Understanding very close low-mass binaries

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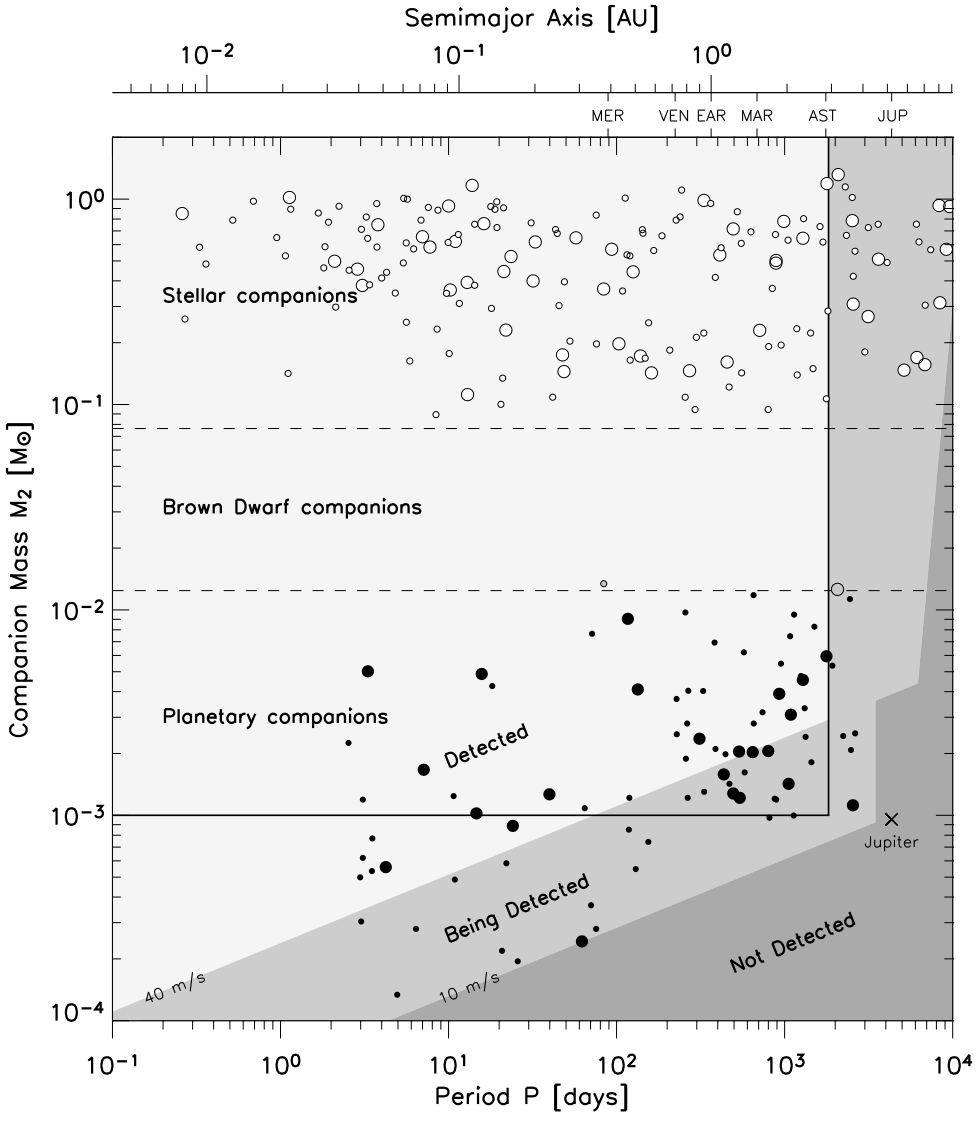
Companions around solar-type stars

→ Most stars are not born alone

fraction of

- close binaries ∼ 15%
  → interaction between components at least once in their lifetime:
  mass transfer
- brown dwarfs < 10 AU:
  < 1% **brown dwarf desert**
- hot Jupiters (< 0.5 AU):
  ∼ 1%

Winn & Fabrycky 2015



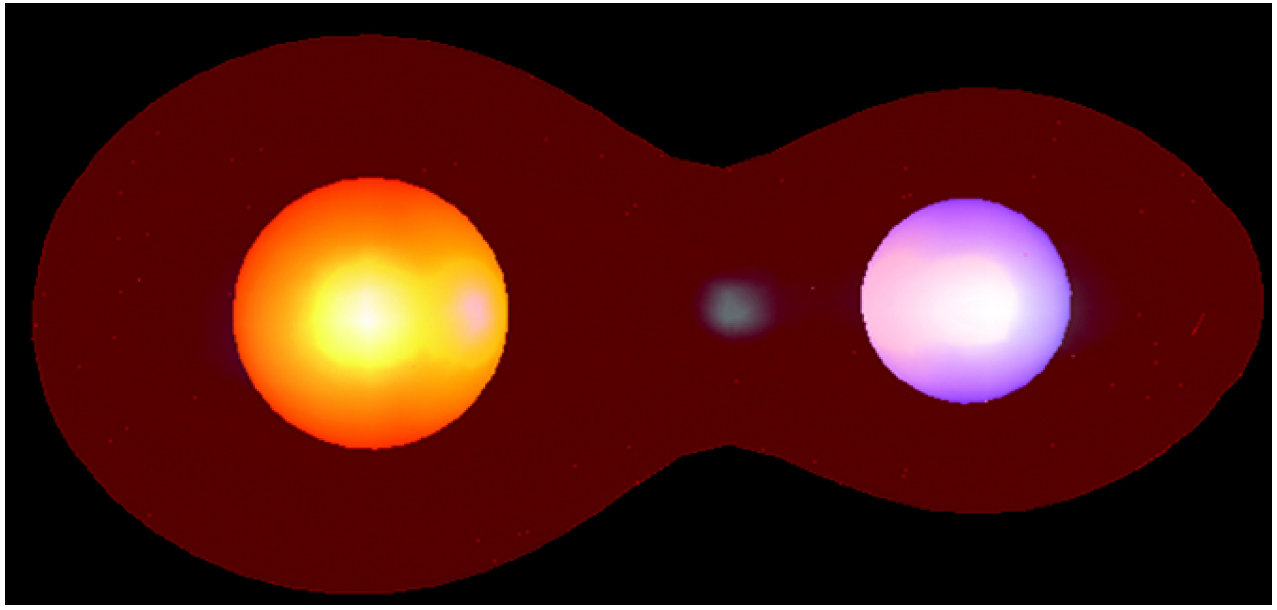
Grether & Lineweaver 2008

Common Envelope Evolution (CEE)

Ohlmann et al. 2016

Common Envelope Evolution (CEE)

→ important for the understanding of close binary evolution



https://astrobites.org/2013/02/12/are-we-seeing-common-envelopes-after-all/cee/

→ poorly understood

→ short-lived phase ($\sim$ 1000 d)

