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THE DECELERATION OF NEBULAR SHELLS IN EVOLVED PLANETARY NEBULAE

M. Pereyra[1], M. G. Richer[1], and J. A. López[1]

We have selected a group of 100 evolved planetary nebulae (PNe) and study their kinematics based upon spatially-resolved, long-slit, echelle spectroscopy. The data have been drawn from the San Pedro Mártir Kinematic Catalogue of PNe (López et al. 2012) with the aim of characterizing in detail the global kinematics of PNe at advanced stages of evolution with the largest sample of homogenous data used to date for this purpose.

OVERVIEW

We have analyzed the kinematics of evolved PNe using the largest homogeneous data set to date, drawn from the SPM Catalogue. Compared with Richer et al. (2010), it is found that the typical flow velocities we measure are usually larger than seen in earlier evolutionary stages. The results reveal two groups that share kinematics, morphology, and photo-ionization characteristics of the nebular shell and central star luminosities at the different late stages under study. Nebular shells with the highest degrees of excitation, largest bulk flow velocities, and best-defined structure usually have moderately evolved, high luminosity central stars (CSs) that inhibit [N II] λ6584 emission. On the contrary, nebular shells with lower degree of excitation, lower bulk flow velocity, and the least structure contain the most evolved CSs. The most evolved objects in our sample tend to expand more slowly. This apparent deceleration during the final stage of PNe evolution is predicted by hydrodynamical models, presumably due to the loss of energy from the central star or possibly its interaction with the surrounding ISM or even due to recombination of the outermost nebular matter.

CONCLUSIONS

These results complement prior work (Richer et al. (2010)), for the first time illustrating the coupling between the CS's evolution and that of the nebular shell predicted by theory over the entire PN lifetime (Villaver et al. 2002b; Perinotto et al. 2004).

[1]Instituto de Astronomía, Universidad Nacional Autónoma de México, C.P. 22800, Ensenada B. C., México (mally, richer, jal@astrosen.unam.mx).

In Fig.1, we present a summary of the kinematical behavior of the nebular shell over the lifetime of a PN. As the central star evolves towards higher effective temperatures the nebular shell is continuously accelerated, until it reaches its maximum temperature and ceases nuclear burning (e.g., Richer et al. 2010). Thereafter, the shell decelerates as the central star approaches the white dwarf stage of evolution, presumably due to the loss of energy from the central star, but other explanations are also possible (Pereyra et al. 2013).

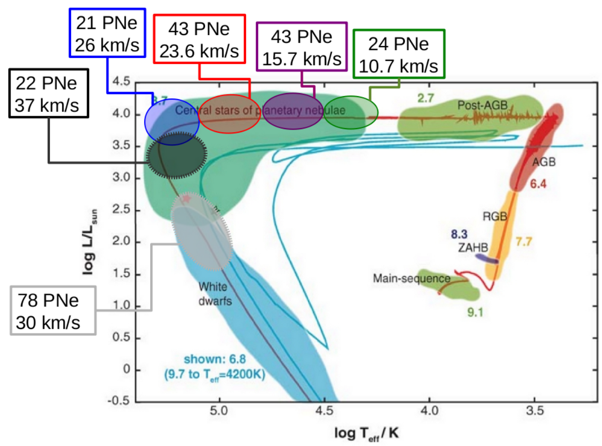

Fig. 1. Mean bulk flow velocities for the nebular shell of a PN at different stages of the central star evolution. The number of PNe considered for each sample and their average bulk flow velocity are indicated on the squares outside the Hertzsprung-Russell (H-R) diagram. The H-R diagram was taken from Herwig (2005).

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