A. A. Zijlstra (UoM)
K. Gesicki (UMK)
E. Lagadec (Cornell)
D. Jones (ESO)
T.J. Millar (Queens)
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Lizette Guzman-Ramirez

The mixed chemistry problem

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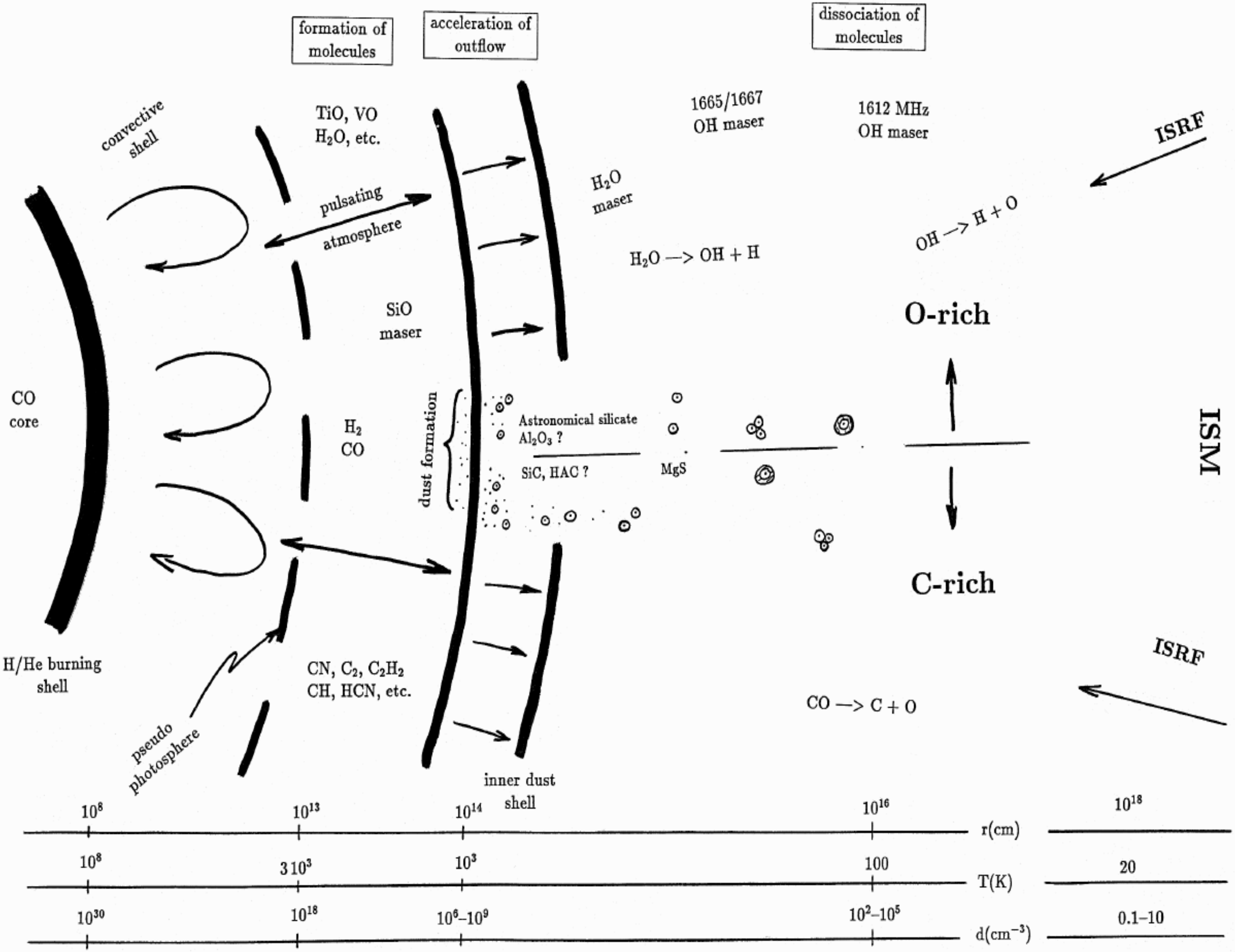
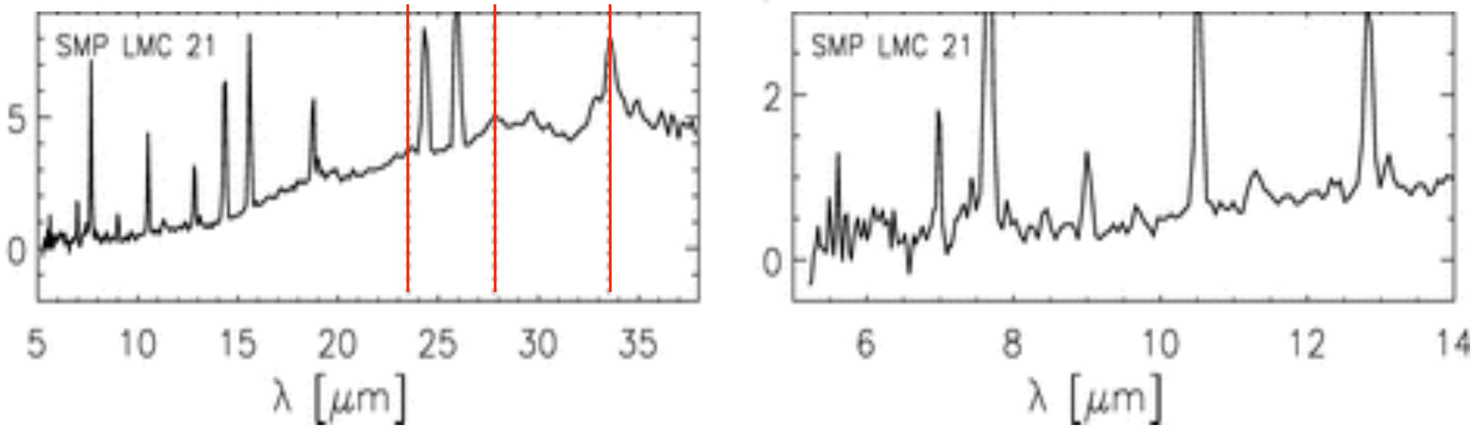
MARIE CURIE ACTIONS


formation of molecules
acceleration of outflow
dissociation of molecules
convective shell
TiO, VO
H_2O, etc.
1665/1667 OH maser
1612 MHz OH maser
ISRF
pulsating atmosphere
H_2O maser
OH —> H + O
H_2O —> OH + H
SiO maser
O-rich
CO core
dust formation
Astronomical silicate
Al_2O_3 ?
SiC, HAC ?
MgS
H_2
CO
ISM
C-rich
H/He burning shell
ISRF
CN, C_2, C_2H_2
CH, HCN, etc.
CO —> C + O
pseudo photosphere
inner dust shell
10^8 10^{13} 10^{14} 10^{16} 10^{18} r(cm)
10^8 $3\,10^3$ 10^3 100 20 T(K)
10^{30} 10^{18} 10^6–10^9 10^2–10^5 0.1–10 d(cm^{-3})