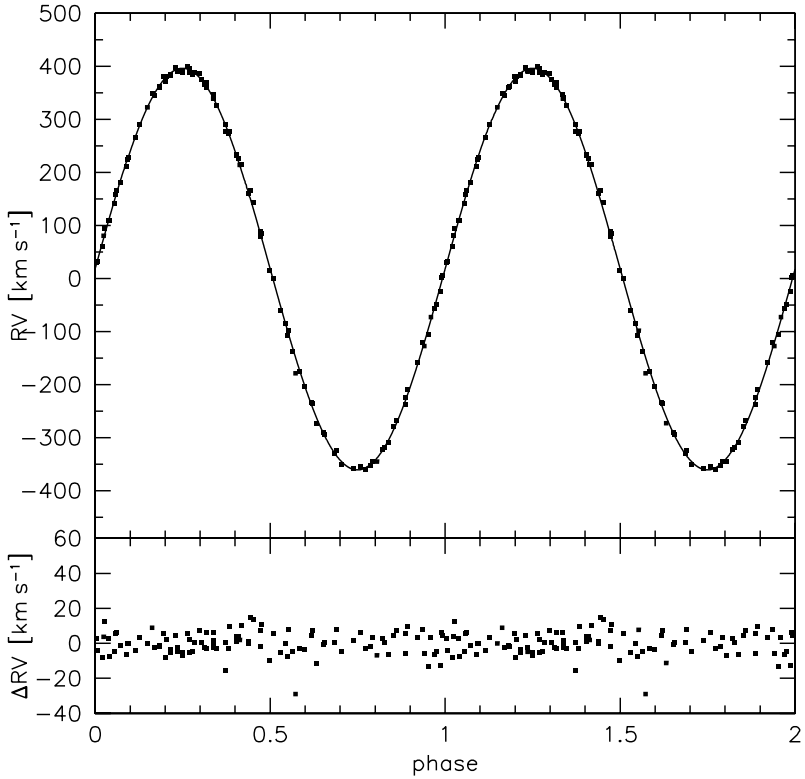
→ not possible to observe directly → post-CE systems

→ gravitational wave calibration sources

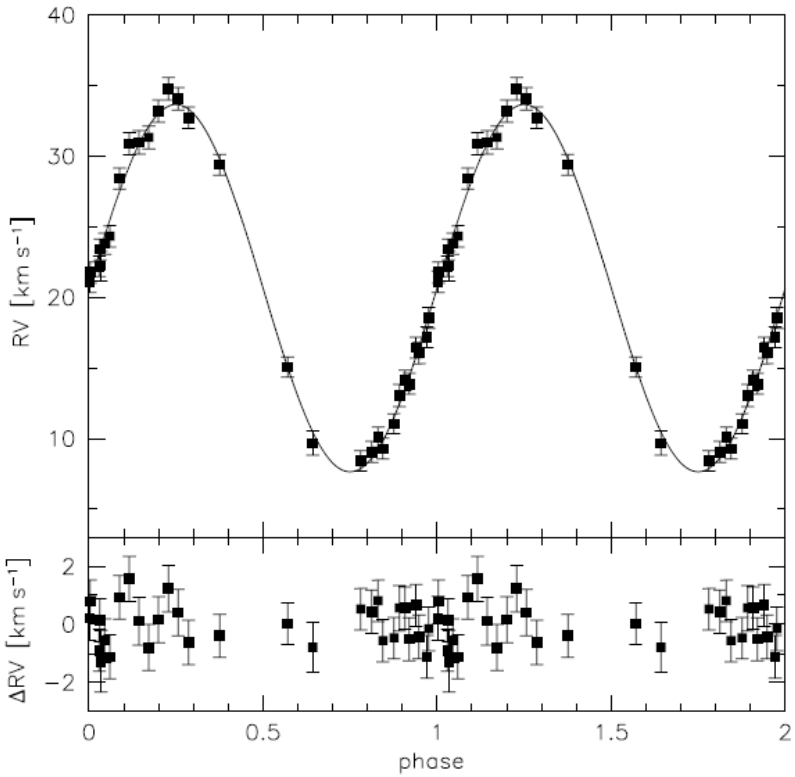
→ SN Ia progenitors

Hot subdwarfs in very close binaries

sdB ≡ stripped low-mass, helium burning core



CD-30°1122, $P = 0.0498$ d
(Geier,.., Schaffenroth et al. 2013)

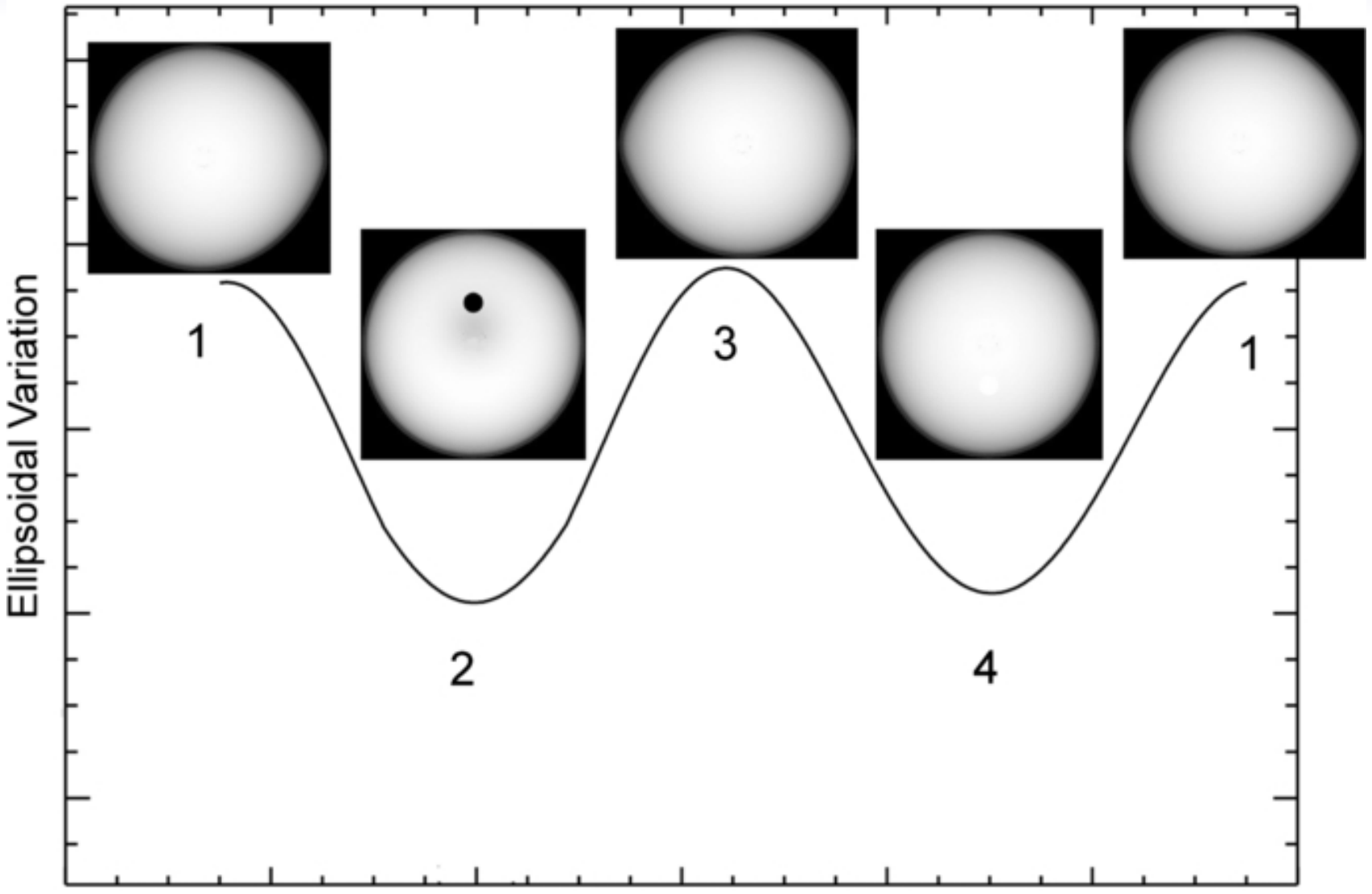


PHL 457, $P = 0.3131$ d
(Schaffenroth et al. 2014)

unseen companions discovered by radial velocity method
about 1/3 of all sdBs in close binaries ($P < 27$ d)

