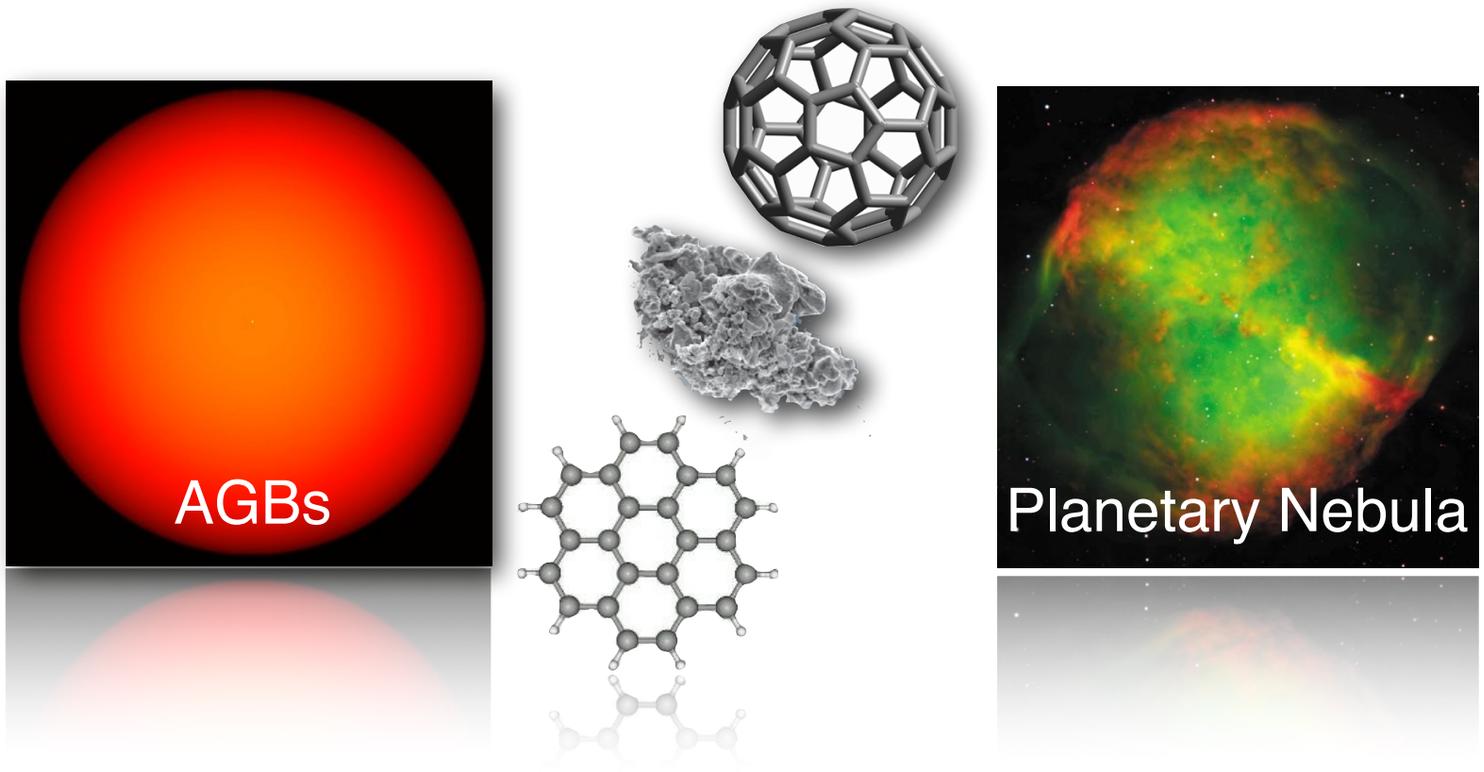
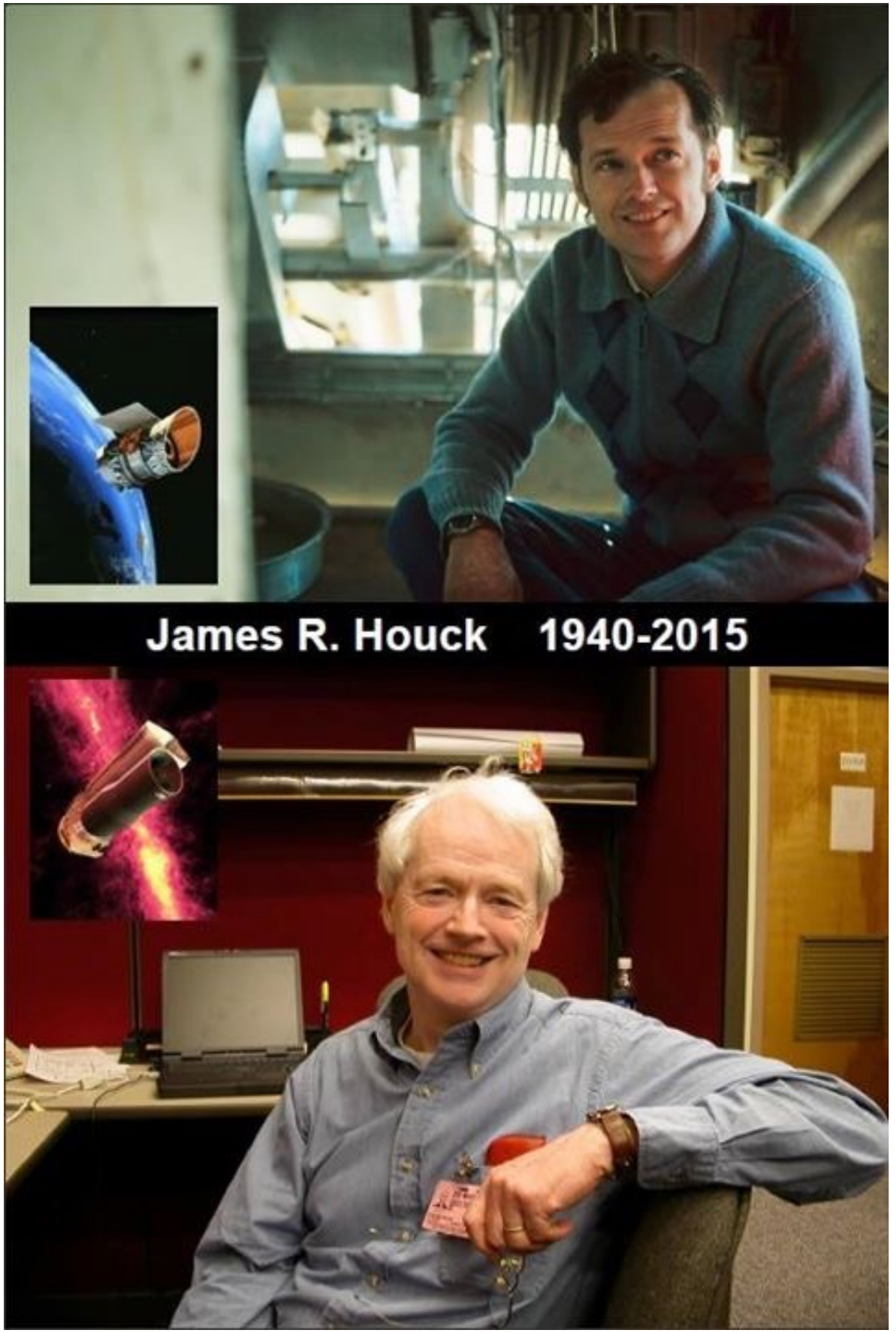
Organic Material in Circumstellar Media

