


## Double chemistry Planetary Nebulae

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Planetary Nebulae (PNe) are ionized and photodissociated remnants of extreme mass loss, which an intermediate-mass central star experienced when it was on the Asymptotic Giant Branch (AGB). Depending on the stellar initial mass, the star could experience several dredge-up events. One of the most important is the third dredge up, which occurs at the end of flash-burning in the He-shell. This dredge-up transports to the surface primary nucleosynthesis products such as carbon. Consequently, in the envelope, the C/O ratio will increase until it exceeds unity and a carbon star is formed. Observations made with *ISO* of some WCPNe, show spectral emission lines from polycyclic aromatic hydrocarbons (PAHs) which are formed from carbon at 6.2, 7.7, 8.6, and 11.3  $\mu\text{m}$ , and also the spectra show emission lines of silicates at 10, 23.5, 27.5 and 33.8  $\mu\text{m}$  which are formed from oxygen, telling us some kind of double-dust chemistry phenomenon is occurring in these PNe (Waters et al. 1998a,b; Cohen et al., 1999, 2002). In this poster, we present observations of 21 PNe located in the Galactic Bulge. The observations were made using the IRS instrument on *Spitzer*. We analyse their double-chemistry phenomena and we present some preliminary result of our analysis.



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# Double Chemistry PNe

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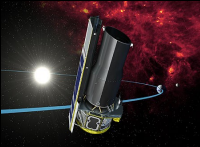
APN5 conference  
20-25 June, 2010

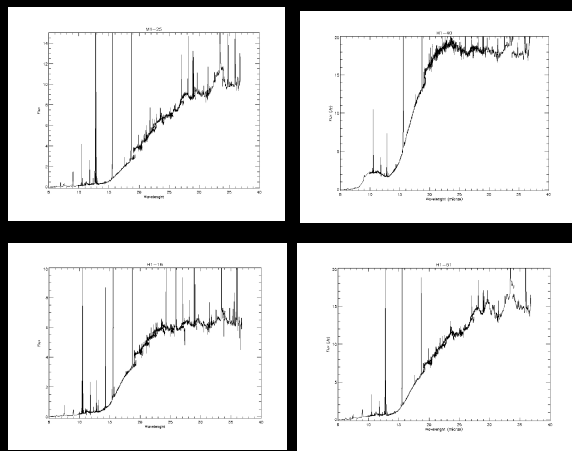
### Evolutionary steps

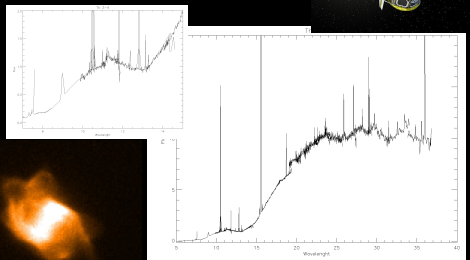
- AGB phase
  - Mass loss up to  $10^{-4} M_{\odot}$
- Formation of a circumstellar envelope made of gas and dust.
  - Strong emission in the IR
- Mixing processes
  - Dredge up, this occurs when the envelope expands and cools as the core contracts after the end of a dominant nuclear burning event.

### Observations

- Data taken from the Spitzer Science Centre Data Archive.
- 21 PNe from the Galactic Bulge using IRS from Spitzer
- Range 5.2 - 37.2  $\mu\text{m}$





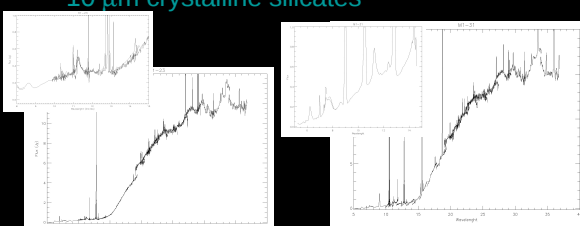


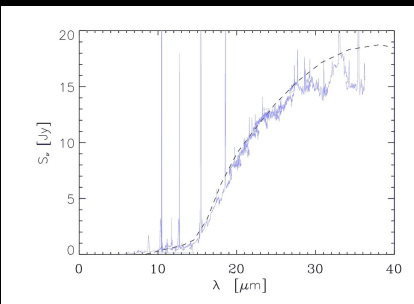
### Double Chemistry

- PAH's - carbon based (C-rich)
  - 6.2, 7.7, 8.6 and 11.3  $\mu\text{m}$
- Silicates - oxygen based (O-rich)
  - 23.5, 27.5, 33.8  $\mu\text{m}$
  - 10  $\mu\text{m}$  crystalline silicates

### Possible scenarios

- Recent thermal pulse
  - Converted an O-rich outflow into a C-rich one.
- Silicate grains in orbit around the system
  - Binary system, disk where O-rich grains have accumulated.
- ISM interaction





### MC3D

- Model the IR Spectrum for the PN M1-31.
- MonteCarlo 3-D (Wolf, T et al., 1999)
  - Inner Radio torus = 5000 AU
  - Outer Radio torus = 50000 AU
  - $M_{\text{dust}} = 5 \times 10^{-3} M_{\odot}$

### Conclusions

- We found a correlation between the 10  $\mu\text{m}$  feature and the torus in the PNe.
- Double chemistry is related to the torus.
- We also found 3 cases with some possible PNe interacting with ISM.

### WCPNe

- WCPNe (BD+30 3639, He 2-113) exhibit a dual dust chemistry (Waters et al., 1998, Cohen et al., 1999, 2002).
- Zijlstra et al., 1991, found OH maser emission in the [WC] IRAS 07027-7934.
- Barlow (1998) showed O-rich dust in the [WC] CPD-56 8032.
- Perea-Calderon et al., 2009 report 21 GB PNe that show this dual chemistry phenomena. This sample contains WC, wels, and neither WC nor wels.