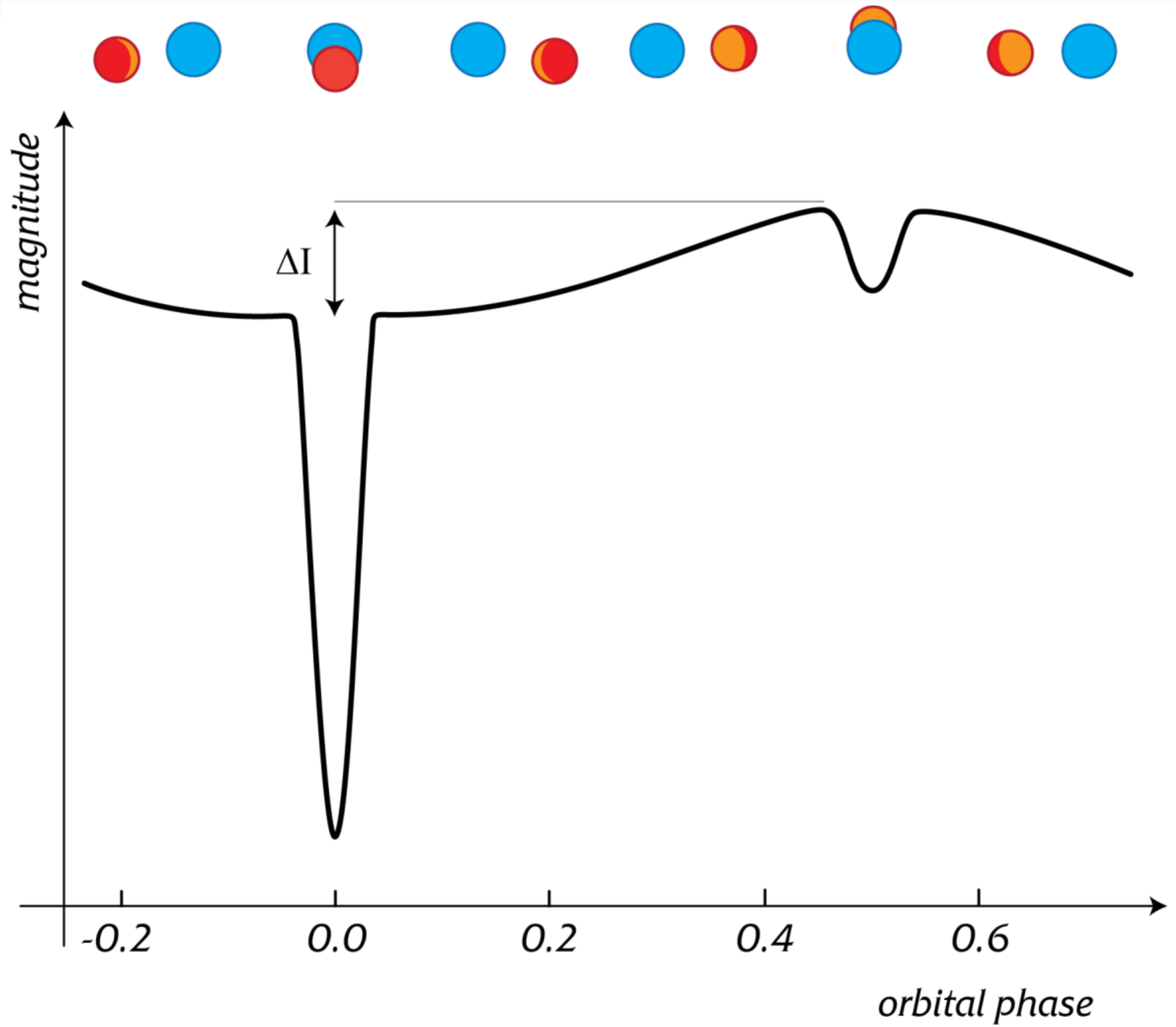
⇒ post-common envelope binaries: sdB + dM/BD or WD

Light variation of compact sdB binaries



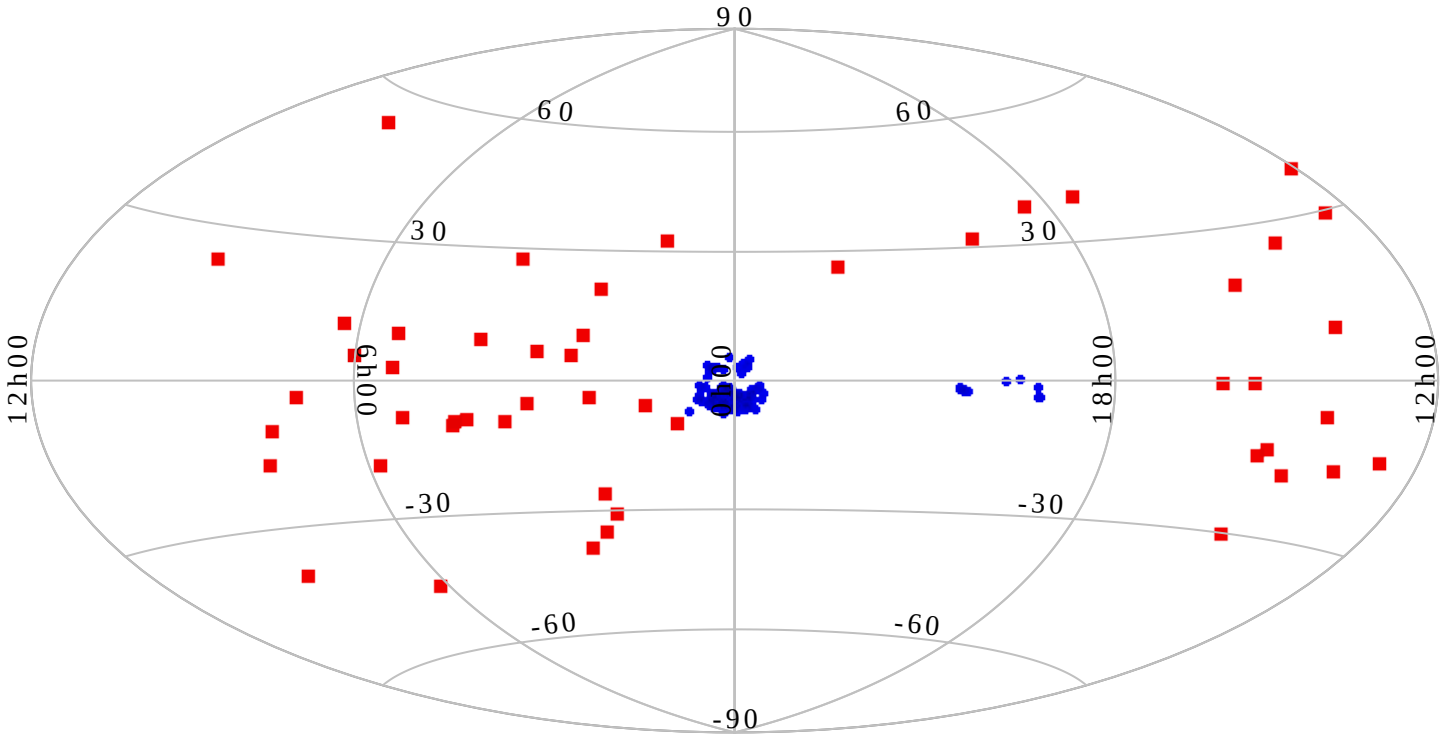
Ellipsoidal Variations (Jackson et al. 2012)