Jeronimo Bernard-Salas

Jan Cami, Els Peeters, Mikako Matsuura, Greg Sloan, Albert Zijlstra



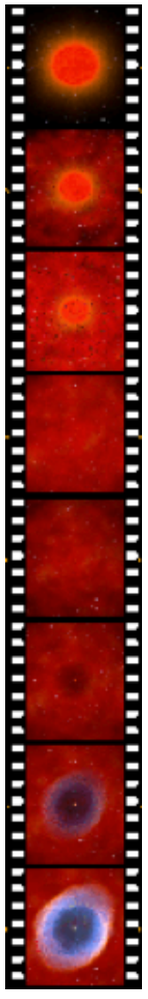
ESA, Oct. 2015


James R. Houck 1940-2015

Organic Diversity

➡ **Origin** & **Evolution** of major mid-IR carbonaceous features not understood!

AGB star



Planetary Nebula

Garcia-Lario+2003

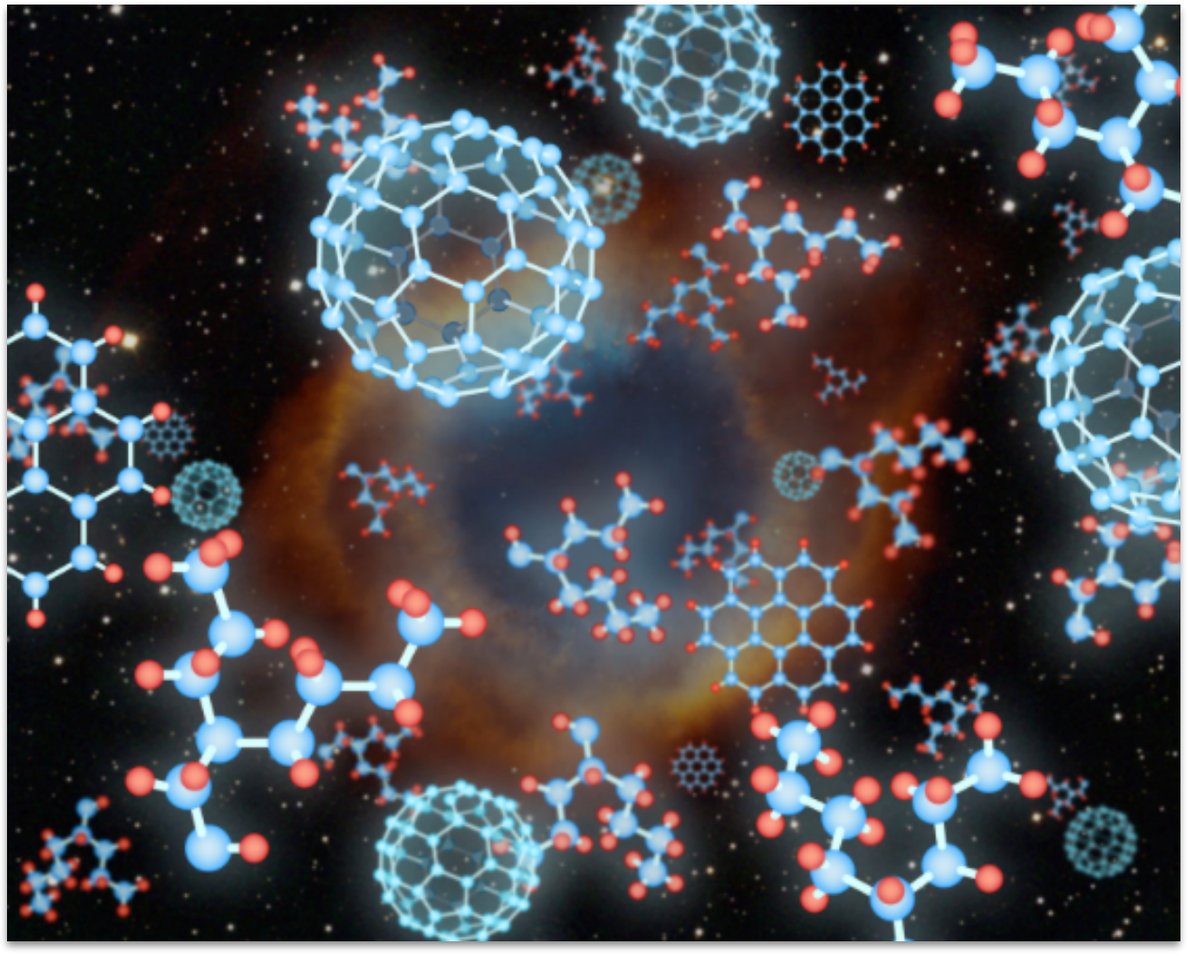


Figure: Pete Marenfeld (NOAO)

