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The growth of the outflows from evolved stars: A live poster

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Abstract. We present our long-term monitoring, using both ground-based telescopes and the HST, of the expansion in the plane of the sky of the outflows from evolved stars. They include the PN M2–9 (suspected of hosting a symbiotic nucleus), the classical nova remnant GK Per, the symbiotic Miras R Aqr, Hen 2–147 and Hen 2–104, and the proto-PNe CRL 618, CRL 2688, and Hen 3–1475.

Keywords. binaries: symbiotic, stars: individual (M2-9, R Aqr, Hen 2-147, Hen 2-104 GK Per), novae, catclysmic variables, planetary nebula: individual (CRL 618, CRL 2688, Hen 3-1475), interstellar medium: kinematics and dynamics

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The image quality achievable with modern telescopes allows the apparent growth of relatively close/fast stellar outflows to be revealed and measured in timescales of few years. The information about the tangential component of the gas and shocks motions, coupled with line-of-sight velocities from Doppler shifts, allows a detailed view of the kinematics of the outflows. Combining this information from two or more epochs provides us with a tool to test the forces acting on the ejecta (i.e its dynamical evolution). With this goal, we have obtained multi-epoch images of several sources over several years. Some results are briefly summarised below (those on pre-PNe can be found in the contribution of B. Balick to these proceedings and in Balick *et al.* 2011, *ApJ*, submitted). Outflows are illustrated in Fig. 1.

M2-9. The unique property of this object is its 90-yr rotating pattern in the inner lobes. Given its corkscrew geometry and associated travelling times, excitation structure, we conclude that the phenomenon is caused by a particle jet from the central source hitting and exciting the walls of the inner lobes of M2-9 (Corradi *et al.* 2011). The speed of the jet – between 11000 and 16000 $\mathrm{km\,s^{-1}}$ – would be unusually high among PNe and symbiotic stars.

GK Per. Kinematical modeling of the nova remnant shows that the nebula is a thick clumpy shell, with knots expanding with a range of speeds between 300 and 1000 $\mathrm{km\,s^{-1}}$. Modest deceleration occurred since their ejection on 1901. The nebula is overall fading, but individual knots show significant brightness changes (Liimets *et al.*, in preparation).

Hen 2-147, Hen2-104, R Aqr. Symbiotic novae illustrate the mass-loss geometry from long-period interacting binaries. The expansion pattern of Hen 2-147 and Hen2-104 (the "Southern Crab"), their expansion parallaxes, the role of shocks, are discussed in

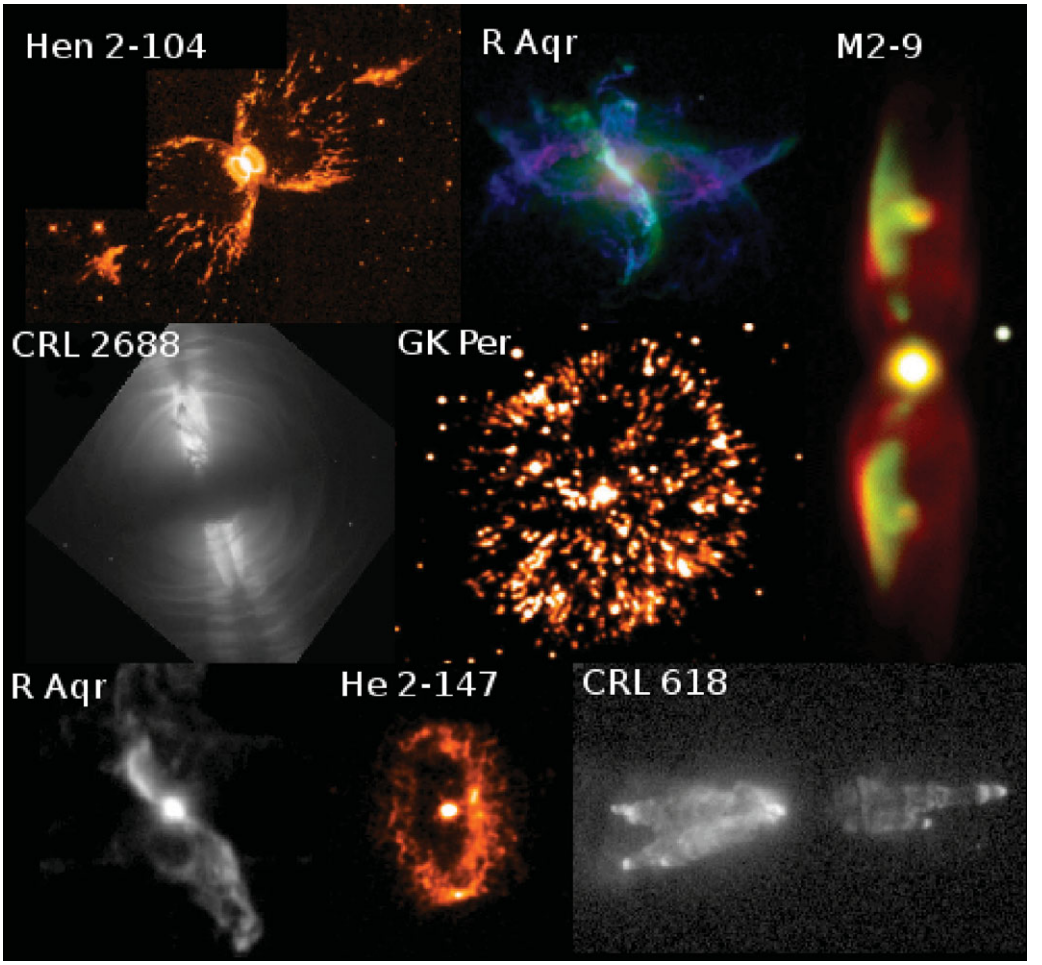

Figure 1. Images of the studied outflows.

Santander *et al.* (2007) and Santander *et al.* (2008). The study of the expansion of the jet of R Aqr is in progress.

References

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