Eclipsing Reflection effect (HW Vir systems)



Finding new (eclipsing) close binaries

→ color selection or crossmatch of hot subluminous star catalogue with different photometric surveys to find close binaries with light variations



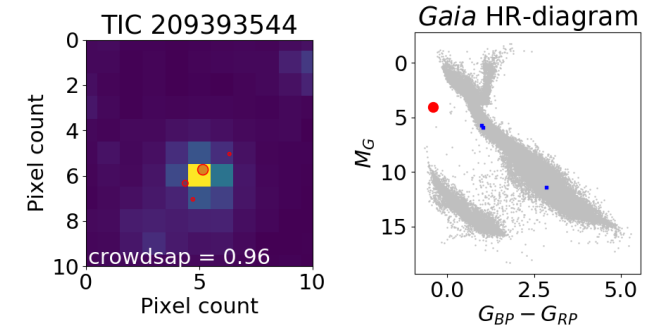
Schaffenroth et al. 2019

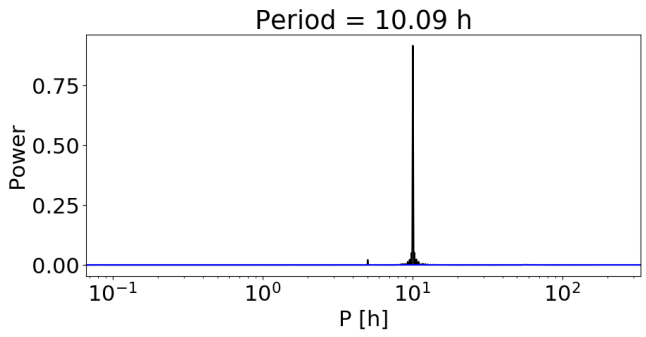
→ more than 150 new eclipsing post-common envelope systems: EREBOS project

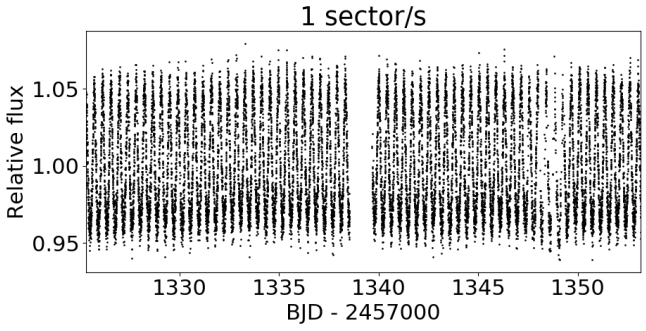
Searching for hot subdwarf binaries with light variations

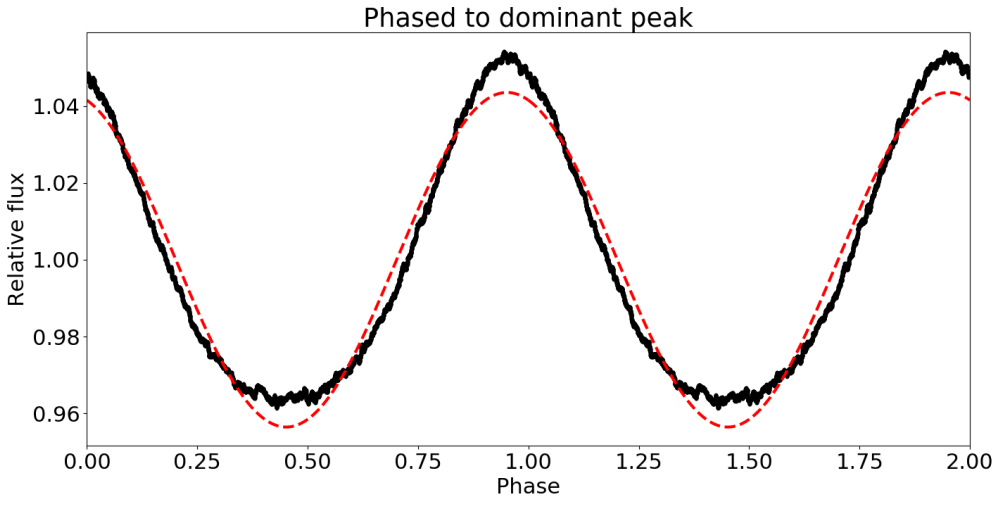
TESS Asteroseismic Science Consortium WG-8:

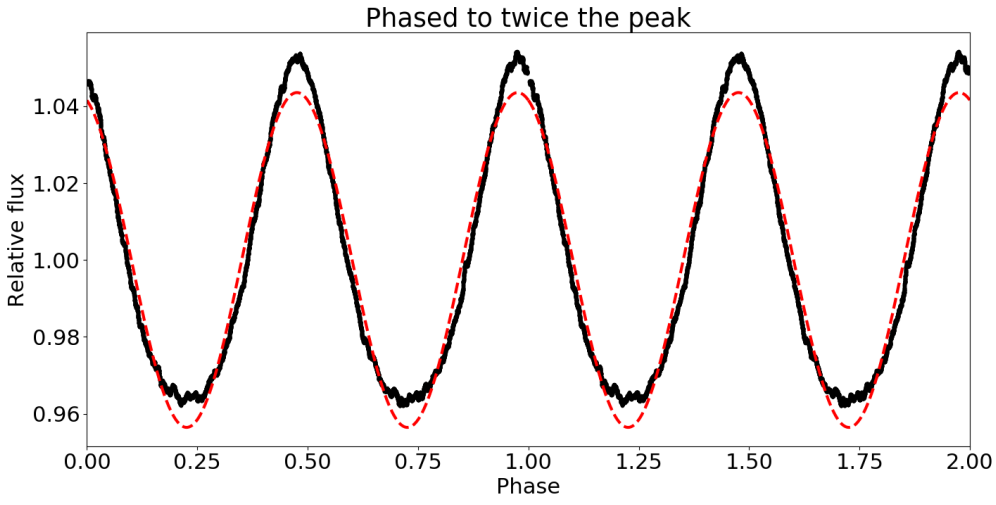
$\Rightarrow$ 3500 hot subdwarf candidates from Geier et al. 2019 observed