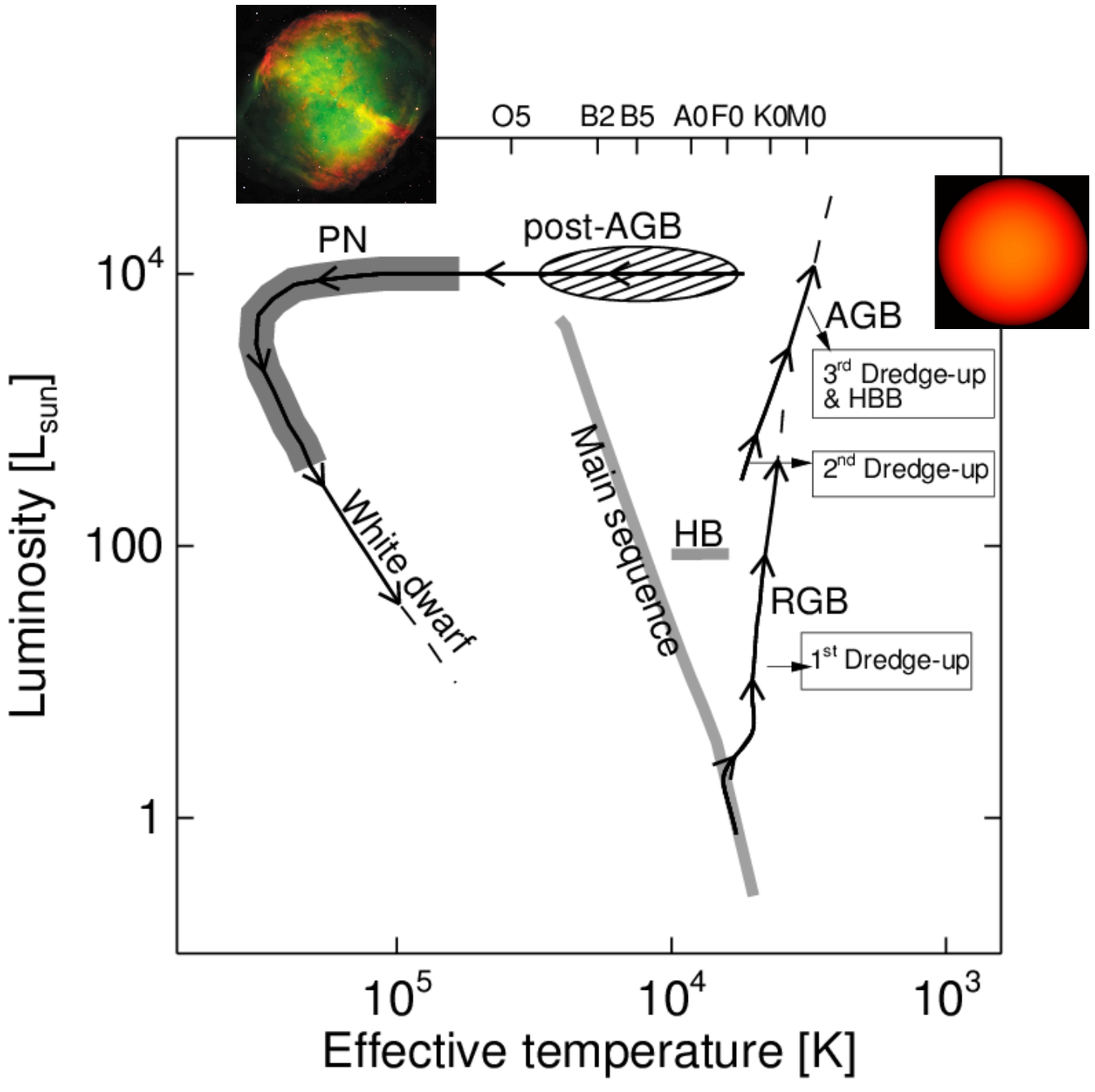
JWST: Self-consistent picture of carbonaceous dust evolution, composition, & production from the AGB to the PNe

Importance of Evolved Stars

- Most active phase of molecular synthesis

- Produce half of new dust in the Galaxy & major organics in space (e.g. PAHs)

- 3rd dredge-up (brings carbon) is important for dust composition



Circumstellar Chemistry

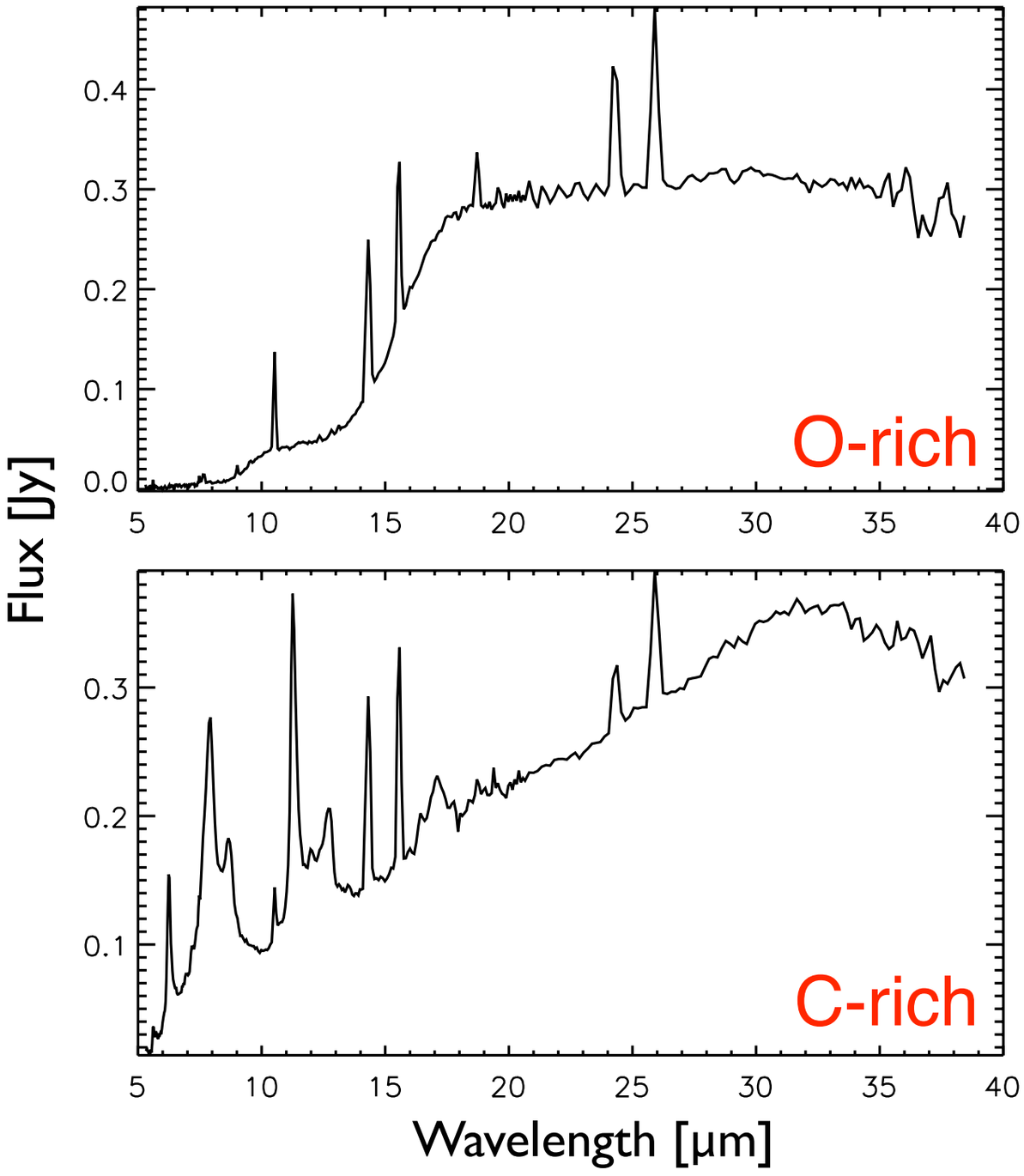
C/O<1

- All carbon in CO
- Extra oxygen ➔ O-rich molecules (amorphous/crystalline silicates)

C/O>1

- All oxygen in CO
- Extra carbon ➔ C-rich molecules (C_2H_2, PAHs, SiC, fullerenes…)

Beware: Some objects show dual chemistry!

