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What the Awkward Relatives Tell Us about Planetary Nebulae Hosting Binary Systems

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Abstract. Relatives to Planetary Nebulae, such as barium stars or symbiotic systems, can shed light on the connection between Planetary Nebulae and binarity. Because of the observational selection effects against direct spectroscopic detection of binary PNe cores with orbital periods longer than a few dozen days, at present these "awkward relatives" are a critical source of our knowledge about the binary PNe population at longer periods. Below a few examples are discussed, posing constraints on the attempts to model nebula ejection process in a binary.

Keywords. stars: chemically peculiar, late-type, mass loss – binaries: general, symbiotic

1. Role of a companion

Various symmetries and asymmetries seen in PNe can be ascribed to companion's influence (e.g. Soker 2003). Moreover, a high incidence of binaries discovered among central stars of PNe (CSPNe) is sometimes taken as a hint that a companion may be vital for the very formation of a PN (e.g. De Marco *et al.* 2004). But the influence is mutual – the process of PN formation causes evolution of binary parameters due to asymptotic giant branch (AGB) mass loss, mass transfer, tidal forces and in some cases a common envelope (CE) event. Present parameters of the binary "relatives" of CSPNe carry information about the past nebular ejection process.

Barium stars, extrinsic S stars, red symbiotics, and post-AGB binaries all cover roughly the same period range, P=10^2–10^4 d, with eccentric orbits present down to P$\sim$ 300 d. These characteristics cannot at present be reproduced theoretically. Numerical simulations of binary AGB evolution (e.g. Pols *et al.* 2003, Frankowski 2004) show that current theoretical models do not produce eccentric systems with periods below $\sim$ 2000–3000 d and that all systems below $\sim$1000 d should enter a CE and undergo a dramatic orbital shrinkage. Attempts have been made to describe mild CE evolution (Nelemans *et al.* 2000), but the jury is still out on this topic. In the meantime, an analysis of the individual systems may provide some hints for these considerations.

2. 56 Pegasi, d' symbiotics, WeBo 1 et consortes

56 Peg is a K0.5II barium star recently found to be a spectroscopic binary (Griffin 2006). It is prominent in having the lowest mass function and the second shortest orbital period (111 d) among Ba stars, together with X-ray activity and unusual spectral line variability. Frankowski & Jorissen (2006) show that the 56 Peg system is very difficult to understand from the stellar evolution standpoint – unless one assumes a very low inclination of 5-8° and the giant's rotation faster than the orbital motion (30–50 km s^{-1}). This hypothesis not only allows to solve the evolutionary issue but also offers a natural explanation of object's activity as being of chromospheric origin. The proposed solution for 56 Peg requires efficient spin accretion during the mass loss/transfer phase preceding

the formation of the present WD. The additional requirement that the accretion event happened rather recently (otherwise the giant would have been spun down) is consistent with the high temperature of the WD (32000 K). The short orbital period calls for an explanation why no drastic orbital shrinkage occurred in a system that apparently should have immersed into a CE in the past. A classical CE would probably also inhibit efficient angular momentum transfer, which is usually associated with wind accretion in wide systems (WIRR: Wind Induced Rapid Rotation, Jeffries & Stevens 1996).

D' symbiotics (Allen 1982) are a small (7 objects) subtype of yellow symbiotics. The cool component is typically a G-type giant, yet there is strong cool-dust IR emission and other evidence for circumstellar matter. D' symbiotics are notable for their high spin rates, with $v \sin i$ up to 100 km s^{-1}. They are disk population objects with Ba overabundance. The orbital period is known for one system (V417 Cen, P=247 d). Jorissen (2003) concludes that they are systems in which the hot component has just evolved off the AGB and explains the cool dust as a remainder of the AGB mass loss. These characteristics make d' symbiotics very similar to 56 Peg. Inferences for the nebular ejection phase are again: efficient angular momentum transfer and some way to escape a classical CE.

Another related case is WeBo 1, a genuine (ring-like) PN hosting a chromospherically active K0 barium giant (Bond *et al.* 2003). The giant exhibits photometric variability with a period of 4.7 d, interpreted as due to rotation. Estimated $v \sin i$ is 90 km s^{-1}. WeBo 1 is closely related to a group of "Abell 35" PNe, consisting of low surface brightness nebulae Abell 35, LoTr 1, and LoTr 5 that possess binary cores containing a hot WD and a fast rotating late-type giant or subgiant (Bond *et al.* 1993). Mild Ba enhancement has been found in Abell 35 and LoTr 5 (Thevenin & Jasniewicz 1997). But as the orbital periods are unknown in any of these cases, it is very well possible that these CSPNe have much longer orbital periods and resemble the barium star HD 165141 (fast rotation, but P=5200d) rather than d' symbiotics and 56 Peg. In this case they would fit nicely in the WIRR scenario.

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