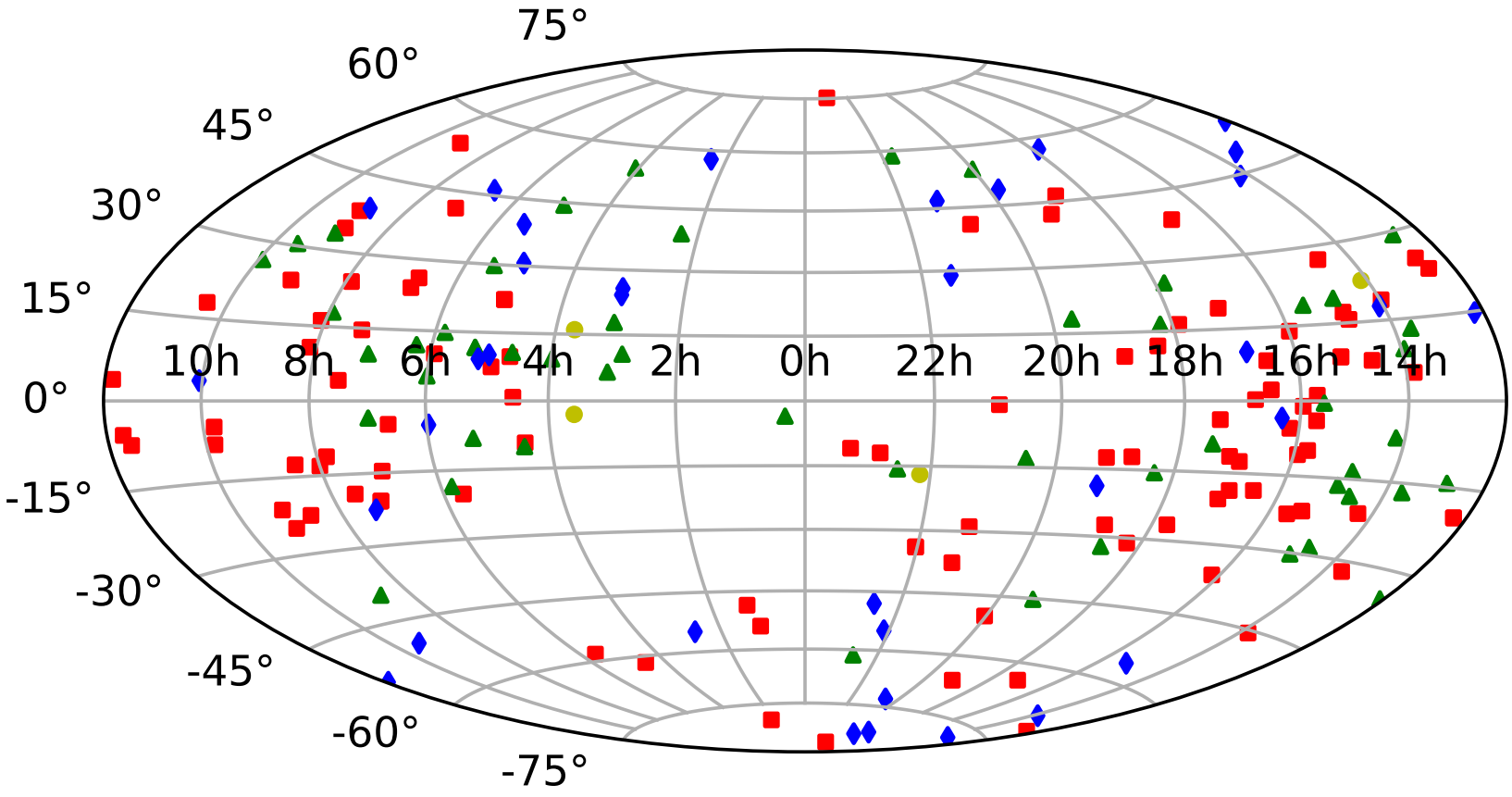








Targets observed by *TESS*



Schaffenroth et al. 2022

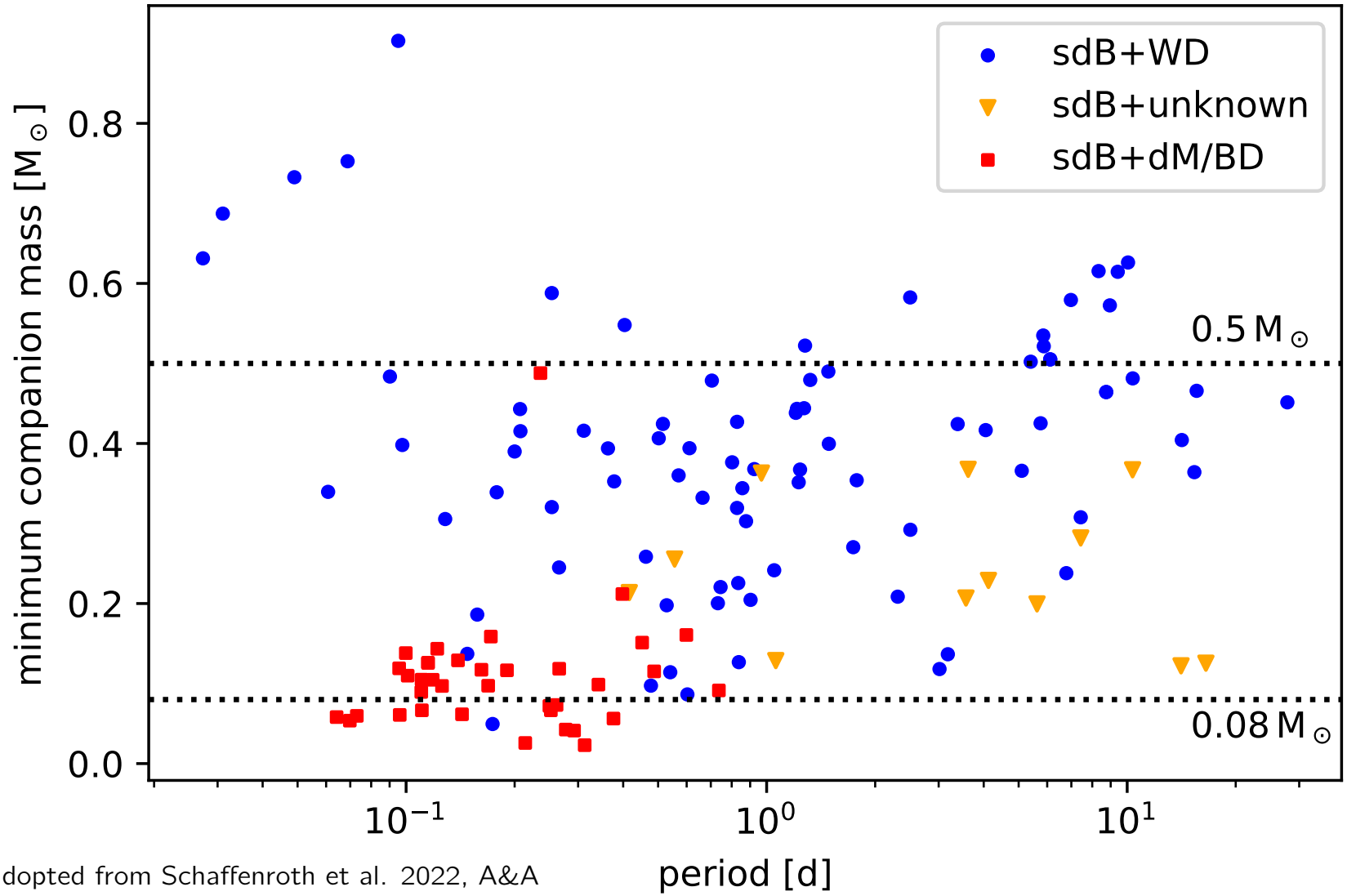
→ 85% of known sdB binaries observed: classifying the nature of the companion of almost all sdB binaries