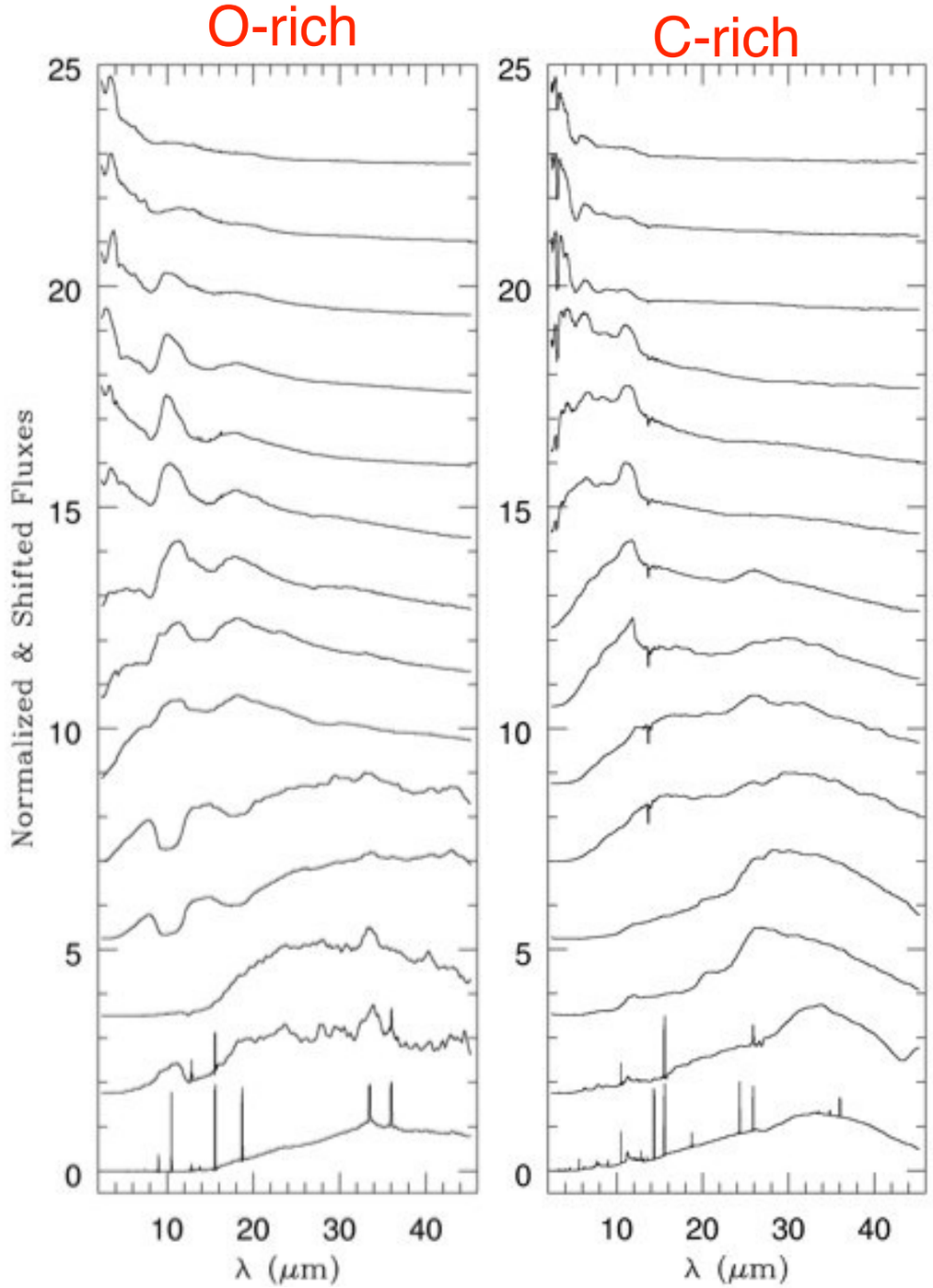


Circumstellar Dust Evolution

Dust changes as:

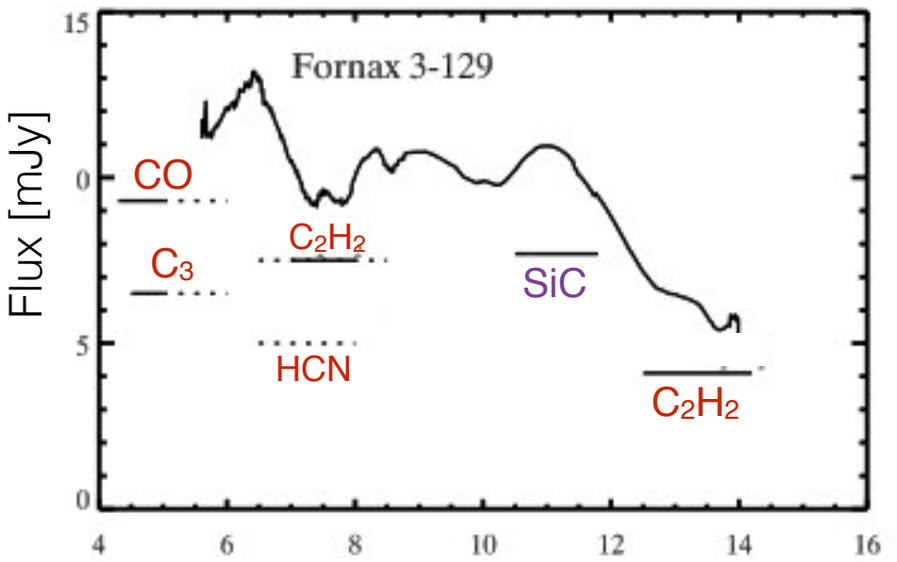
- Increase mass loss rate
- Gradual cooling of circumstellar envelope
- Strong evolving UV radiation field

