

Expansion Velocities From Different Ions of Planetary Nebulae with [WC]-Type Central Stars

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1. Observations

High resolution spectroscopic data of a sample consisting of 24 planetary nebulae (PNe) with WR-type nuclei ([WC]) from the list of Tylanda et al. (1993) plus 1 late-[WC] presented by De Marco et al. (2001), and 7 PNe with weak emission line stars (WELS) nuclei listed in Tylanda et al. (1993) are analyzed. The data were collected using the 2.1 m telescope at the Observatorio Astronómico Nacional, San Pedro Mártir, México and were used to determine the expansion velocity (V_{exp}) of the gaseous component in each sample object in the following ions: [N II] λ 6584, [O II] λ 3729, [O III] λ 5007, H β , HeI λ 5876, and HeII λ 4686. A sample of 8 non-WR type (typical) PNe were observed as a control sample. All observational data were systematically gathered using the REOSC Echelle Spectrograph on 1995 July 29-31, 1996 June 14-17, 1997 August 3-4, 1998 December 11-14, 1999 October 4-7, and 2000 November 1-3. In order to take the highest V_{exp} of the gaseous component in each ion, it was taken the half width of the line at one tenth of the maximum intensity ($HW_{\frac{1}{10}I}$) when the line featured either a single Gaussian profile or a Gaussian with extended wings profile. For two-peaks profiles, V_{exp} was measured taking into account both the peak-to-peak displacement and the $HW_{\frac{1}{10}I}$ of the lines.

2. Results

It was found that the velocity fields from [WC] and typical PNe apparently differs. It is important to be noticed, however, that WELS are rather grouped among the PNe than the [WC]. A tendency could be noticed between the ionization degree He^{++}/He^+ and the V_{exp} . There is no object with low V_{exp} showing a high He^{++}/He^+ value. Since He^{++}/He^+ is a function of the stellar temperature, this could be reflecting that the gaseous component around stars with stellar temperatures $T_* > 80000$ K, should have high V_{exp} . This tendency applies in all the objects of the sample, regardless the stellar type. In addition, it was found that [WC] objects with low He^{++}/He^+ , cover a wider V_{exp} range than WELS and typical planetary nebulae. This fact may be due to the high mass-loss rates and terminal velocities of the winds in [WC] central stars.

It was found that objects with electron densities $N_e < 4000 \text{ cm}^{-3}$, show $V_{exp} > 45 \text{ km/s}$, while objects with $N_e > 6000 \text{ cm}^{-3}$ show $V_{exp} < 45 \text{ km/s}$. Since N_e can be considered as an indicator of the age of the nebula, we found that the the V_{exp} of the nebulae can be seen as an age indicator. Furthermore, it was found that objects with T_* between 30000 and 70000 K have V_{exp} laying within a range from 30 to 60 km/s, while objects with T_* between 70000 and 200000 K show V_{exp} from 40 to 80 km/s.

3. Conclusions

It is evident that typical PNe have a different velocity structure from the [WC]. It is striking to notice that WELS were found to have a V_{exp} field very much alike to the typical PNe, rather than to the [WC]. This evidence would indicate that WELS do not belong to the [WC] evolutionary track, at least in their nebular behaviour, despite their strong stellar winds. These results suggest that the nebular V_{exp} increases with the nebular age.

References

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- Tylenda, R., Acker, A., & Stenholm, B. 1993, A&AS, 102, 595



Mike Dopita demonstrating the art of wine tasting.