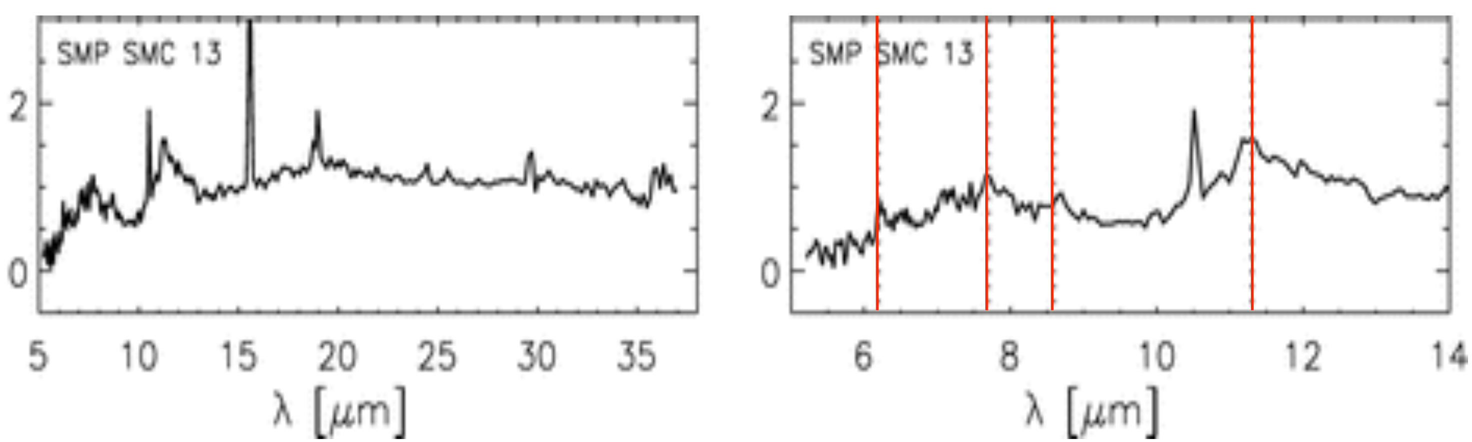
Dichotomy

Lower mass, O-rich

- Silicate dust - 23.5, 27.5 and 33.8μm



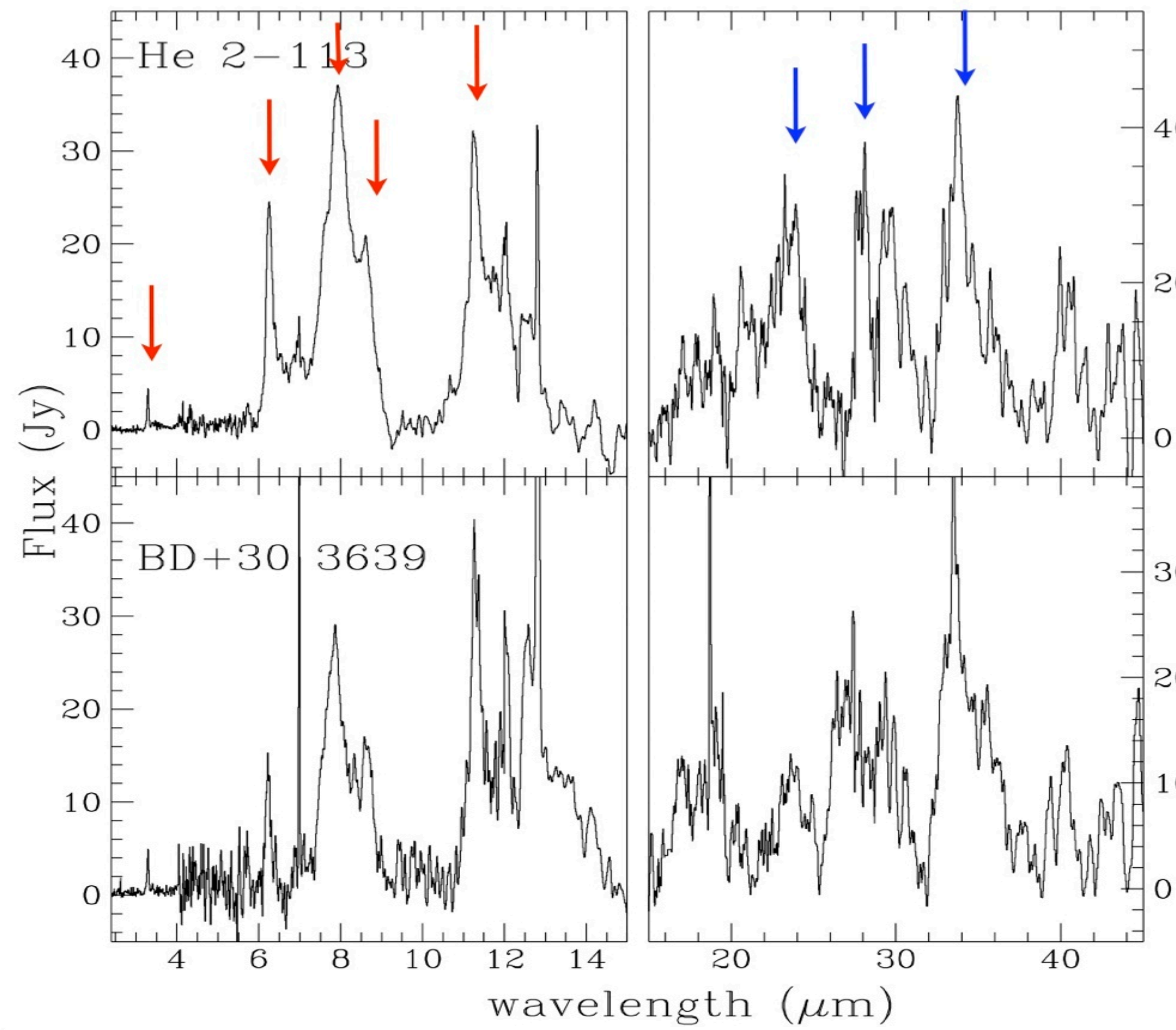
- Higher mass, C-rich ($M_{cs} > 1.5\ M_o$)
  - PAH bands - 6.2, 7.7, 8.6 and 11.3μm



The Mixed Chemistry Problem in Galactic Disk PNe

Zijlstra et al. 1991
IRAS 07027-7934
[WC 11] showed
OH maser line.