Garcia-Lario et al. (2003)
Garcia-hernandez et al. (2012)



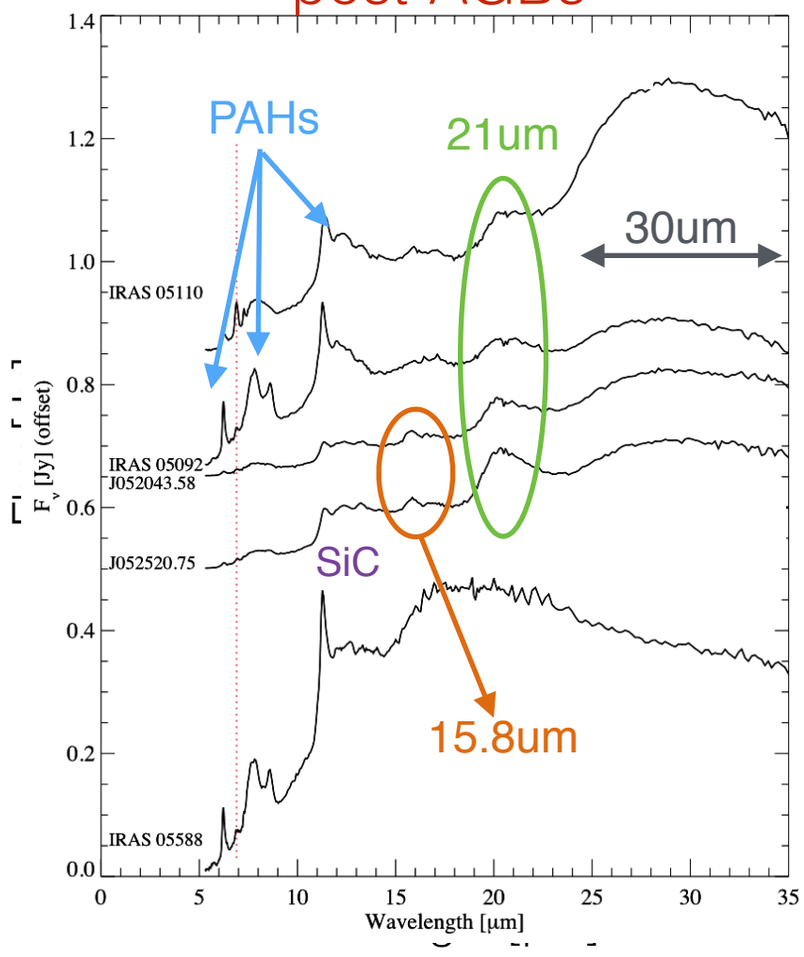
Carbon Chemistry?

AGBs

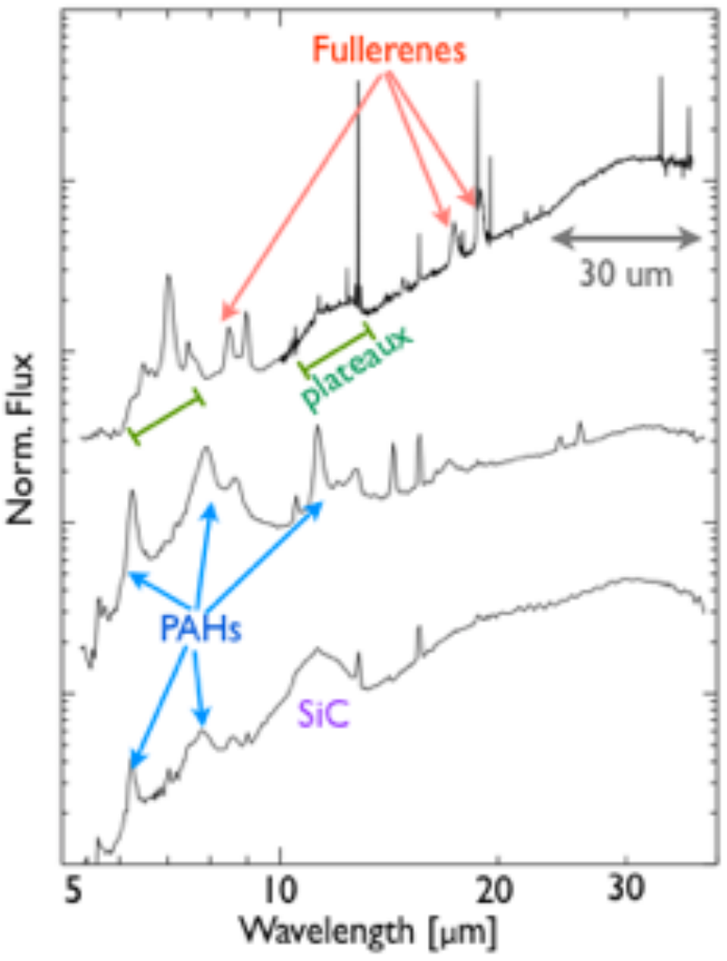


References: Matsuura et al. (2007; 2014), Sloan et al. (2014), Bernard-Salas et al. (2012)

post-AGBs



PNe



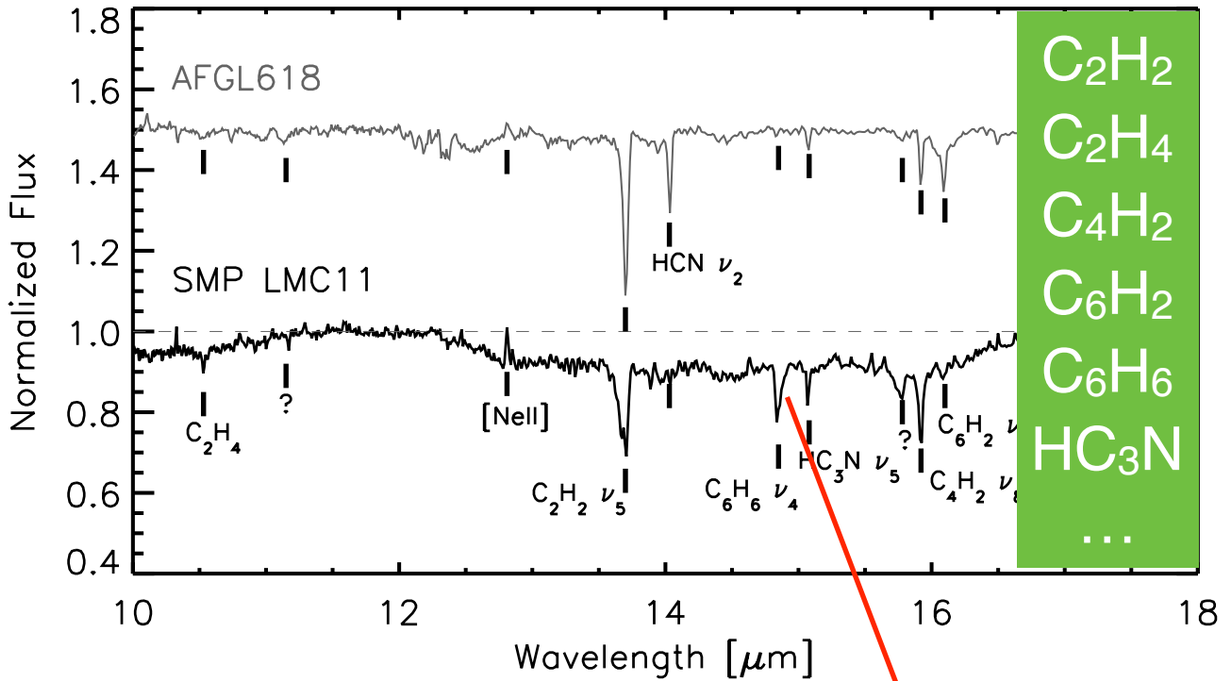
What is the origin of this diversity?

