Towards finding the missing intermediate period binaries in planetary nebulae

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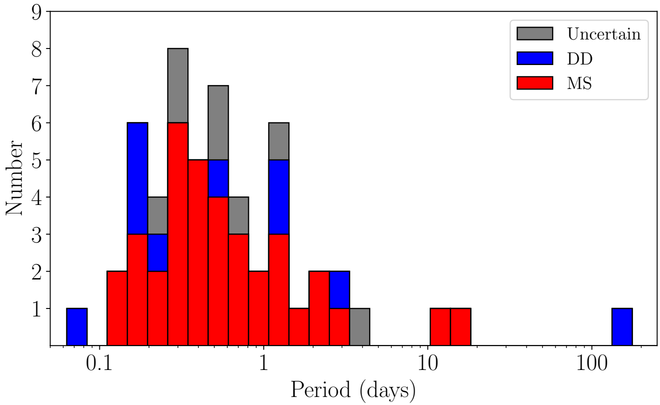
based on Sowicka et al. 2017, MNRAS accepted

THE IMPACT OF BINARIES ON STELLAR EVOLUTION

ESO GARCHING, JULY 3-7, 2017

Key points

- $\sim$80% PNe are non-spherical → Binaries
- Only 20% have detectable close binary stars
- Almost all P $\leqslant$ 1 day, but CE models predict many with P $\geqslant$ 1 day

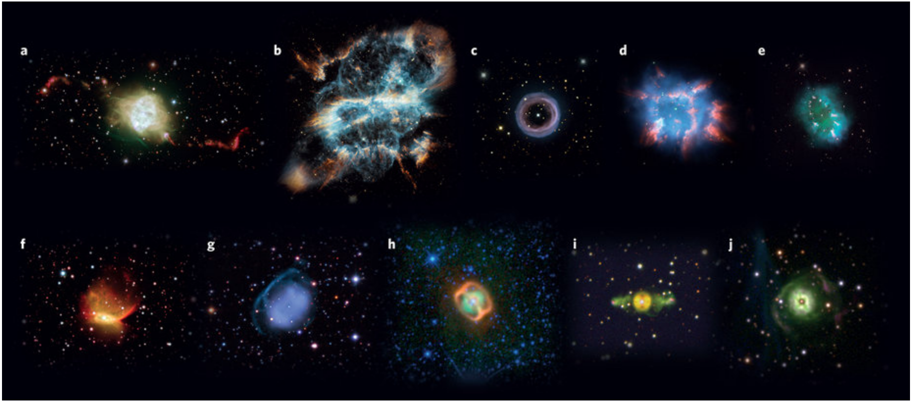


Jones & Boffin (2017)

Key questions

- DO THEY EXIST? HOW TO FIND THEM?
- By targeted radial velocity monitoring (Boffin et al. 2012; Van Winckel et al. 2014; Manick et al. 2015; Miszalski et al. 2017; Jones et al. 2017)

A Zoo of morphologies



Jones & Boffin (2017)

Pre-selection based on morphology

Basic data :

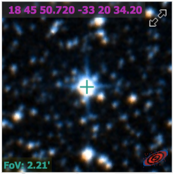
IC 4776 -- Planetary Nebula

Other object types:	**PN** (Ref,Hen,...), ***** (CD,GCRV,...), **Rad** (NVSS,PMN,...), **G** (ESO), **cm** (AT20G), **IR** (IRAS)
ICRS coord. *(ep=J2000) :*	**18 45 50.72 -33 20 34.2 (Optical) [ ] C 2014yCat....1.2023S**
FK5 coord. *(ep=J2000 eq=2000) :*	18 45 50.72 -33 20 34.2 [ ]
FK4 coord. *(ep=B1950 eq=1950) :*	18 42 33.74 -33 23 46.3 [ ]
Gal coord. *(ep=J2000) :*	002.1002 -13.4437 [ ]
Radial velocity / Redshift / cz :	**V(km/s) 18.9 [0.9]** / z(~) 0.000063 [0.000003] / cz 18.90 [0.90] **A 1953GCRV..C......0W**
Spectral type:	**[WC]pec D 1985PASP...97.1142A**
Angular size *(arcmin)*:	**0.117 0.117 90 (Rad) D 2008ApJ...689..194S**
Fluxes (2) :	**B 10.6 [~] D ~** **V 9.7 [~] E ~**

notes:

