Planetary Nebulae: Multi-Wavelength Probes of Stellar and Galactic Evolution
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Characterizing global expansion evolution of the ionized matter in planetary nebulae

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Abstract. Bulk outflow or global expansion velocities are presented for a large number of planetary nebulae (PNe) that span a wide range of evolutionary stages and different stellar populations. The sample comprises 133 PNe from the Galactic bulge, 100 mature and highly evolved PNe from the disk, 11 PNe from the Galactic halo and 15 PNe with very low central star masses and low metallicities, for a total of 259 PNe. These results reveal from a statistical perspective the kinematic evolution of the expansion velocities of PNe in relation to changing characteristics of the central star's wind and ionizing luminosity and as a function of the evolutionary rate determined by the central (CS) mass. The large number of PNe utilized in this work for each group of PNe under study and the homogeneity of the data provide for the first time a solid benchmark form observations for model predictions, as has been described by López *et al.* (2016).

Keywords. ISM: kinematics and dynamics, planetary nebulae: general, stars: evolution, low-mass

1. Introduction

We have used the SPM Kinematic Catalogue of Galactic Planetary Nebulae (López *et al.* (2012) as the single source of data for all our measurements. This catalogue contains long-slit, echelle data for nearly 700 Galactic PNe. The spectral resolution in the data ranges from 6 to 12 km s^{-1}, perfectly adequate to resolve the internal kinematics of PNe. We concentrate our measurements on the luminosity-weighted emission for the matter projected within the spectrograph slit. When line splitting is clearly present the expansion velocity is measured form the peaks separation. When the profile is unresolved we fit a gaussian and correct the observed profile for instrumental, thermal and fine structure broadening. We do not apply hydrodynamic corrections as suggested by Shoenberner *et al.* (2010) since we are not interested in measuring the velocity of the outer shock, which in any case is a pattern that cannot be measured directly. The present results have been compiled from several works that we have published on this subject since the last IAU Symposium.

Details for the bulge sample appear in Richer *et al.* (2008) and Richer, *et al.* (2010), those for the mature and highly evolved PNe in Pereyra *et al.* (2013) and for the halo and low metallicity PNe in Pereyra *et al.* (2016) and see their contribution in this volume. A detailed summary of these works has also been recently presented by López *et al.* (2016).

Figure 1 shows the overall results from these works where the approximate distribution in the H-R diagram of the different groups are shown over evolutionary tracks from Vassiliadis & Wood (1994).

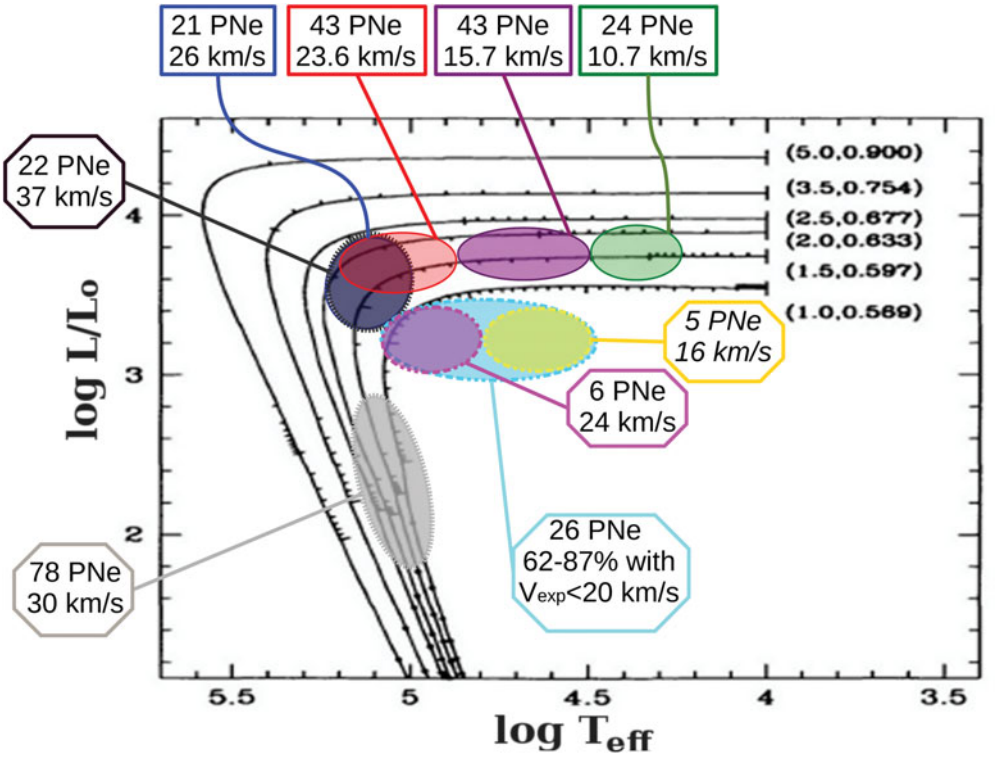

Figure 1. For each group are indicated the number of members measured and their average V_{exp}. The kinematic evolution with evolutionary stage is apparent. V_{exp} increases with T_{eff} in all cases, though within different ranges that indicate a dependance on CS masses and possibly metallicity. Labels at the top of the diagram point to the groups from the bulge. Labels on the left of the digram point to the mature and highly evolved groups. Labels within the diagram point to the halo and low metal sample.

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References

Lopez, J. A., Richer, M. G., & Garcia-Diaz, M. T. *et al.* 2012, *Rev. Mexicana AyA*, 67, 4679

Lopez, J. A., Richer, M. G., & Garcia-Diaz, M. T. *et al.* 2016, in: Sun Kwok & Kam-Ching Leung (eds.), *11th Pacific Rim Conference on Stellar Astrophysics: Physics and Chemistry of the Late Stages of Stellar Evolution*, Journal of Physics: Conference Series, 728, 032003

Pereyra, M., Richer, M. G., & López, J. A 2013, *ApJ*, 771, 114

Pereyra, M., López, J. A., & Richer, M. G., 2016, *AJ*, 151, 53

Richer, M. G., López, J. A., Pereyra, M., Riesgo, H., & García-Díaz, M. T. 2008, *ApJ*, 689, 203

Richer, M. G., López, J. A., García-Díaz, M. T., Clark, D. M., Pereyra & Díaz-Méndez, E. 2010, *ApJ*, 716, 857

Schoenberner, D., Jacob, R., Sandin, C., & Steffen, M. 2010, *A&A* 523 A86

Vassiliadis, E.. & Wood, P. R. 1994, *ApJS*, 92, 125

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