Waters et al. 1998
silicates (O-rich) in
several C-rich PNe.

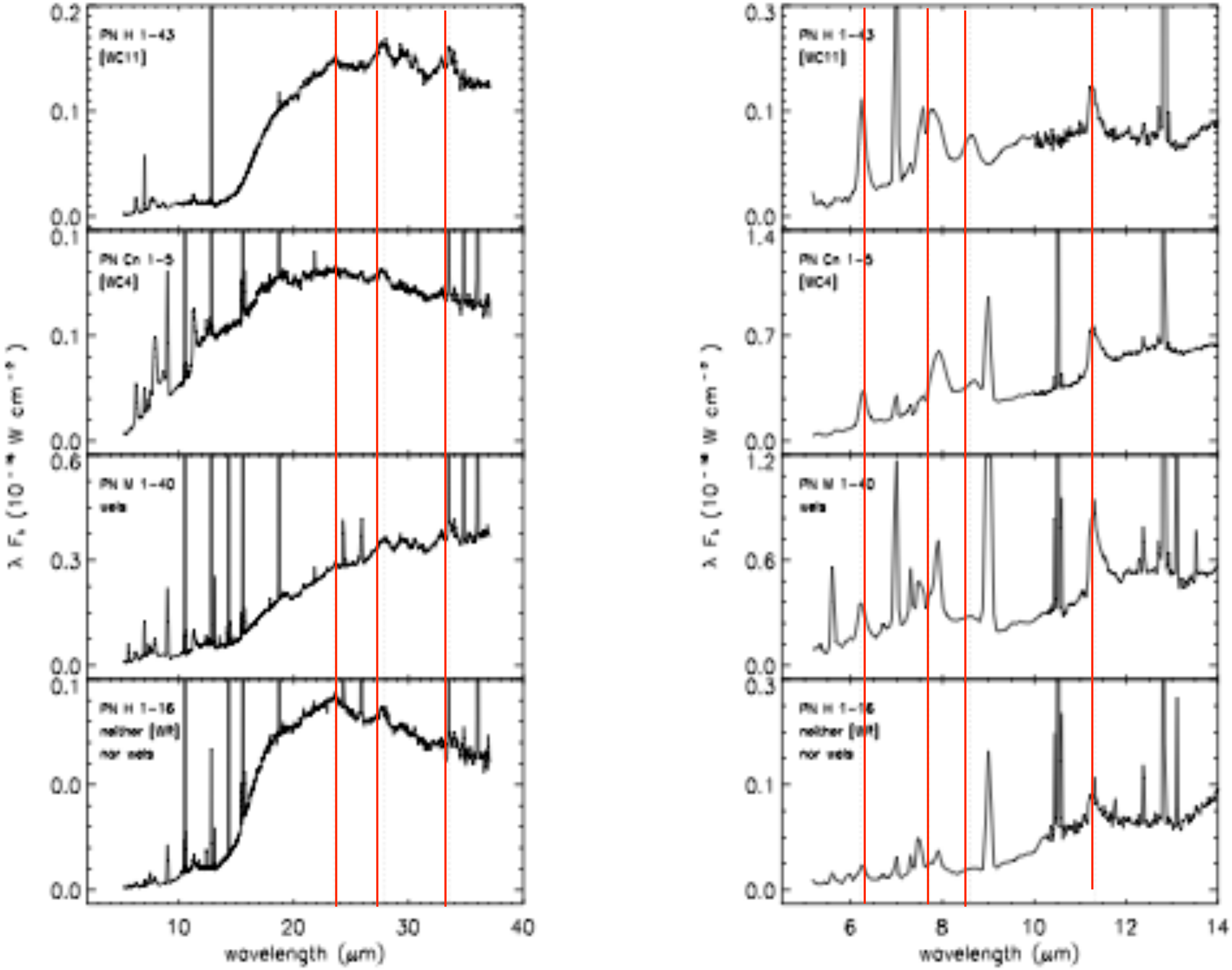


- Only in [WC] stars
- Attributed to a VLTP
- O-rich inner part of the nebu... torus)
- C-rich in the ...
- Ce... 1.5 M_o

Problem solved!!!

