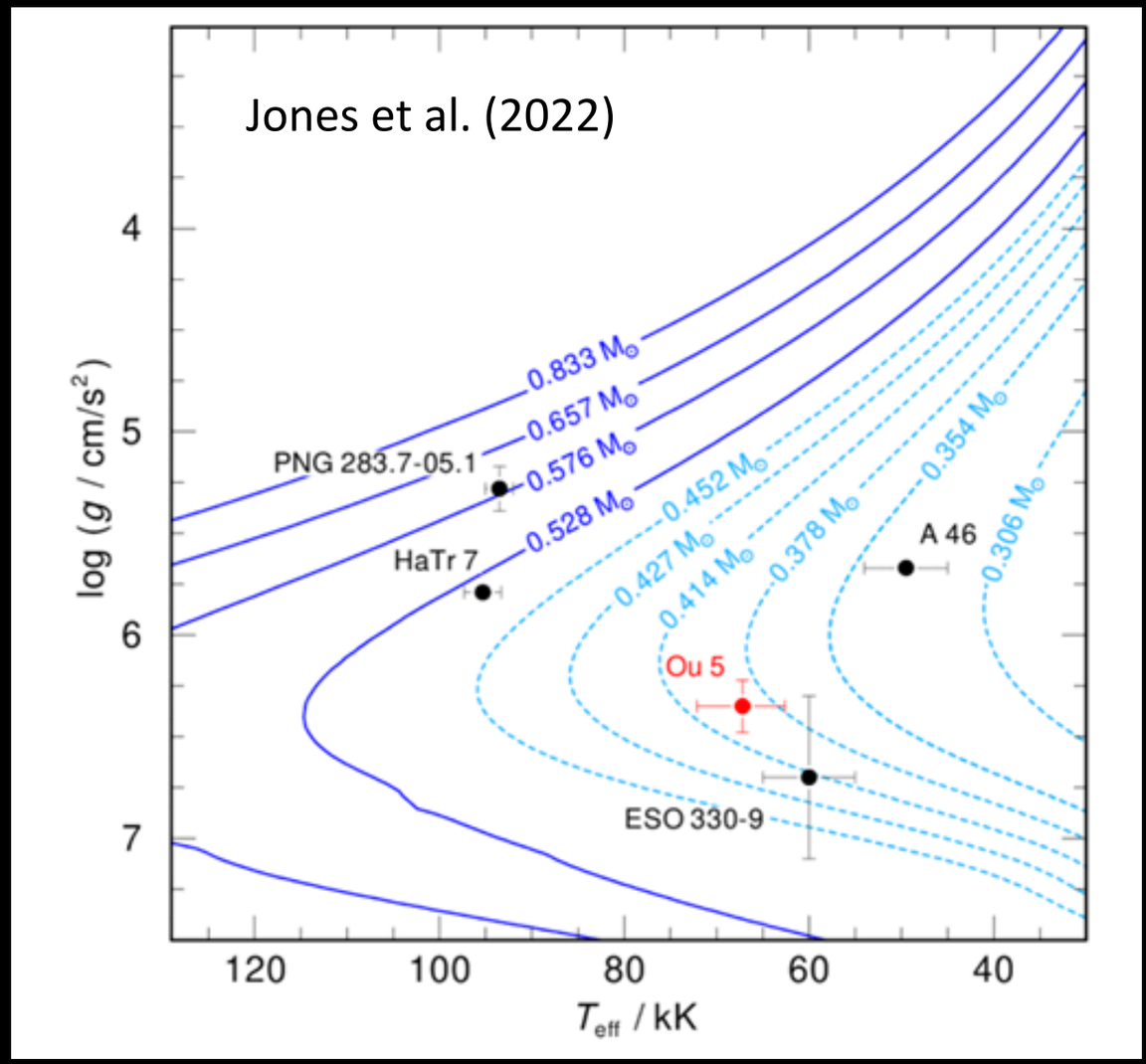


Abate et al. (2013, A&A, 552, 26)