→ about 100 new sdB binaries with light variations

P-min. comp. mass diagram of the close sdB binaries

nature of companion of 120 of 160 known, close sdB binaries

derived: 2/3 sdB+WD, 1/3 sdB+dM/BD

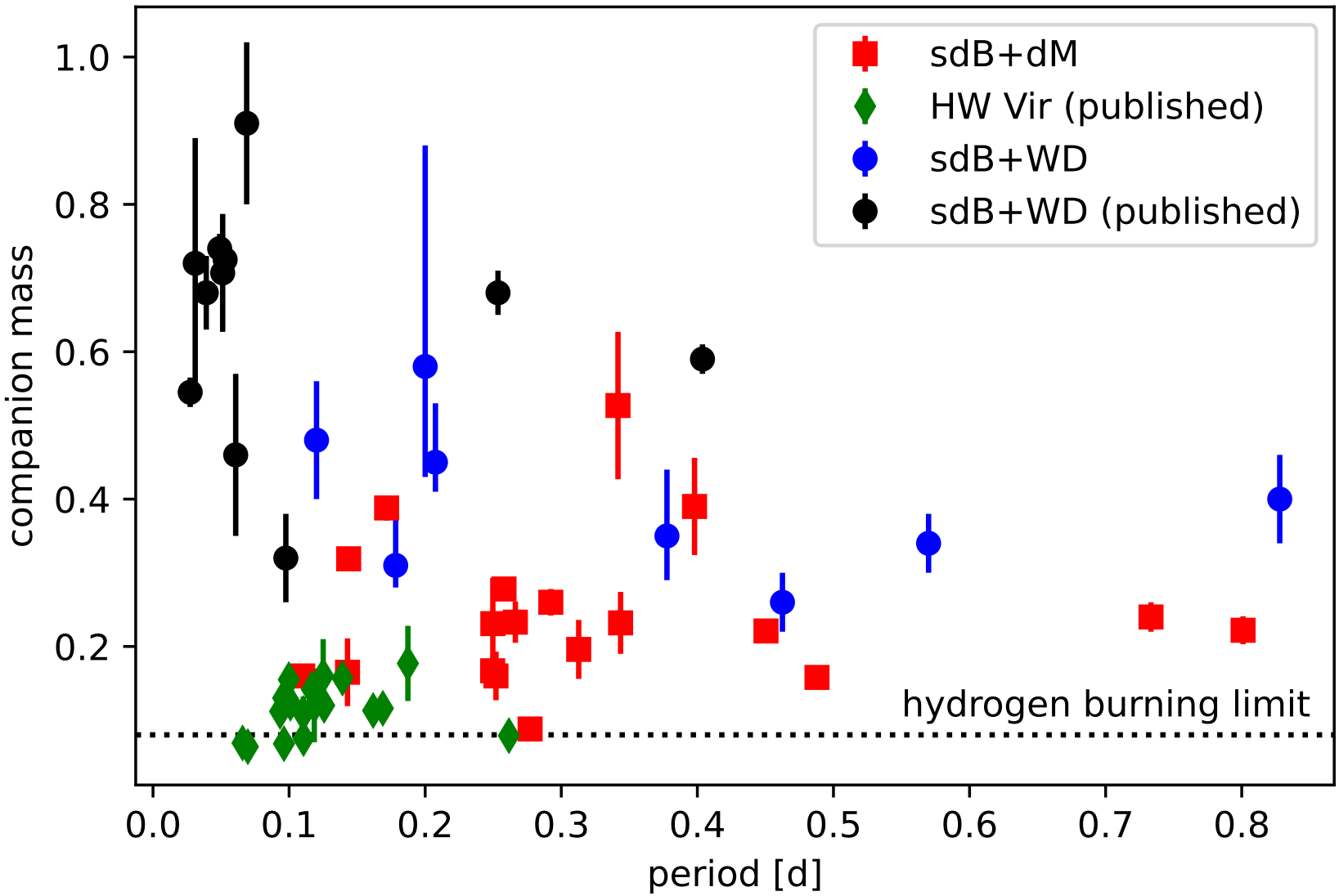


adopted from Schaffenroth et al. 2022, A&A

→ minimum mass by assuming an inclination of 90°

P-companion mass diagram of the close sdB binaries

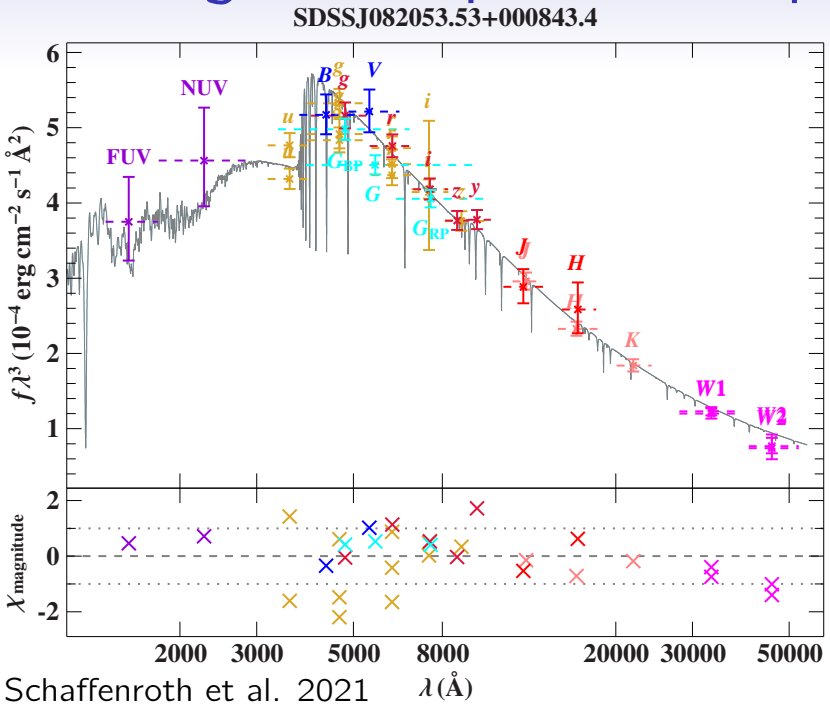
Light curve and spectroscopic analysis of compact sdB binaries