BD+30 3639

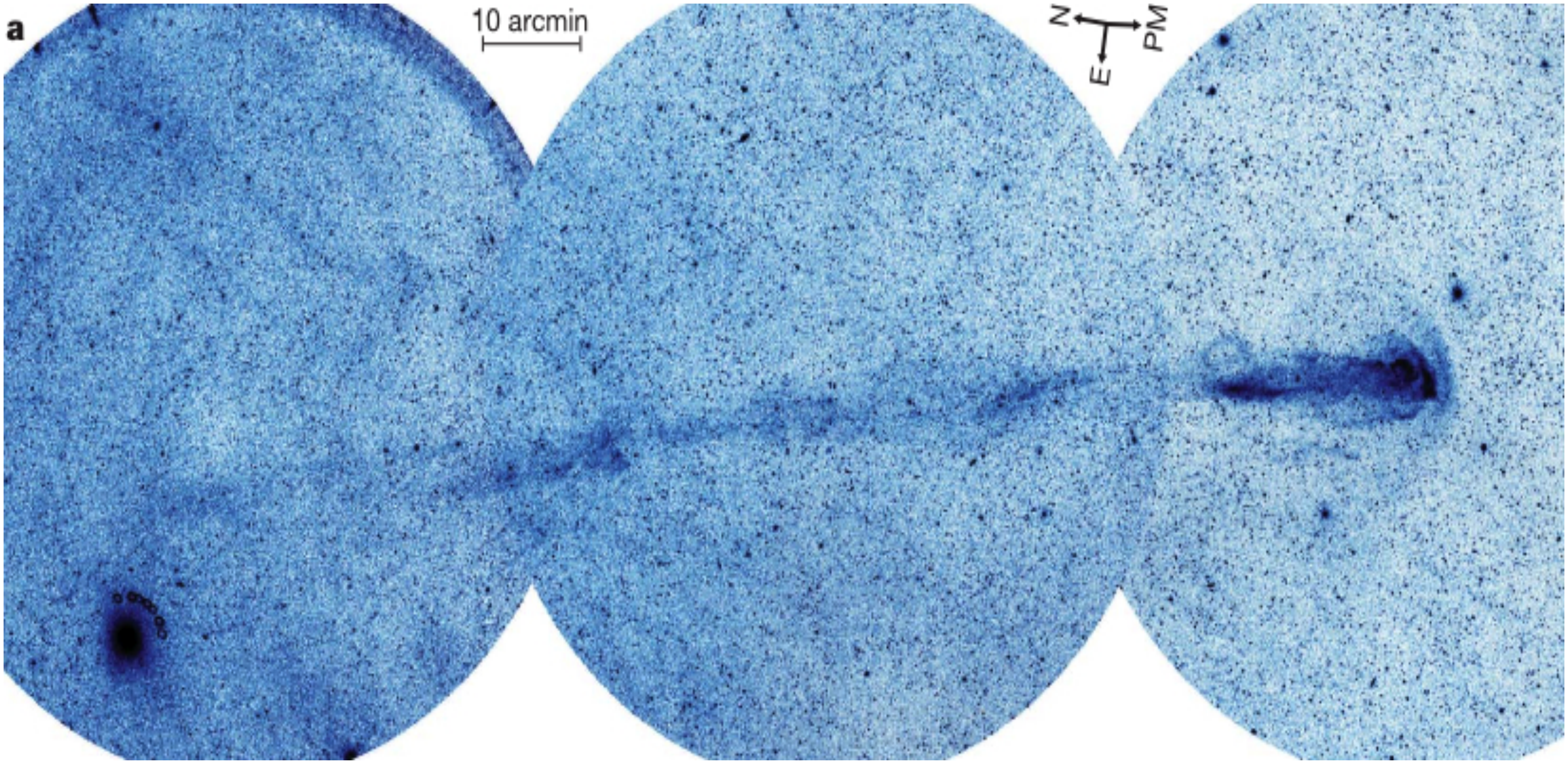
Gutenkunst et al. 2008 and then Perea-Calderon et al. 2009 observed this phenomenon among Galactic Bulge PNe.



Back to the problem!!!

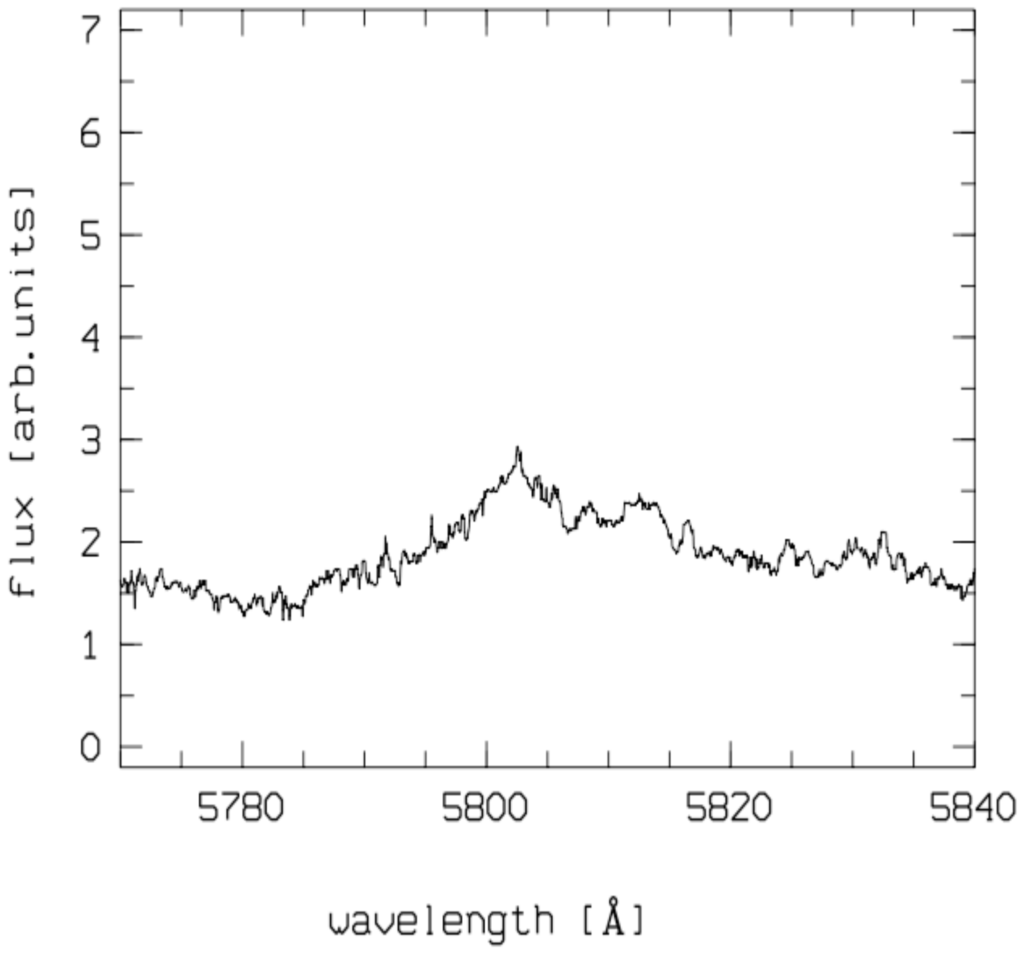
- Azzopardi et al.,1988 showed that the very few AGB C st[illegible] in the bulge do not originate from third dredge-up.
- Le Bertre et al., 2003 encounter that Carbo[illegible] the inner Galaxy.
- Feast 2007, found them abs[illegible]
- Uttenthaler et al. 20[illegible]jects only 4 of them showed Tc, (3r[illegible] in 2011 he observed 45 GB AGB findi[illegible].
- T[illegible]planation relating the mixed chemistry to a r[illegible]ion towards C star is unlikely for the bulge objects.
- Different explanations are needed.