How do the species form & evolve, are they linked?

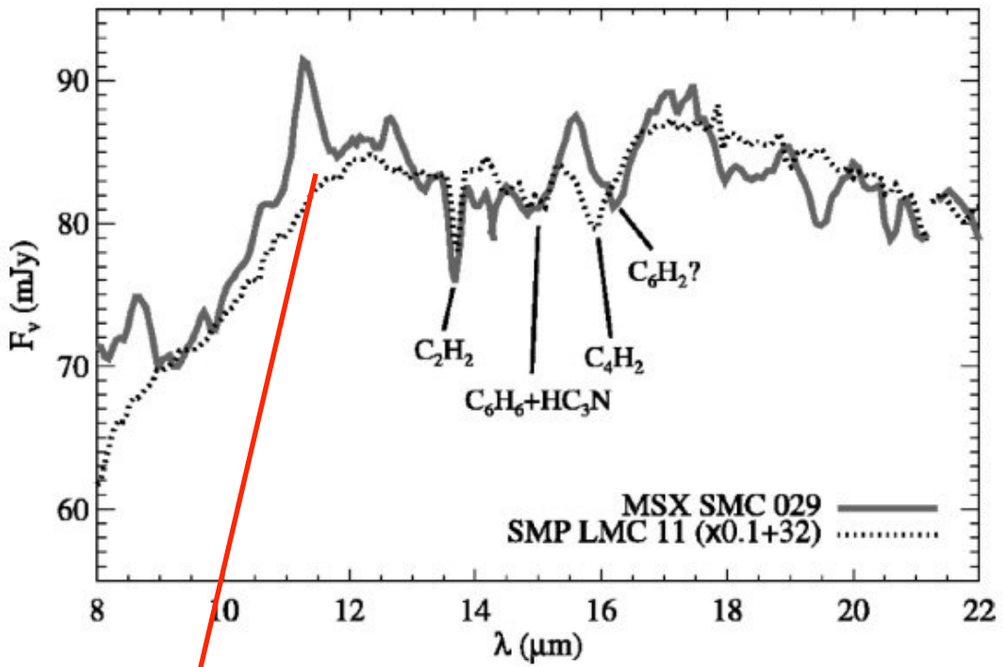
What's their dust composition and production over cosmic time?

How are PAHs formed?

Detection of the basic PAH components, and freshly produced PAHs!

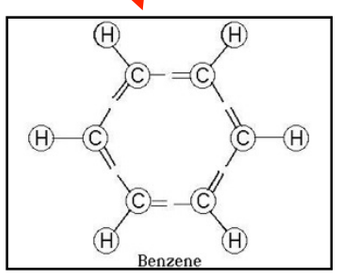


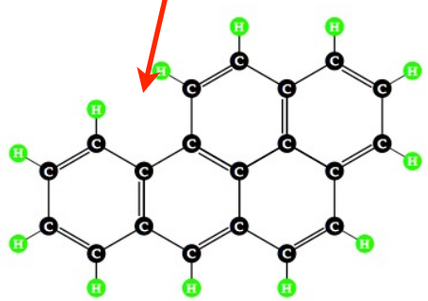
Cernicharo et al. (2001)
Bernard-Salas et al. (2006)



Kraemer et al. (2006)

Benzene





PAHs

JWST: Spectroscopically resolve the overlapping bands
Can we pinpoint this short phase of evolution (sizeable sample)?

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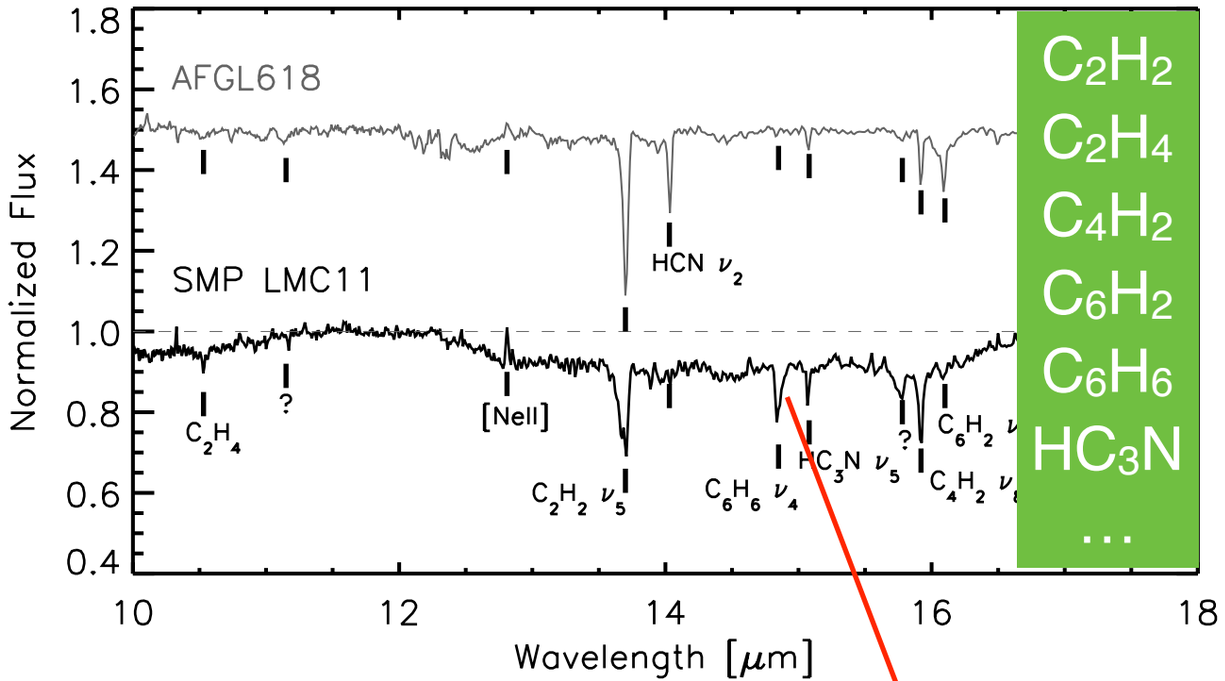