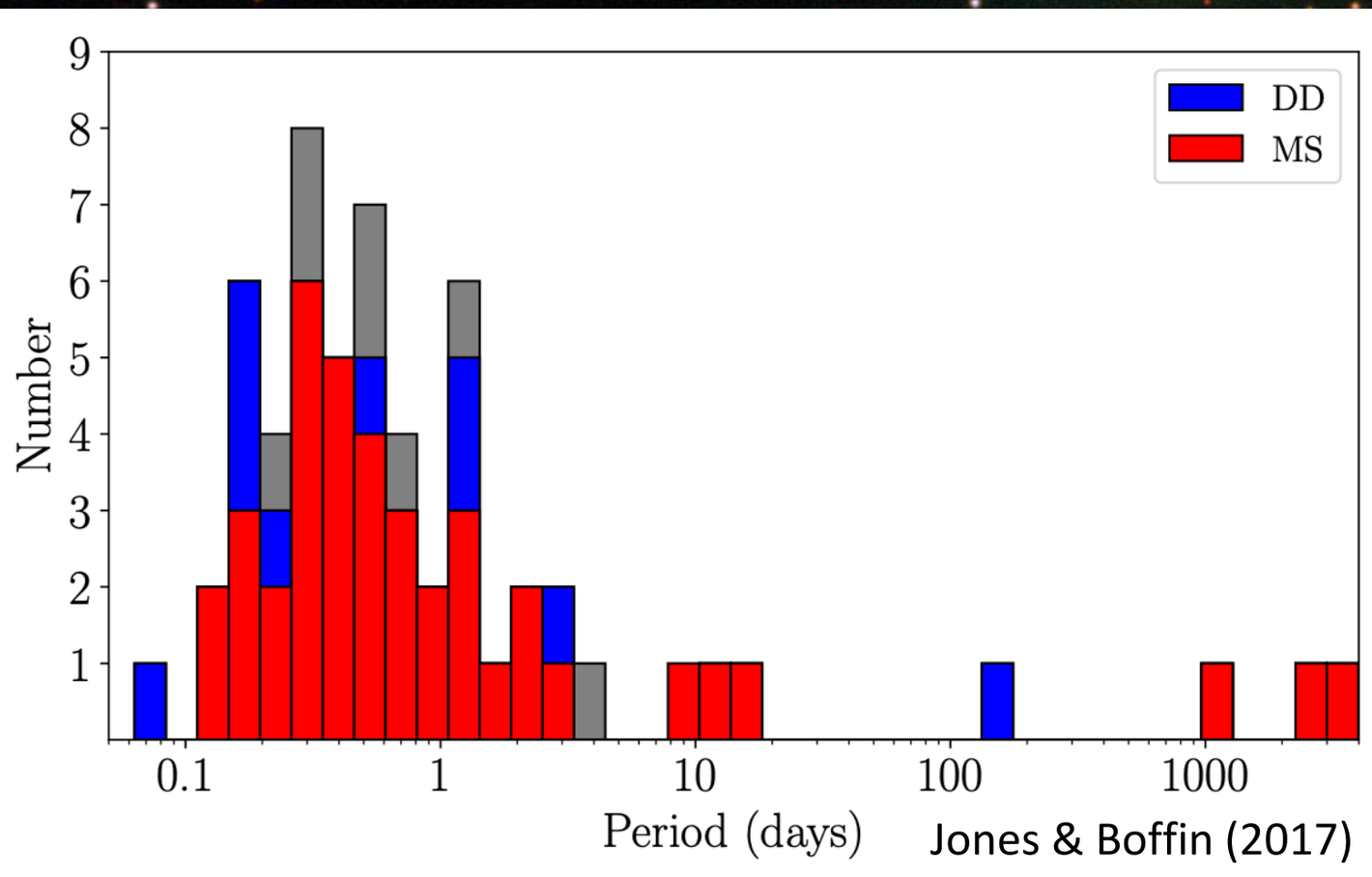
- Wind rather than star fills Roche lobe
- Accretion rate 100x Bondi-Hoyle-Lyttleton rate!

What else can they tell us?