External: PAHs from the ISM

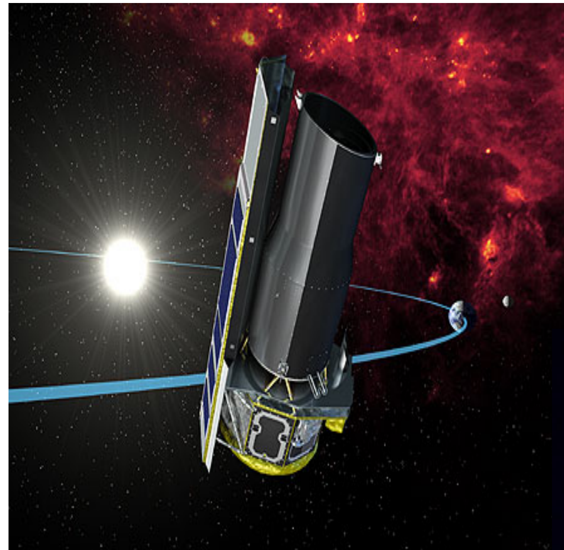


Zijlstra, A. A. & Weinberger, R., ApJ, 2002

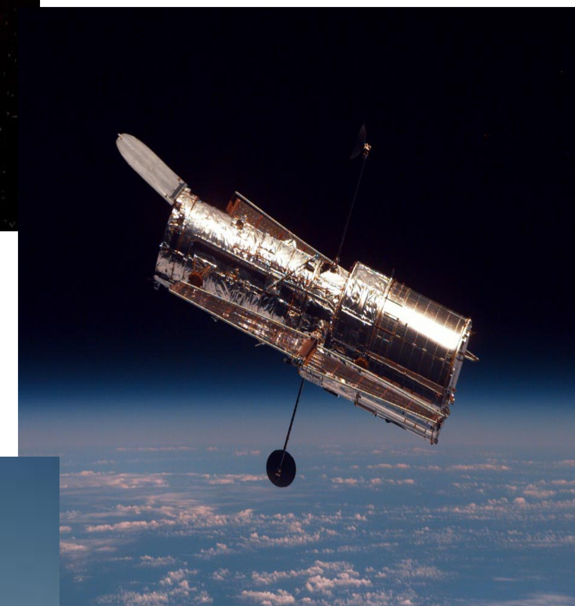
Internal: PAHs from the nebula



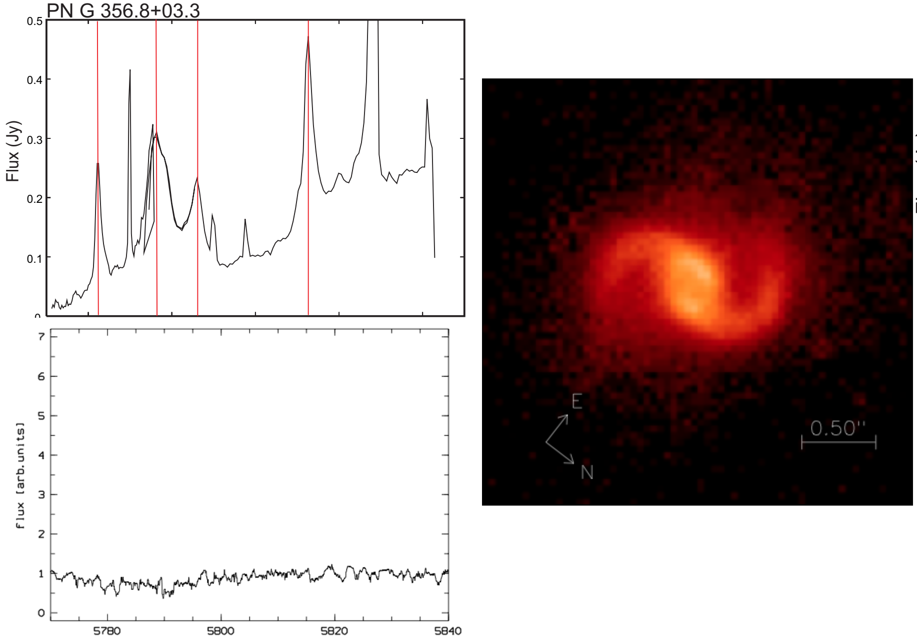
- *Spitzer* - 40 PNe
  - IR (5.2 -37.2μm)