Cernicharo et al. (2001)
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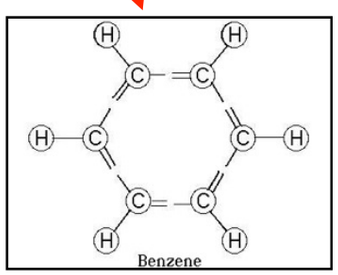
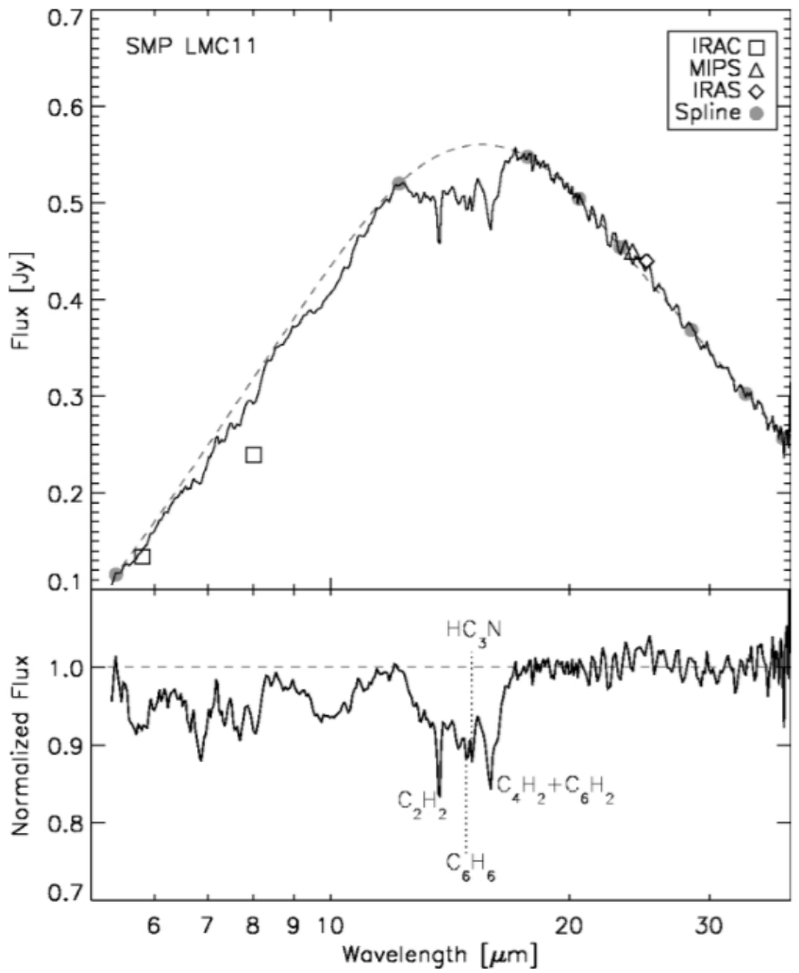
Benzene



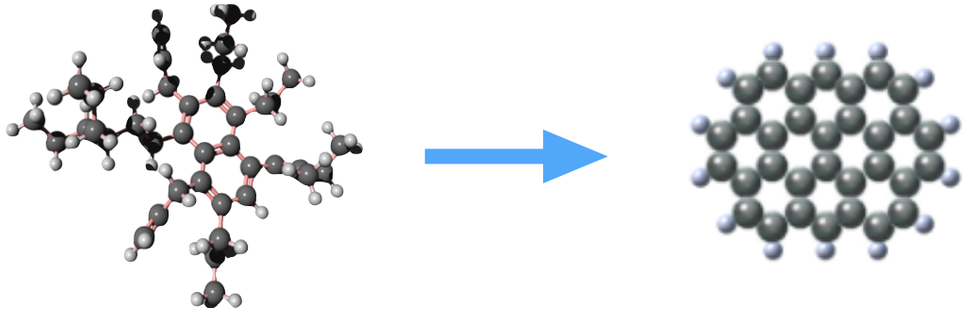


Bernard-Salas et al. (2006)

JWST: Spectroscopically resolve the overlapping bands
Can we pinpoint this short phase of evolution (sizeable sample)?

How do PAHs evolve?

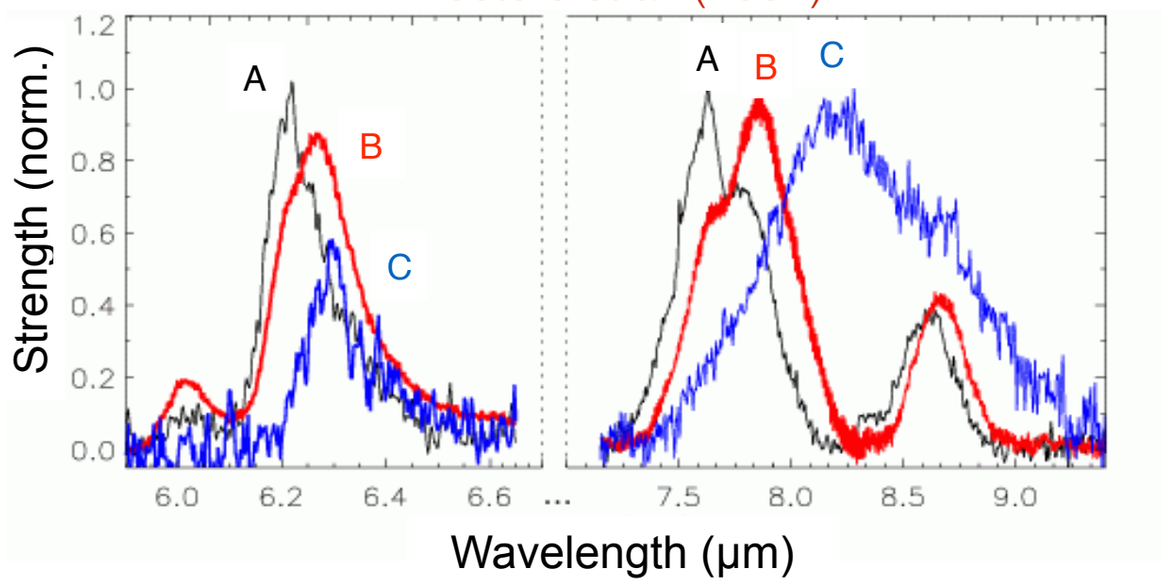
- Fresh PAHs belong to class C
- PAH profile correlates with T_{eff}
- Are we seeing photo-processing aliphatic to aromatic?