- Common envelopes on the RGB can produce PNe (Hillwig et al. 2017, Jones et al. 2020, 2022)
- Only one early type secondary (Brown et al. 2019), all others are K/M-type (Boffin & Jones 2019).
  - CE needs extreme initial mass ratios otherwise mass transfer is stable? (Passy et al. 2012, Pavlovskii & Ivanova 2015)

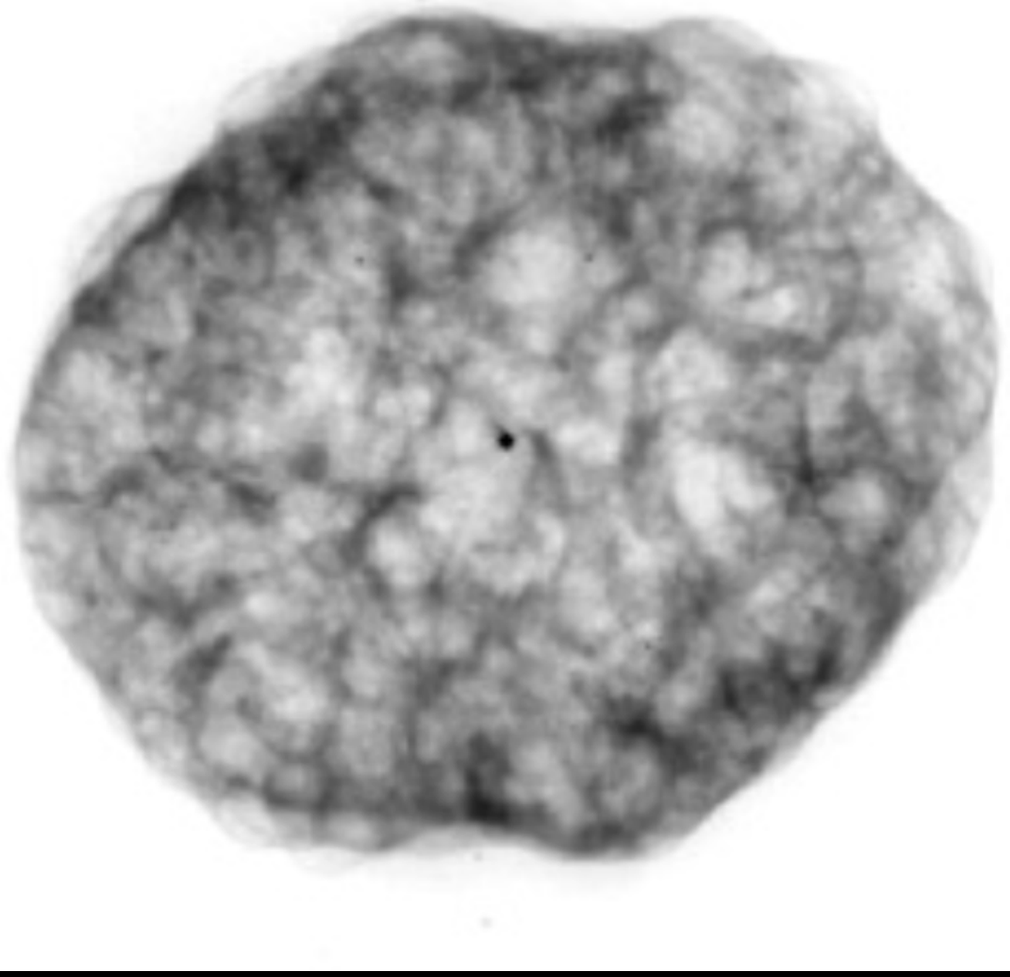


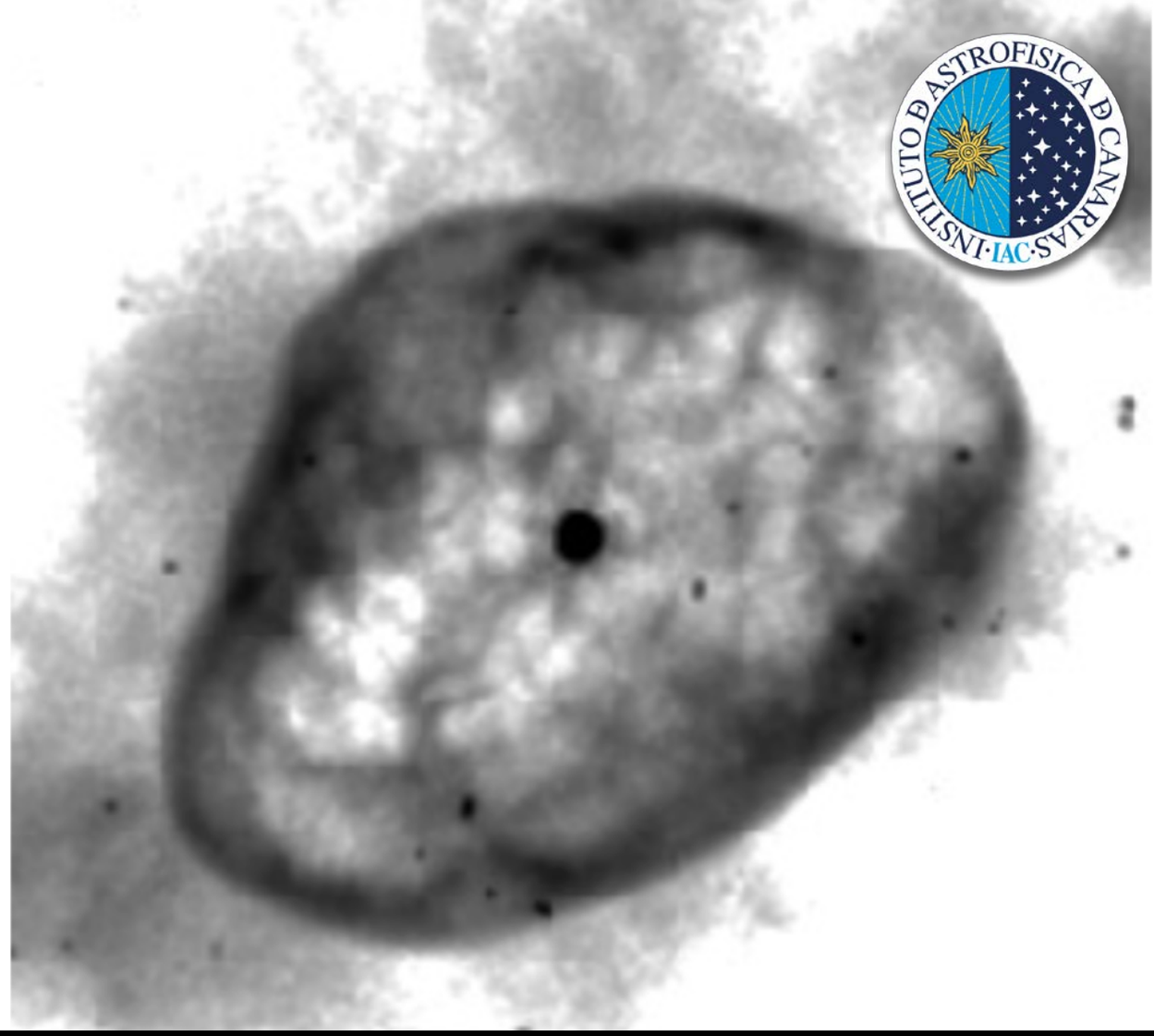
Double-degenerates should be rare!



Jones & Boffin (2017)

but they aren’t …





The importance of mergers?