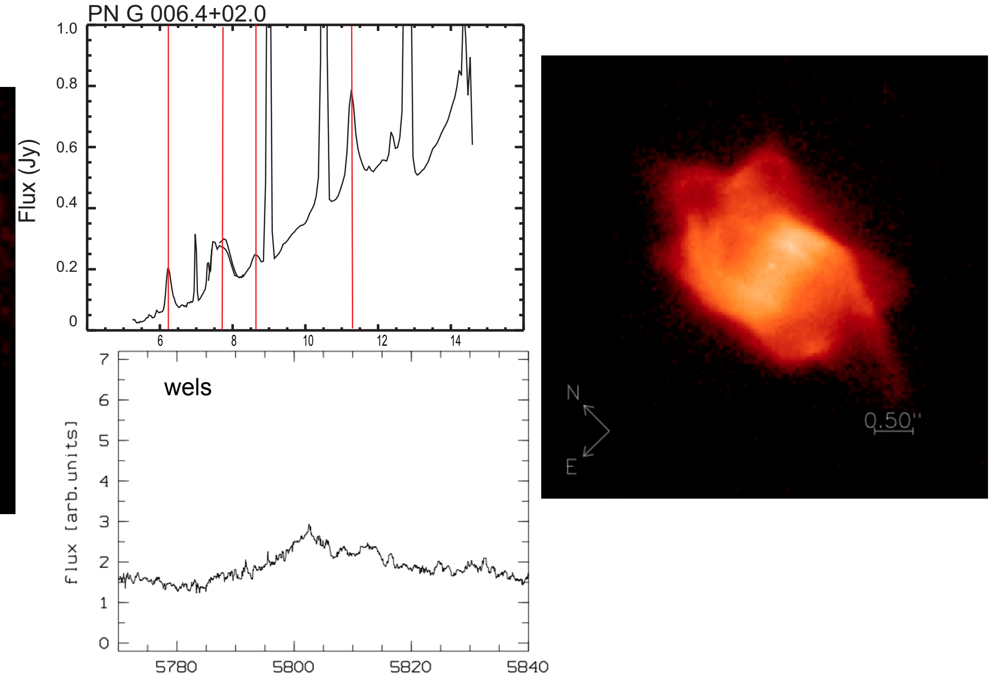


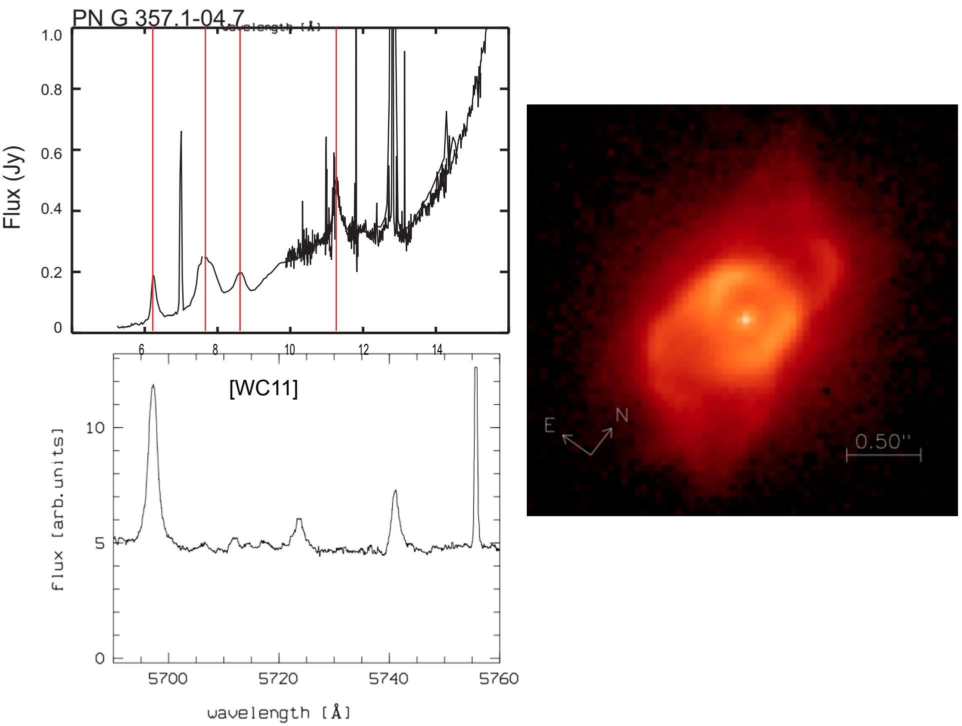
- *HST* - 22 PNe
  - Visible - Hα image

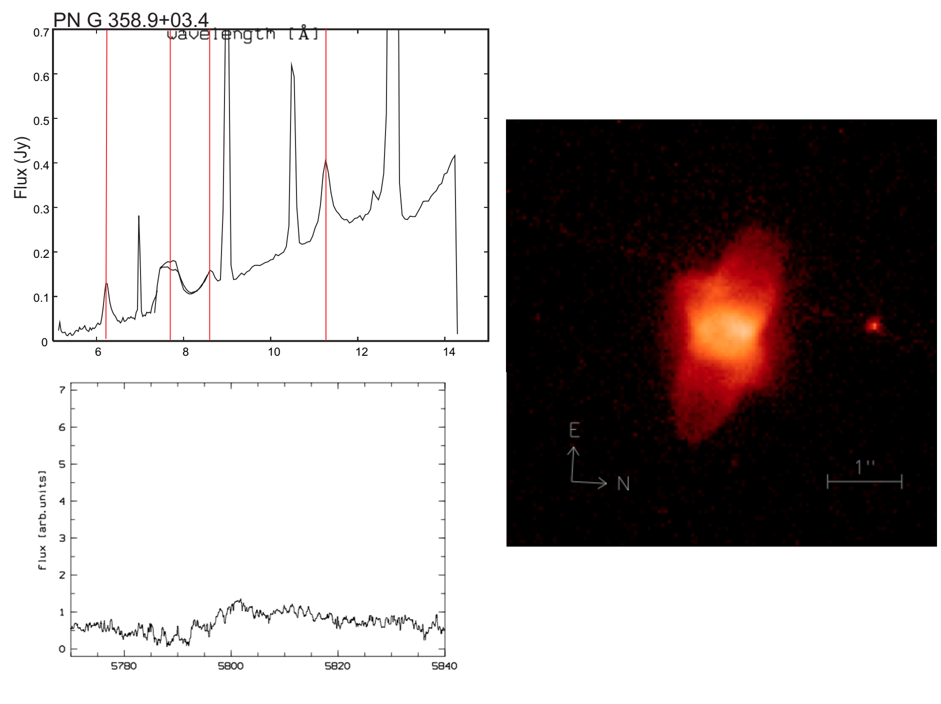


- *VLT* – 22 Pne
  - -UVES - Central Star spectrum (3300 - 6600 A)
  - -VISIR – 11 PNe
    - N band (9 - 14μm)