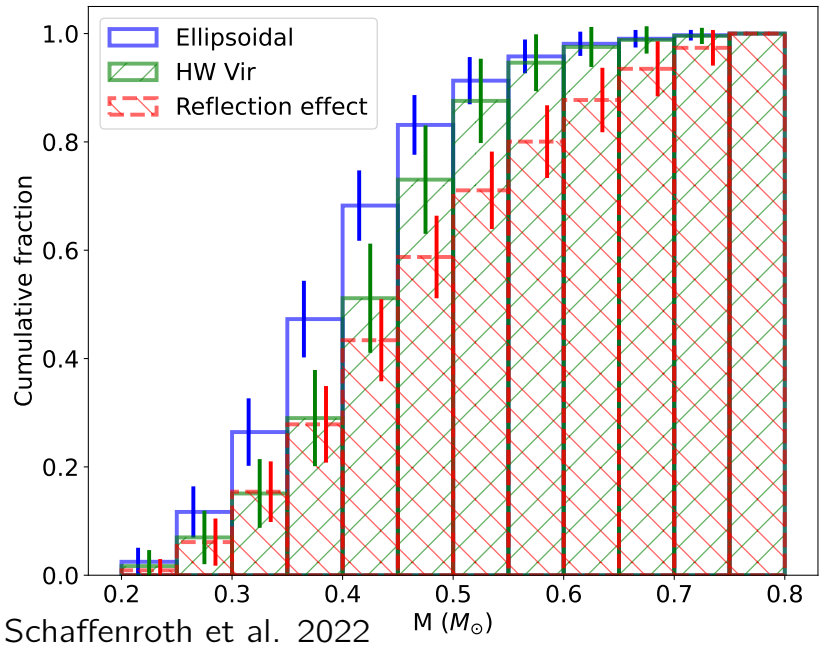
Schaffenroth et al. 2023, A&A, accepted

→ first step for statistically significant sample

Advantages of spectroscopic and photometric UV data



Schaffenroth et al. 2021

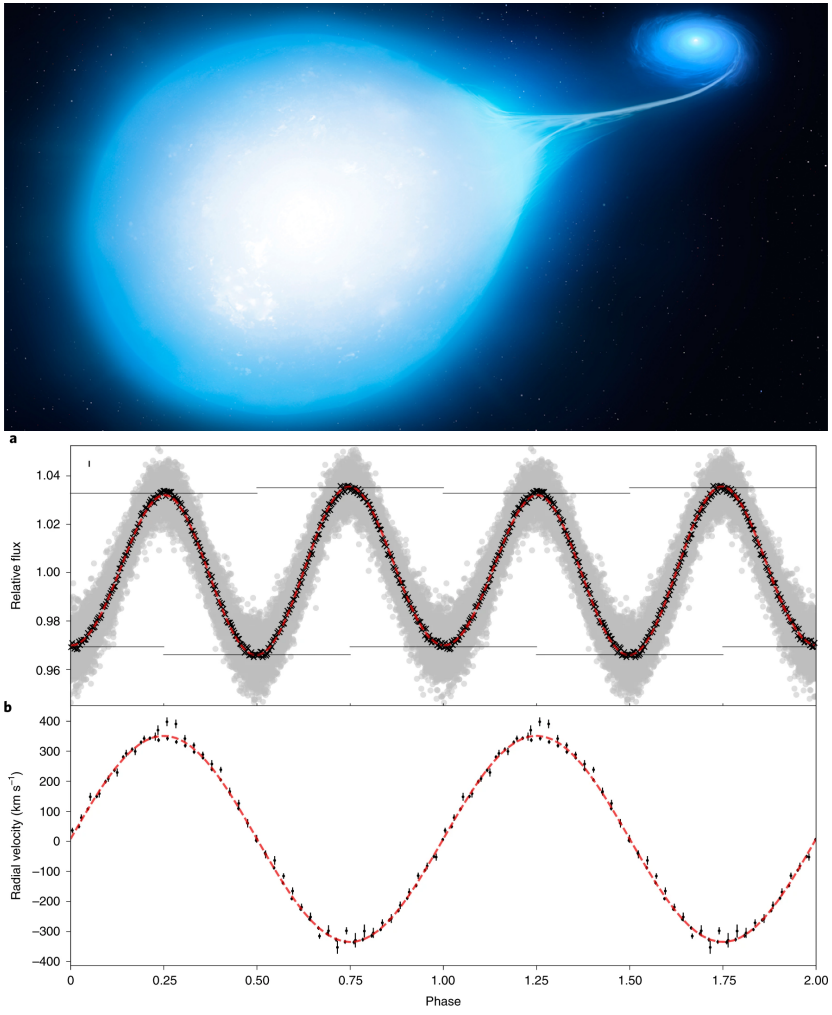


Schaffenroth et al. 2022

Spectral energy distribution

- disentangling temperature and reddening
- combination with spectroscopy and *Gaia* parallax:
  mass determination
  $M = gR^2/g$

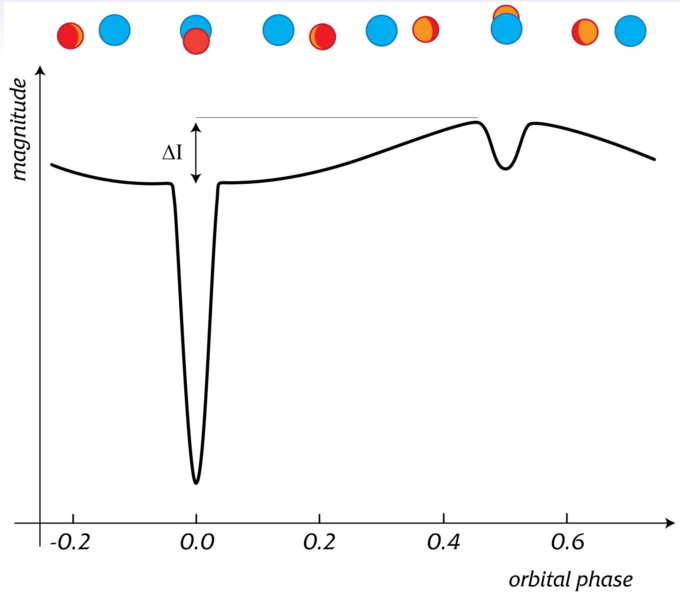
Advantages of spectroscopic and photometric UV data

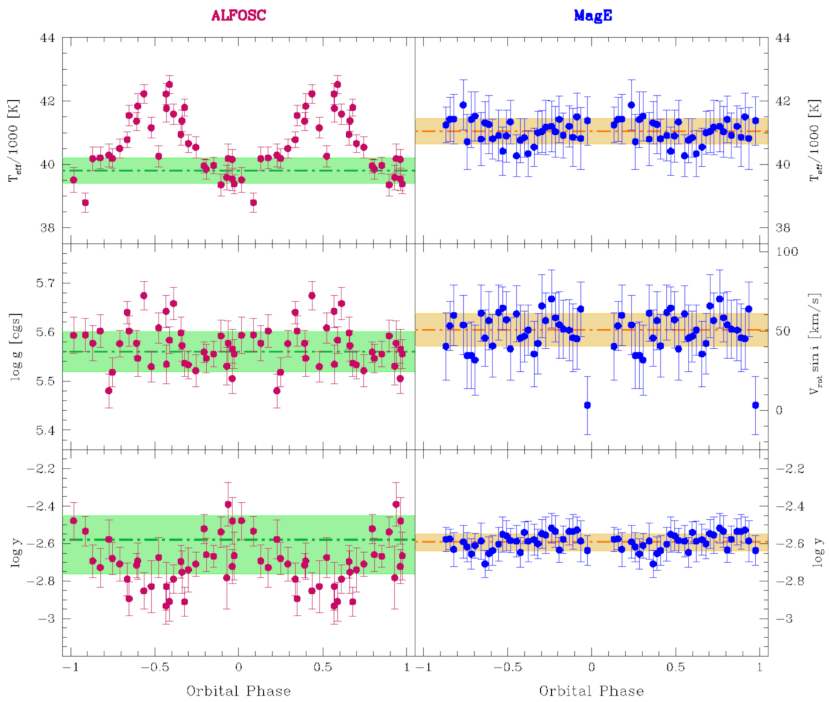


Pelisoli, ..., Schaffenroth et al. 2021

- Supernova Ia progenitors consisting of hot subdwarfs and massive WD companions are young
- found in direction of the disk
- easier to find in UV, less crowded