SIMBAD query around with radius 2 arcmin

Interactive AladinLite view

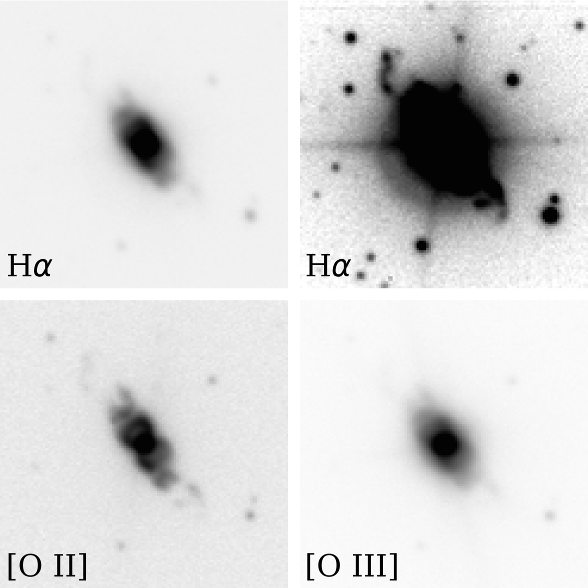


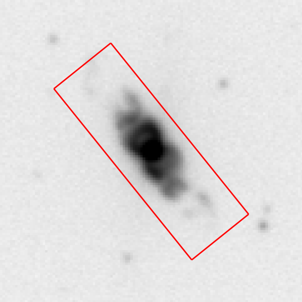
2MASS DSS SDSS

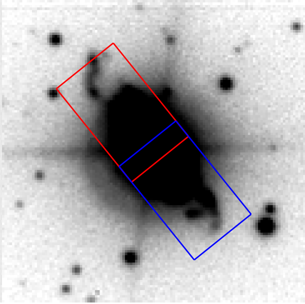
VizieR photometry viewer

Search within radius Max 30 arcsec

IC 4776 imagery







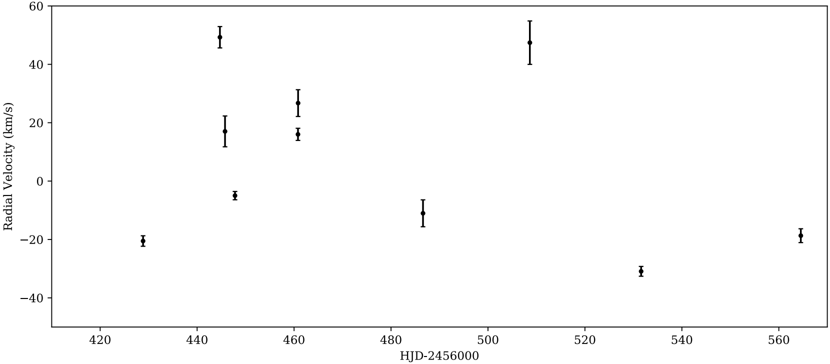
Central star of IC 4776

- Spectral type unclear, but often classified as [WC] (e.g. Aller & Keyes 1985)
- → some other long period binaries also Wolf-Rayet
- *wels*?

Central star of IC 4776

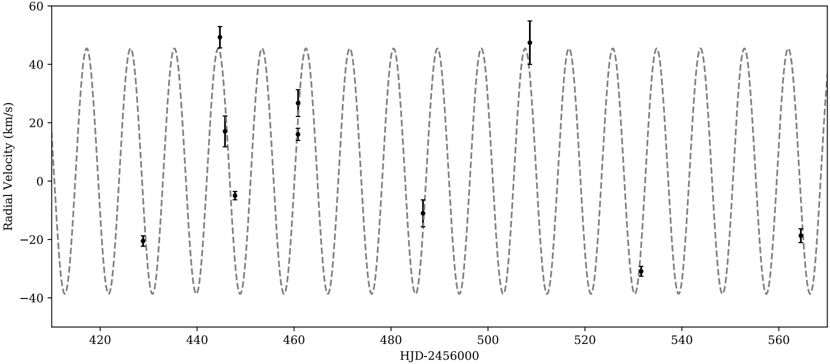
- Observed 10 times using FORS2@VLT-UT1
- Standard reduction technique
- He II λ4541 in absorption used for cross-correlation