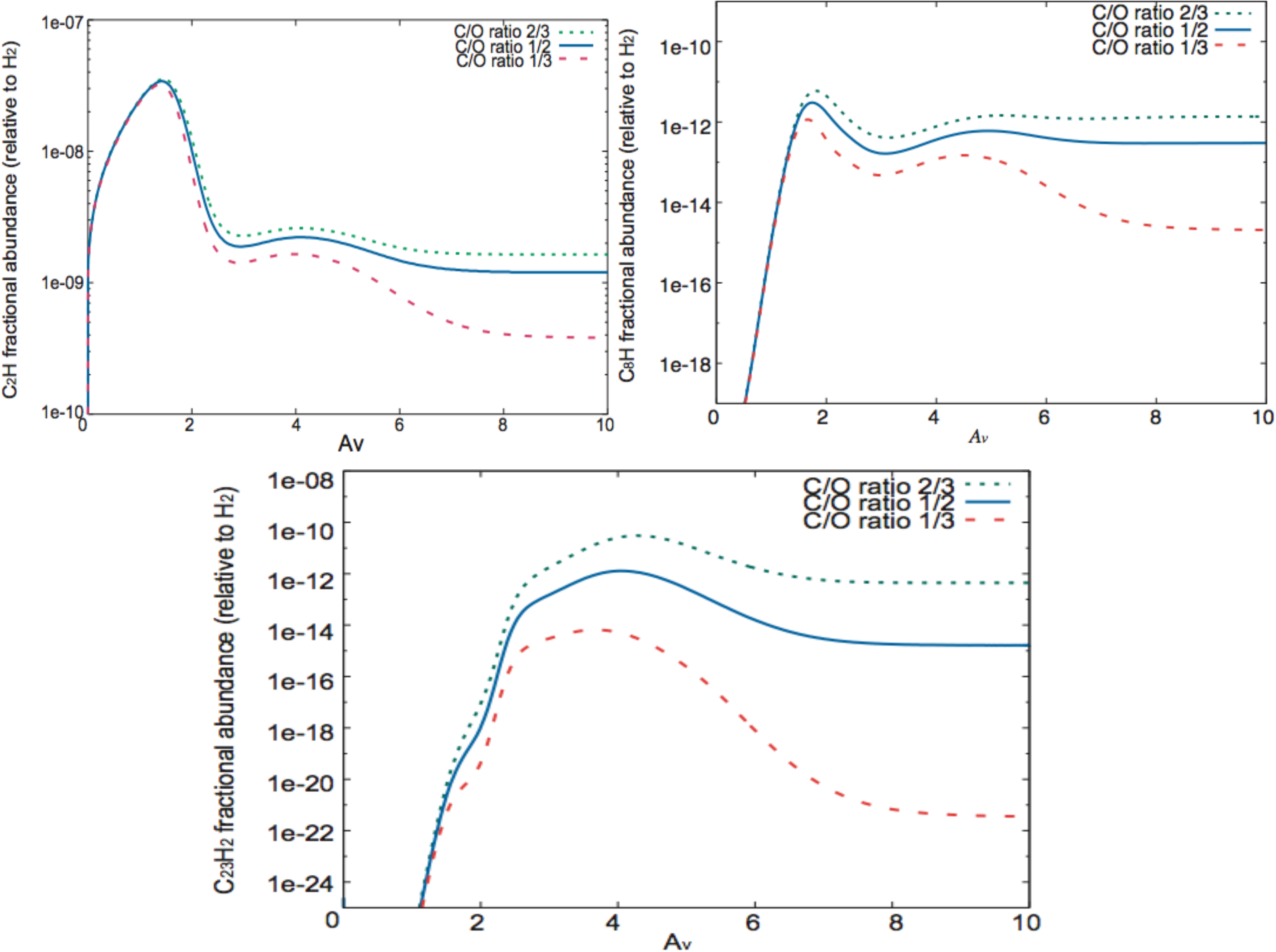




Guzman-Ramirez, L., et al. 201

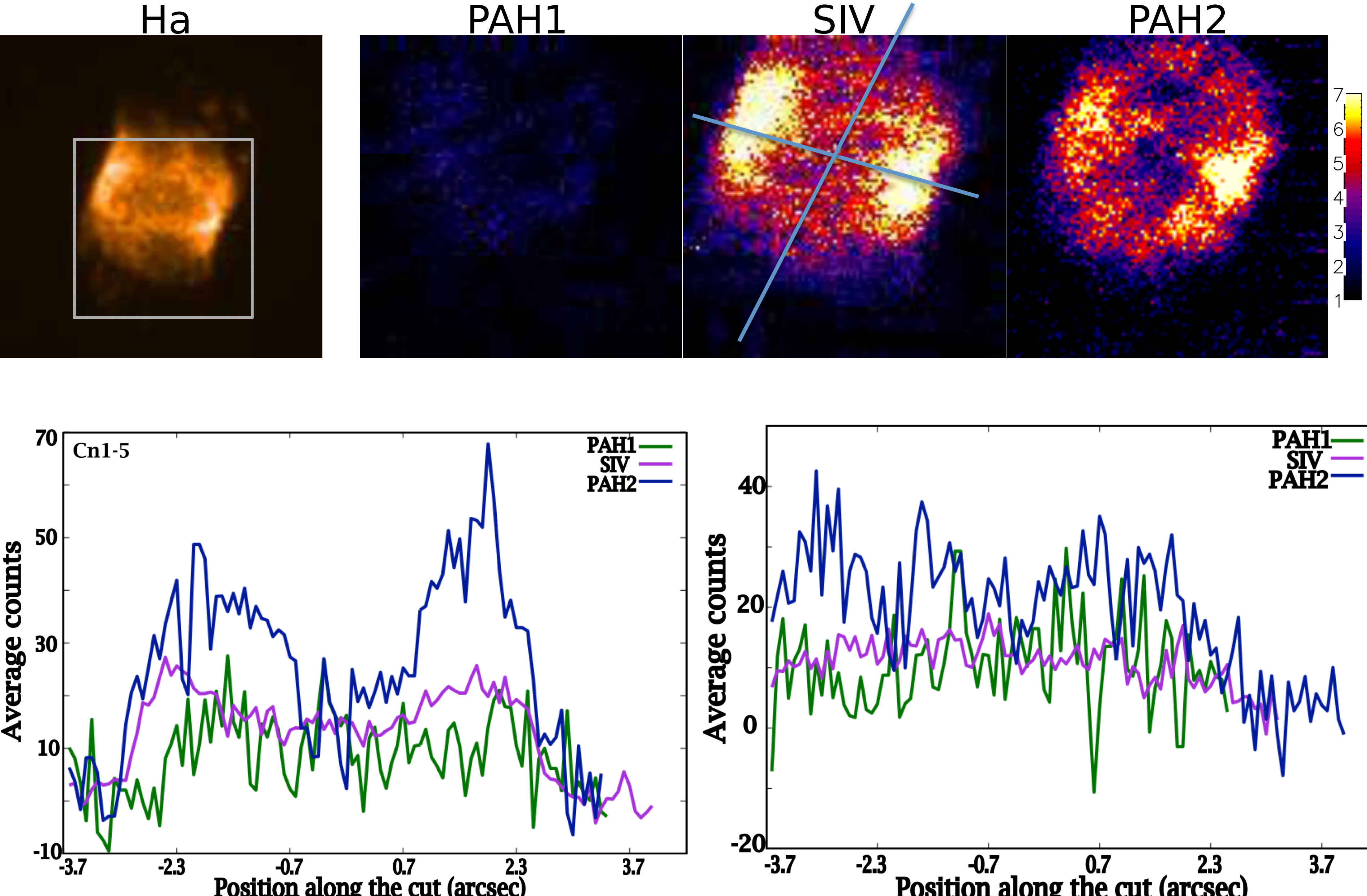
Where does the C comes from?

