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3-D modeling of the collimated outflows of M1-32 and M2-42

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Abstract: We present high resolution long-slit spectra from the San Pedro Martir kinematic catalogue ([**?**]) of M1-32 & M2-42 planetary nebulae and their modeled PV diagrams using the 3-D morpho-kinematic code SHAPE. We find high-speed collimated outflows, surrounded by a equatorial thick torus/ring. The same SHAPE model is able to fit both planetary nebulae assuming one cylindrical velocity field for the outflows and one Hubble-law for the torus/ring. We conclude that they may be akin objects which just appear at different projections.

1 Introduction

Many surveys have been made to discover as many as possible Planetary nebulae (PNe) (see [**?**]) revealing a variety of complex morphologies. Based on the theoretical models, the complexity of PNe structure occur due to the presence of magnetic field and/or the rotation of the central star ([**?**], [**?**]) and the binarity of central star (CS) ([**?**]). The fraction of spherically and non-spherically symmetric PNe has been found at 19% and 81%, respectively ([**?**]). Spectroscopic and imaging data are used in order to reconstruct the 3-D structure of two seemingly morphologically different PNe, M1-32 and M2-42, making usage of the 3-D morpho-kinematic code SHAPE ([**?**]). Based on their narrow band images, M1-32 has been classified as a spherical PN and M2-42 as a bipolar PN.

2 Observations

High resolution spectra of M1-32 & M2-42 were obtained with the 2.1 m telescope at San Pedro Martir Observatory in Baja California, Mexico, with the Manchester echelle spectrometer (MES-SPM) in June 2007 and in July 2009 (The SPM Kinemtatic Catalogue of Planetary Nebulae ([**?**]). The slit width was 1.9 arcsec (150 m) for a spectra resolution equivalent to 11 km/s. The observed PV diagrams are presented in figure 1.

3 SHAPE modeling

In order to understand better the nature of the highly collimated outflows of M1-32 & M2-42, we use the morpho-kinematic code SHAPE and their PV diagrams from the San Pedro Martir kinematic catalogue. Both nebulae show highly collimated outflows surrounded by a equatorial thick torus/ring. A cylindrical velocity field is needed in order to produce the high moving collimated outflows along the polar direction. A similar cylindrical velocity field is used to produce the outflows of the young planetary nebula BD +30 3639 (Akras & Steffen. in prep.) In addition, an homologous expansion law (Hubble law) is use for the torus/ring component. Hence, the same SHAPE model is able to replicate the observations for both nebulae. The final synthetic PV diagrams are shown in figure 1 with the corresponding observed PV diagrams. In figure 2, we present the modeled PV diagrams for different inclination angles. M1-32 and M2-42 seem to be akin objects with highly collimated outflows surrounded by an equatorial torus/ring which just viewed in different projections on the sky.

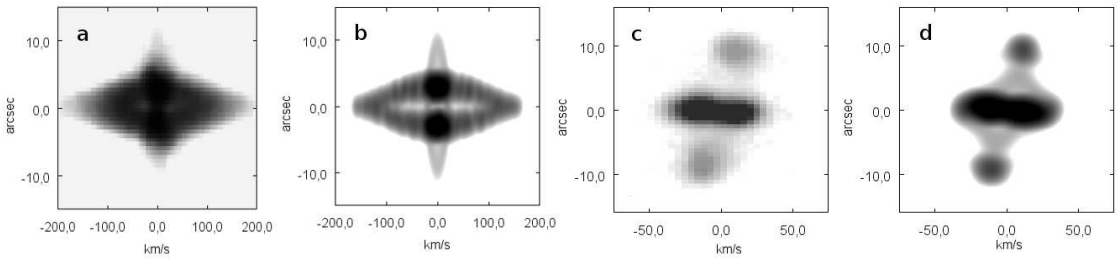

Figure 1: The observed and modeled synthetic PV diagrams of [N II] emission line of M1-32 (a & b) and M2-42 (c & d)

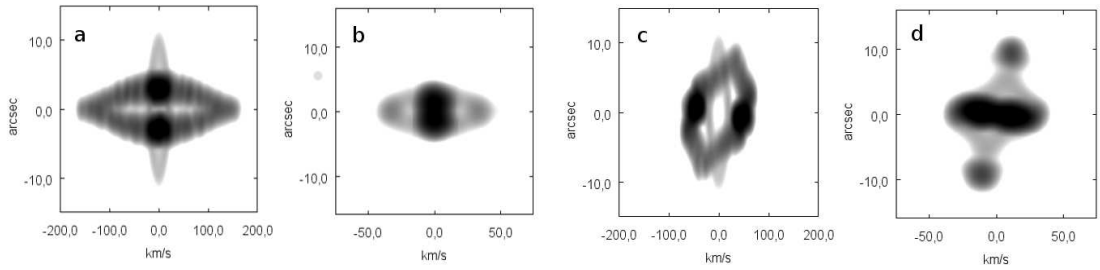

Figure 2: The synthetic PV diagrams of M 1-32 & M 2-42 for inclination angle of 0 degree (a & c) and 90 degrees (b & d).

4 Conclusions

1) A cylindrical velocity component, increasing linearly with the distance from the central star, can adequately reproduce the high collimated bipolar outflows. 2) The equatorial thick torus/ring expands radially following an homologous expansion law. 3) M1-32 shows higher polar and equatorial expansion velocities than M2-42. 4) According to our modeled PV diagrams, both PNe may be akin objects, formed by similar mechanisms and just appear at different projections on the sky. Consequently, the same model is able to reproduce the main morphological and kinematical characteristics for both PNe. 5) We also conclude that the collimated outflows may be formed by the similar mechanisms either for PNe with WR central star (M1-32) or weak emission lines (wels) central star (M2-42).

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References

[1] Balick, B., & Frank, A., 2002, ARA&A, 40, 439

[2] García-Segúra, G., 1997, ApJ, 489, 189

[3] García-Segúra, G., Langer, N., Różyczka, M. & Franco, J., 1999, ApJ, 517, 767

[4] López, J. A., Richer, M. G., García-Díaz, Ma. T., Clark, D. M., Meaburn, J., Riesgo, H., Steffen, W., & Lloyd, M., 2012, RevMexAA, 48, 3.

[5] Parker, Q. A., & Frew, D., 2010, arXiv1011.0857

[6] Parker, Q. A., et al., 2006, MNRAS, 373, 79

[7] Steffen, W., Koning, N., Wenger, S., Morisset, C. & Magnor, M., 2011, Transactions of Computer Graphics and Visualization, 17, 454