

ISO-SWS spectra of Planetary Nebulae with low-mass [WC] central stars: a mixed C- and O-rich dust chemistry

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1. The mixed chemistry of [WC] dust shells

The timing of PNe formation around low-mass WC stars is unsettled with respect to pulsations early in the post-AGB phase, or later thermal pulses (*e.g.*, Tylenda & Gorny 1997). The chemistry of the dust in the nebulae can be used to trace the mass-loss history. Using ISO-SWS spectroscopy, the PNe BD+30°3639 [WC9] and He2-113 [WC11] have been identified by Waters *et al.* (1998) to exhibit emission from *C-rich dust* (PAHs) in the surrounding envelopes at $\lambda < 15 \mu\text{m}$, while *O-abundant* silicate features are present at longer wavelengths. Figure 1 shows the PAH features, which include additional WCPNe observations to extend the range of stellar spectral subtypes.

Crystalline silicate features are also present beyond $20 \mu\text{m}$, suggesting that the O-rich phase of the central stars underwent strong mass-loss at or near the end of the AGB phase. This was probably followed by a change to C-rich chemistry at the surface as traced by the PAHs.

2. Basic implications

A dust model for BD+30°3639 (Waters *et al.* 1998) indicates that the mass of the C-rich shell is about the same as the H+He layers of many post-AGB stars, suggesting that the post-AGB pulse is responsible for exposing the He- and C-rich inner layers. The persistence of PAHs in all observed envelopes indicates that pulsed ejection of the C-rich layers is most likely to have occurred no later than the [WCL] phase, when surface H may still be present (*e.g.*, Hamann 1997). Because of the H-free chemistry at [WCE] surfaces (NGC 6369 in our sample), formation of the PAH-bearing shell during later thermal pulsing is unlikely. The dynamical age (~ 1050 yr) of the O-rich shell around BD+30°3639 suggests that the chemistry change was also initiated by a post-AGB pulse rather than by a late thermal pulse (Waters *et al.* 1998).

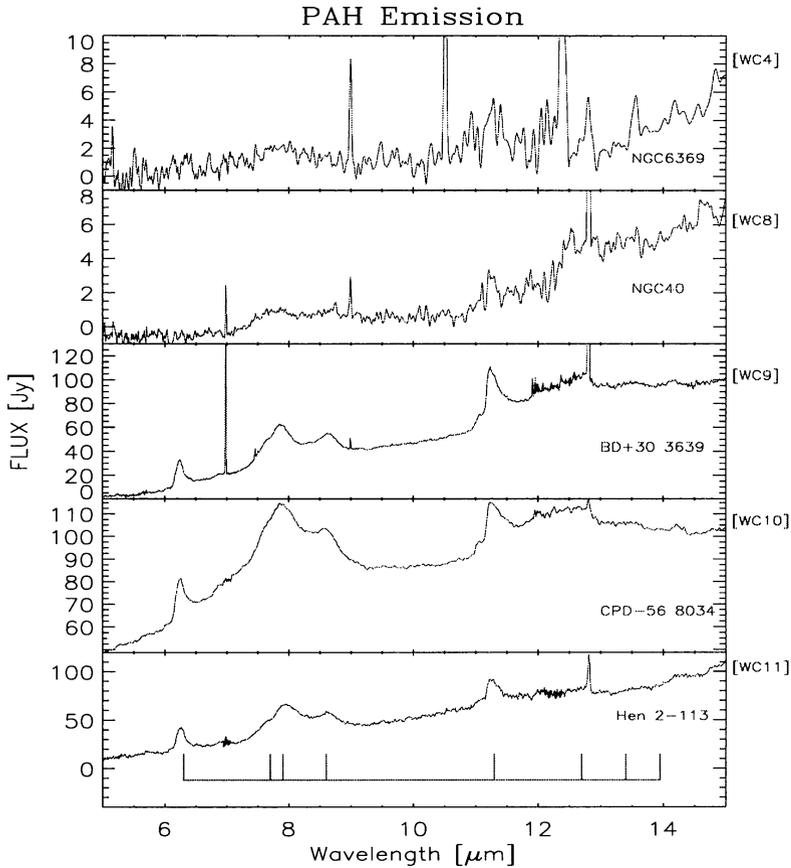


Figure 1. Persistent presence of the family of UIR bands in ISO-sws [WC] spectra, associated with H- and C-rich PAH molecules.

References

- Hamann, W.-R. 1997, in: H.J. Habing & H. Lamers (eds.), Planetary Nebulae, Proc. IAU Symp. No. 180 (Kluwer: Dordrecht), p. 91
- Tylenda, R., Górný, S.K. 1997, in: H.J. Habing & H. Lamers (eds.), Planetary Nebulae, Proc. IAU Symp. No. 180 (Kluwer: Dordrecht), p. 371
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