Radial velocities



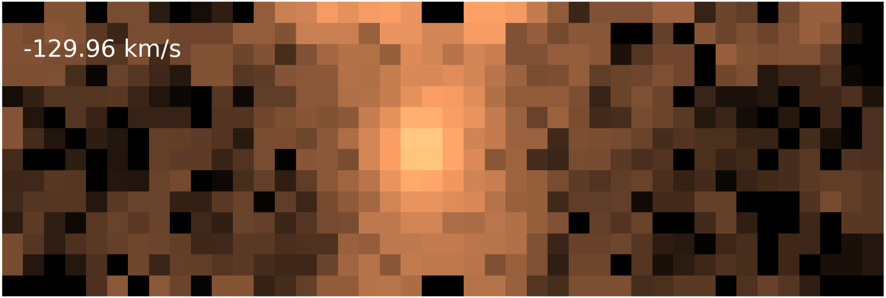
Radial velocity variations, K $\sim$ 30–40 km s^{-1}

Radial velocities



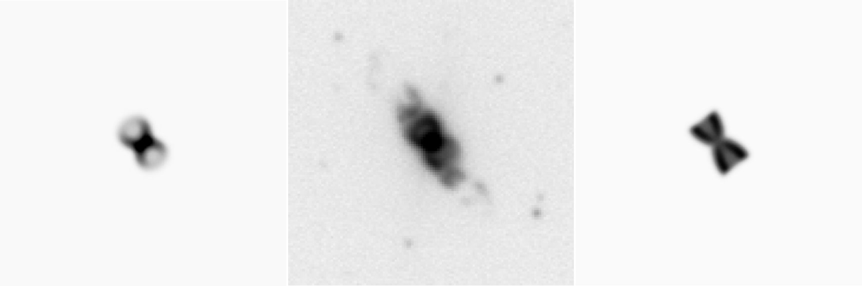
P = 9 days

FLAMES-GIRAFFE integral field spectroscopy



SHAPE modelling

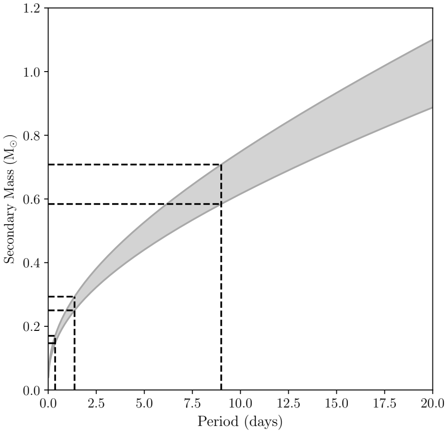
- Hourglass-like structure, inclined at $42^{\circ} \pm 4^{\circ}$
- Age of the nebula of about $\sim$ 1500 years



Each image measures $0.5' \times 0.5'$

Possible secondary masses

- Assumptions:
  inclination i = 42$^{\circ} \pm$ 4°,
  amplitude $K_1 \sim$ 40 km s^{-1},
  period P = 9 days
  primary mass M_1 = 0.6 M$_{\odot}$
- Possible secondary masses 0.1 - 0.7 M$_{\odot}$



Possible trends?

- Abundance analysis indicates IC 4776 has a very low adf
- Only other low-adf binary PN also has a “relatively” long period ($\sim$4 days) and a [WR] central star
- Connection between low-adfs and [WR]? Between low-adfs and long periods? Between long periods and [WR]?
- Two more [WR] binaries known, no measured adf but both have quite long periods (1.2 d and 142 d)

Take away points

- Missing population of intermediate period post-CE CSPN?
- Definitely a problem for models, but uncertain how much of a problem due to observational bias
- Long-term RV monitoring can help to constrain this by finding these illusive systems (even to very long periods, e.g. 142 d NGC 1360, Miszalski et al. 2017)
- Possible connections between [WR], nebular chemistry and long periods?
- FURTHER STUDIES NEEDED!

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