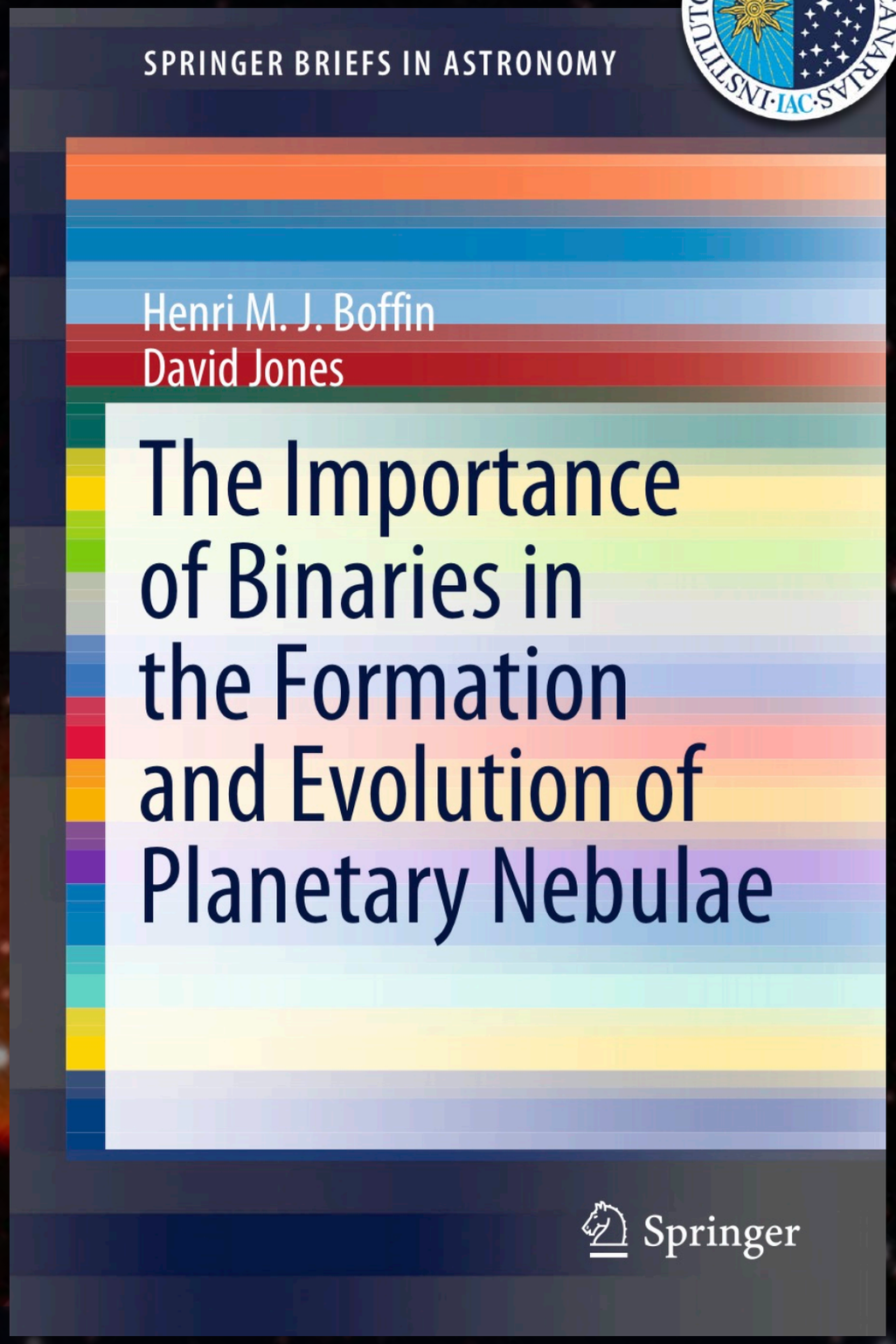
- High precision photometry can reveal rapid rotators (either via wind modulation or astroseismology) which are likely merger products.
- Already one good example (NGC6826, Handler et al. 2013)
- Extensive ground-based campaigns can do this too (Sowicka et al., in prep)

Are pre-PNe actually mergers?

- Pre-PNe are somewhat similar to luminous red novae (Kaminski et al. 2018)
- NO CONFIRMED POST-CE CENTRAL STARS
- Massive effort has been made searching for them, but they just don’t seem to be there (Hrivnak et al. 2011, 2017, 2020, 2021, 2024)
- Are pre-PNe principally the products of CE mergers?
- Do post-CE PNe evolve too quickly to be observed as pre-PNe?

Summary

- Binaries are responsible for shaping (some/most/all) PNe
- Strong evidence for pre-CE mass transfer
- Growing links with supernovae, novae, luminous red novae (mergers)
- Important for studying binary evolution (and a plethora of associated phenomena)



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