Advantages of spectroscopic and photometric UV data

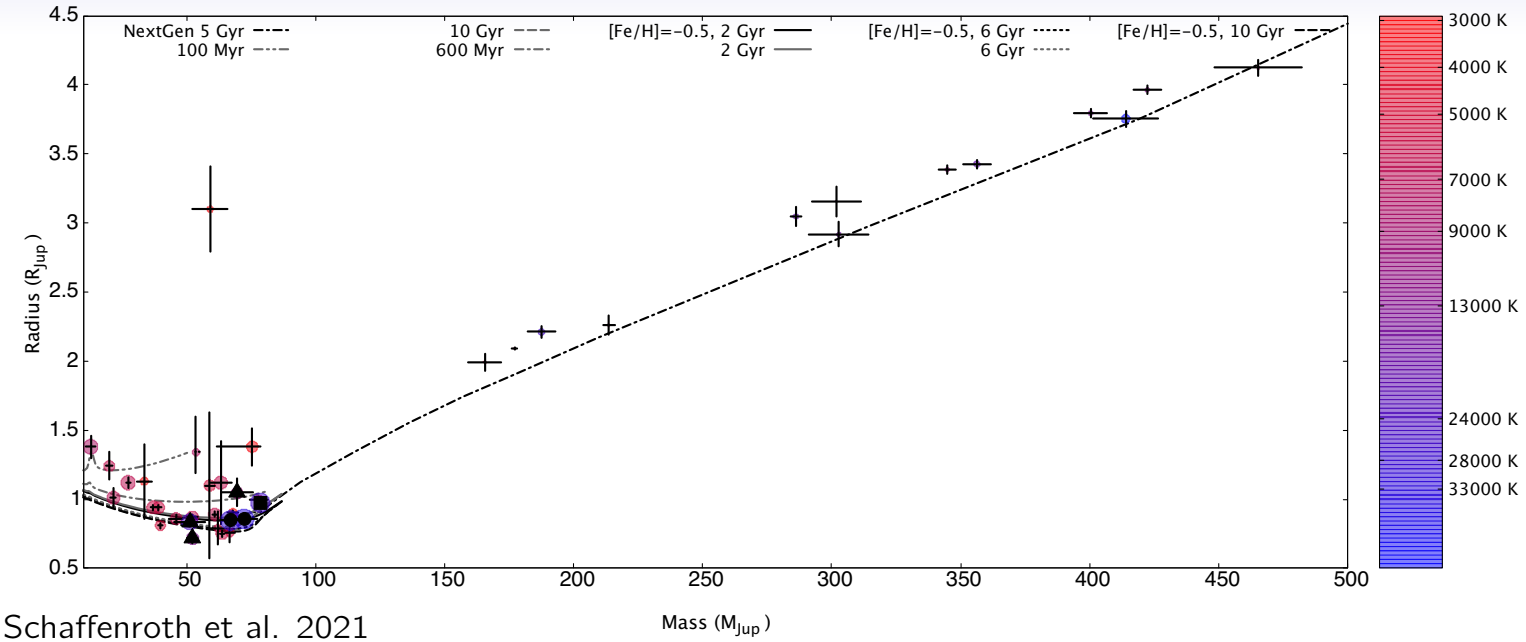




Silvotti, Schaffenroth et al. 2021

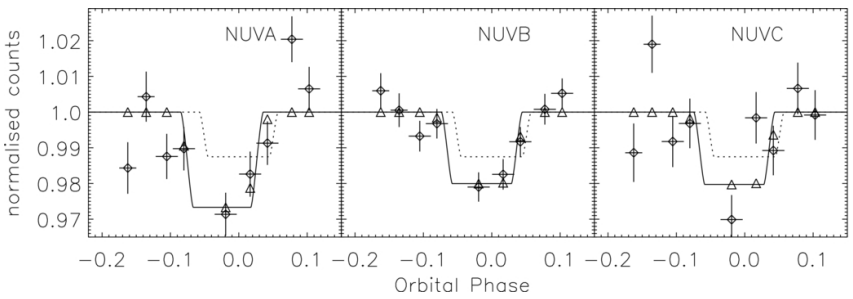
- influence of irradiated hemisphere to the spectrum much less in the UV
- better parameter determination
- finding also systems in the disk
- UV spectroscopy essential for parameter determination in the hottest primaries (sdO, WD)
- no UV light curves available so far

Advantages of spectroscopic and photometric UV data



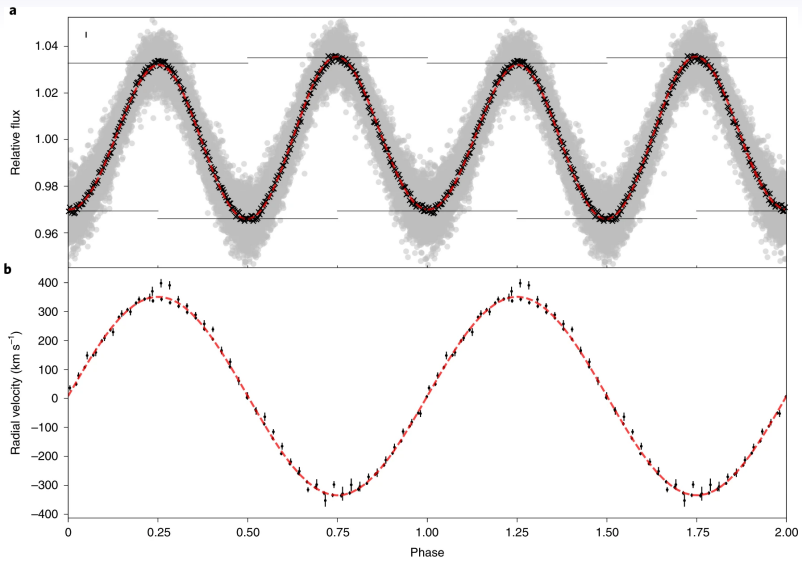
Schaffenroth et al. 2021

Inflation observed in sdB/WD with dM or BD companions

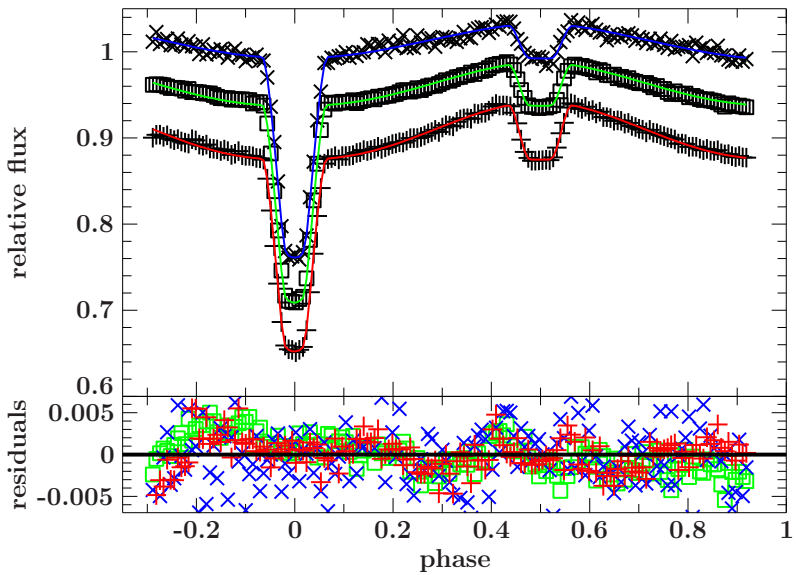


Haswell & Fossati 2012

- due to strong UV radiation?
- evaporation, as observed in close-in planets?
- extended atmosphere seen in the UV



Pelisoli et al. 2021



Schaffenroth et al. 2020

Questions?

Eclipsing Reflection Effect Binaries from Optical surveys