- Long C-chain molecules in an Oxygen rich environment.
- Ni Chuimin (2009) Meudon 2006 PDR chemistry code.
- Formation and destruction rates for a number of large hydrocarbons chains, up to $C_{23}H_2$, where added.
- Elemental C abundance is kept constant at a value of 1.32×10^{-4} relative to the total H abundance, while the elemental O abundance is varied to give a range of C/O values of 2/3, 1/2 and 1/3.

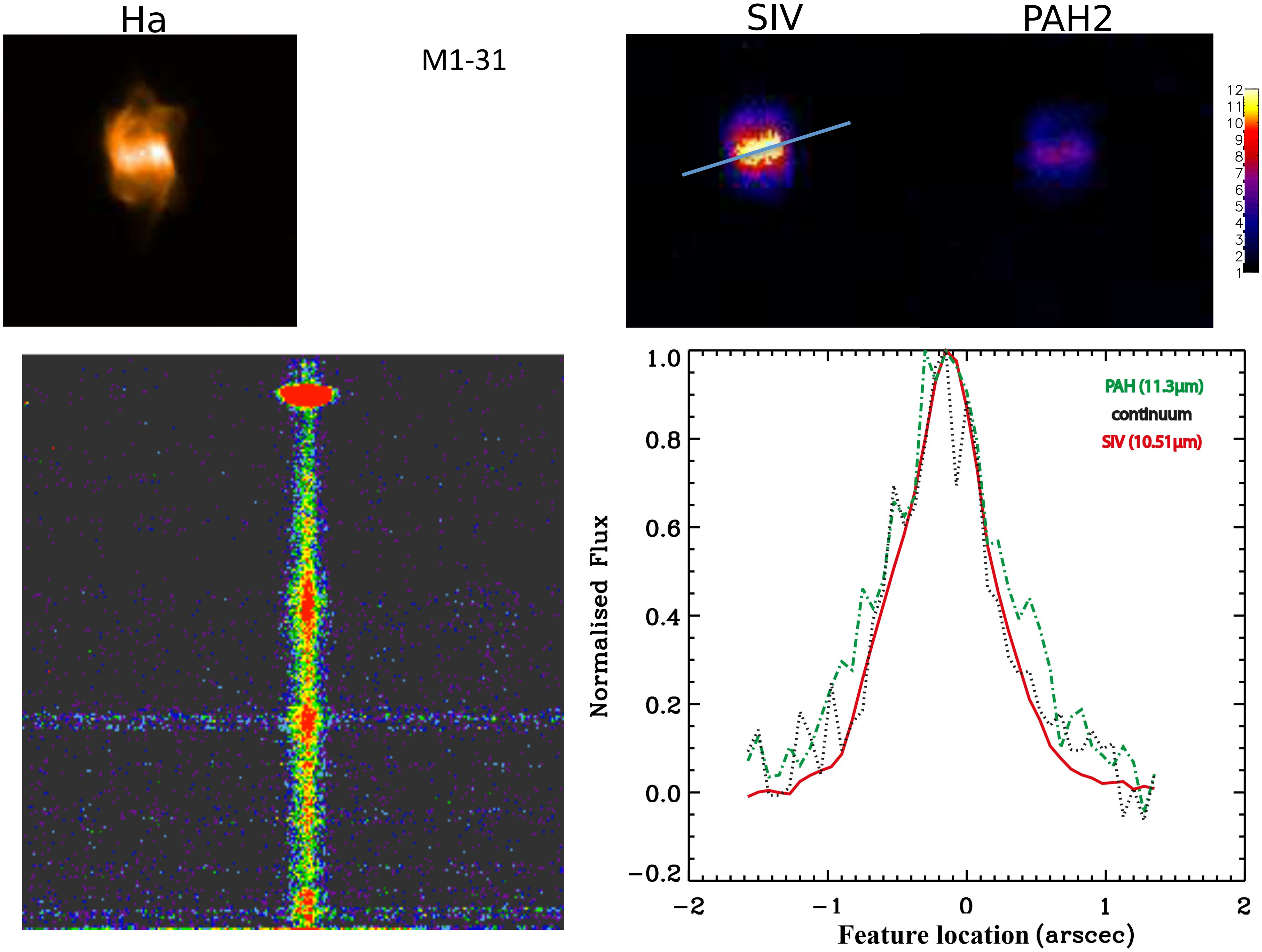

C/O ratio 2/3
C/O ratio 1/2
C/O ratio 1/3
C2H fractional abundance (relative to H2)
1e-07
1e-08
1e-09
1e-10
0
2
4
6
8
10
Av
C8H fractional abundance (relative to H2)
1e-10
1e-12
1e-14
1e-16
1e-18
Av
C23H2 fractional abundance (relative to H2)
1e-08
1e-10
1e-12
1e-14
1e-16
1e-18
1e-20
1e-22
1e-24
Av

VISIR imaging and spectroscopy

- Images of 11 objects using 3 filters: PAH1(8.59μm), SIV(10.49μm), and PAH2(11.25μm).
- Spectra of 3 objects (9.0-13.46μm) split in three filters of the N band, centered at 9.8, 11.4 and 12.4μm (R ~ 350 at 10μm).
  - The long-slit spectrograph gave us an spatially resolved 2D spectra for each object, from which we extracted the PAHs features, the [SIV] emission line and the continuum.



Guzman-Ramirez, L. et al., submitted



Ha
M1-31
SIV
PAH2
12
11
10
9
8
7
6
5
4
3
2
1
PAH (11.3μm)
continuum
SIV (10.51μm)
Normalised Flux
1.0
0.8
0.6
0.4
0.2
0.0
−0.2
−2
−1
0
1
2
Feature location (arscec)

Conclusions

- Strong correlation between strength of the PAH bands and morphology (torus).
- Modeled the formation of large hydrocarbons in an O-rich environment.
- The ionised [SIV] material is located inside the dusty tori, while the PAHs are present at the outer edges of these tori.
- The PAHs are present in the torus and not in the outflows. This confirms that the PAHs formation is must be due to the photoionisation of CO.

Future

- Bipolar morphology
  - Binarity
    - Sample of eclipsing binaries to be observed with SOFIA.
- PAHs
  - SFR, PNe, ISM up to AGNs.
- Planets
  - Observed around new post-common-envelope systems (Beuermann et al. 2010). The torus offers the possibility to form new circumbinary planets very quickly after the common-envelope phase.

ALMA proposals?
Looking for someone to work on the OT?
I’m happy to help and collaborate.

Thanks