Estimating the binary fraction of planetary nebula central stars

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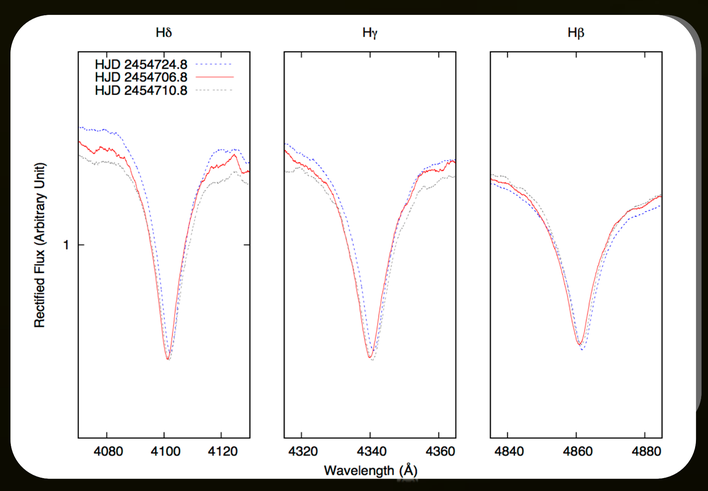
- We want to estimate the binary fraction of central stars of PN to determine whether PN are primarily a binary interaction phenomenon.
- ~80% of observed PN are non-spherical. They are mostly elliptical or bipolar, often with substructures and jets. These shapes cannot be explained by currently-known single star processes. Indeed, a binary interaction is more likely to be responsible for such structures (De Marco 2009).
- Estimating the binary fraction of central stars of PN would reveal if the formation of PN is mostly a binary phenomenon, in case this fraction is higher than the one predicted considering single stellar evolution (~35% for binaries with any separation less than ~500 AU).

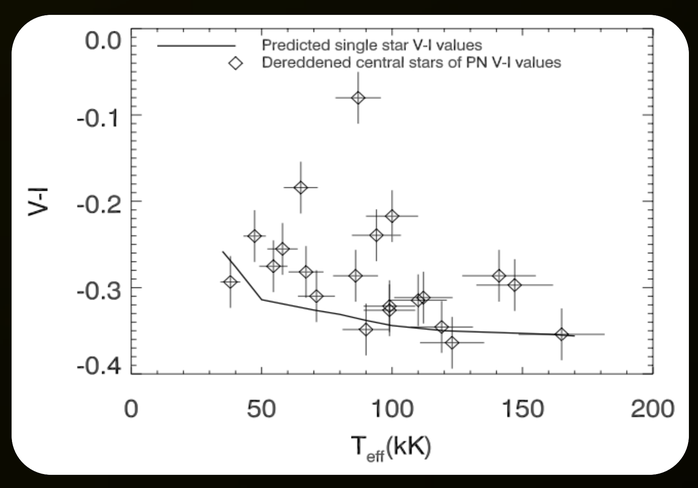
Methods of binary detection

★ Radial velocity variability ★



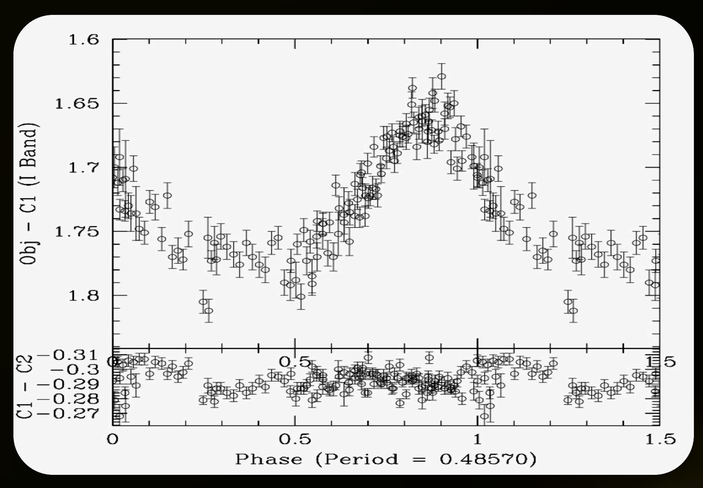
- Out of 7 stars observed 3 times with the VLT over several months, one is a clear radial velocity variable (Abell 14, see figure above).
- We can detect binaries with periods up to a month, if the wind variability was not an issue.
- Stars with radial velocity changes smaller than ~15 km/s cannot be detected with the current dataset.

★ Red and Infrared excess ★



- The technique relies on high precision optical and NIR photometry to detect the faintest possible companions. Detection limit is ~M8 for intrinsically faint (M_V= 6 - 8) central stars.
- Out of a sample of 25 CSPN we have detected 8 objects with an I-band excess; 4 at the 3σ level, plus another 4 tentative detections.
- This techniques is not biased with respect to binary separation.
- We aim to perform high precision optical and NIR photometry for the entire 2 kpc volume-limited sample of Frew (2008; see also Frew & Parker 2007).

★ Photometric variability ★



- This reliable method gives constantly new results. On the image, the lightcurve of Hen2-84, whose variability has been discovered recently by our team. The shape of the curve is consistent with an irradiated binary system with mid- to high- inclination (to be confirmed soon)
- Return a fraction of ~20% close binaries (Bond 2000, Miszalski et al. 2009,).
- Biased to periods <2 weeks.
- We are monitoring the 6 known PN in the Kepler field, including Kn61 (confirmed by us). The high incidence of periodic variability is surprising and extremely interesting. See posters #33 by D. Douchin and #78 M. Kronberger.

★ Astrometry ★

- This technique detects the reflex orbital motion of the primary using high precision astrometry.
- GAIA will potentially be used for this purpose.

Conclusions

Estimating the binary fraction requires :

- The least biased source of targets ➔ Volume-limited sample from Frew (2008).
- A wealth of complementary methods ➔ Infrared Excess, flux variability, RV variability, etc.
- Large amounts of high precision data ➔ Much is already in hand.

- We have determined a preliminary binary fraction in central stars of PN in the range 30-60% (separations less than ~500 AU).
- This uncertainty will be drastically decreased by our forthcoming datasets.
- This fraction can be compared with the 35% binary fraction (with separation less ~500 AU) expected in the single star scenario. It seems that binary interaction has a huge impact on PN formation.

References:

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