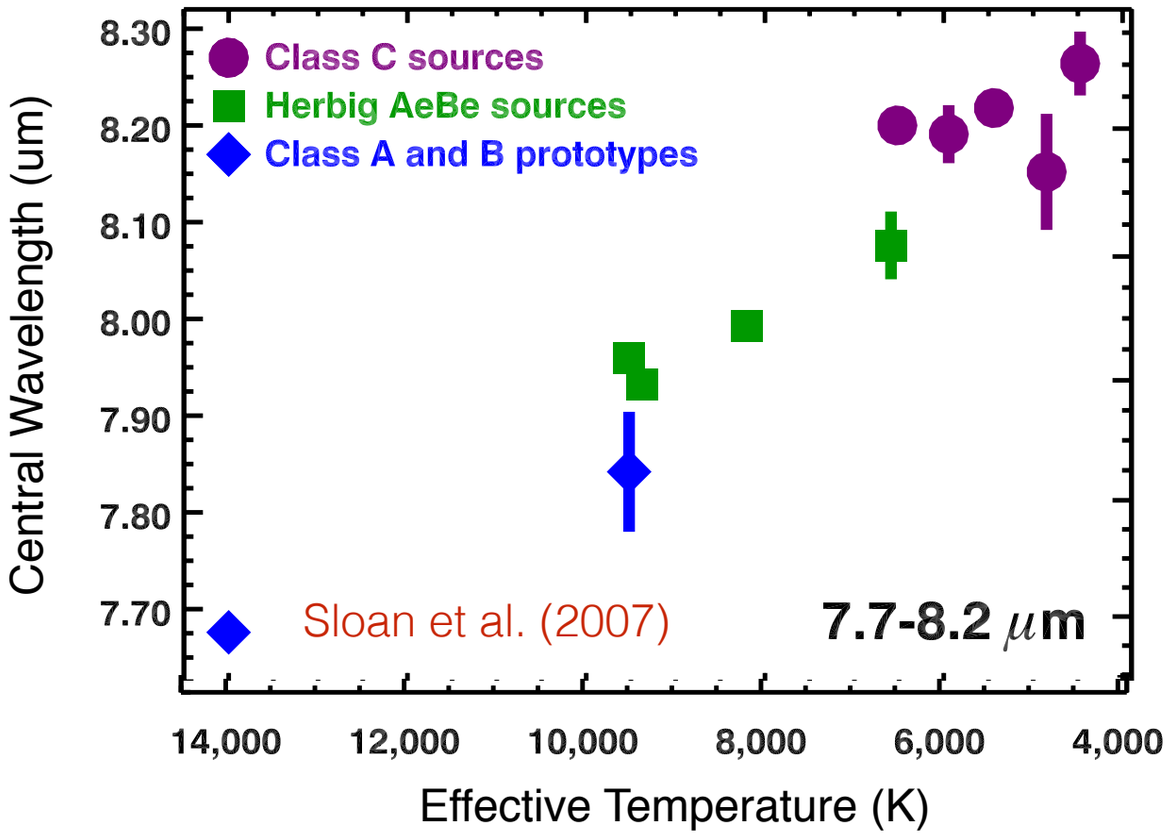


JWST

- Excellent resolution to characterise PAH profile
- Spatial information to follow PAH evolution (evolved stars & protoplanetary disks)
- Better study of aromatic/aliphatic bands: 3.3/3.4um (but also 6.9, 7.2um)

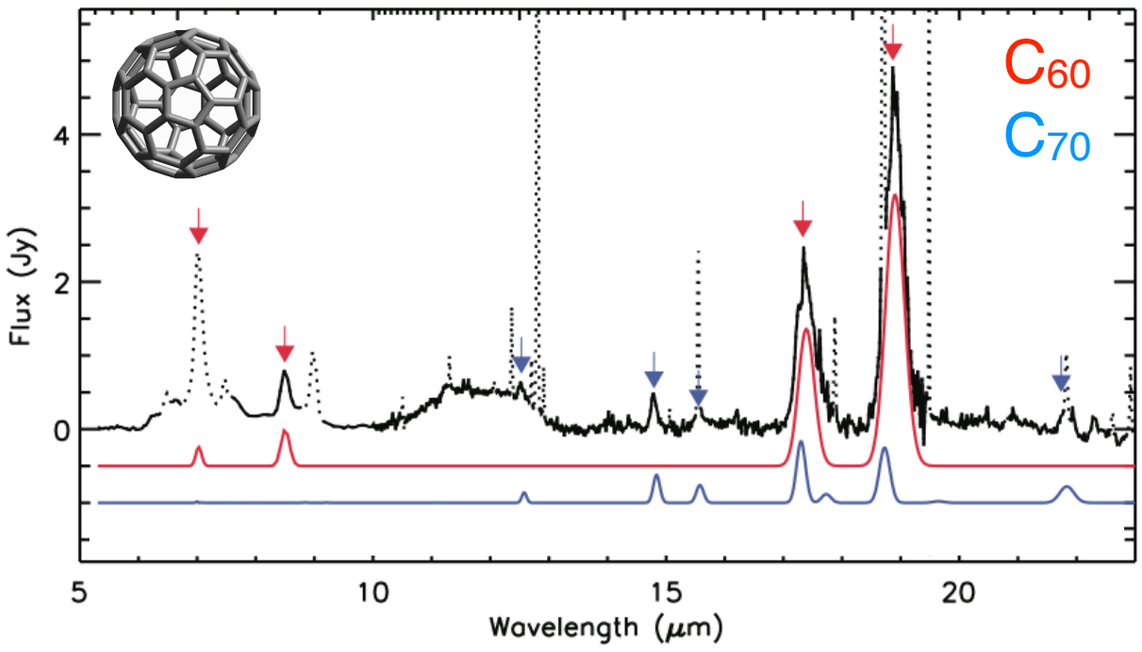
Peeters et al. (2002)



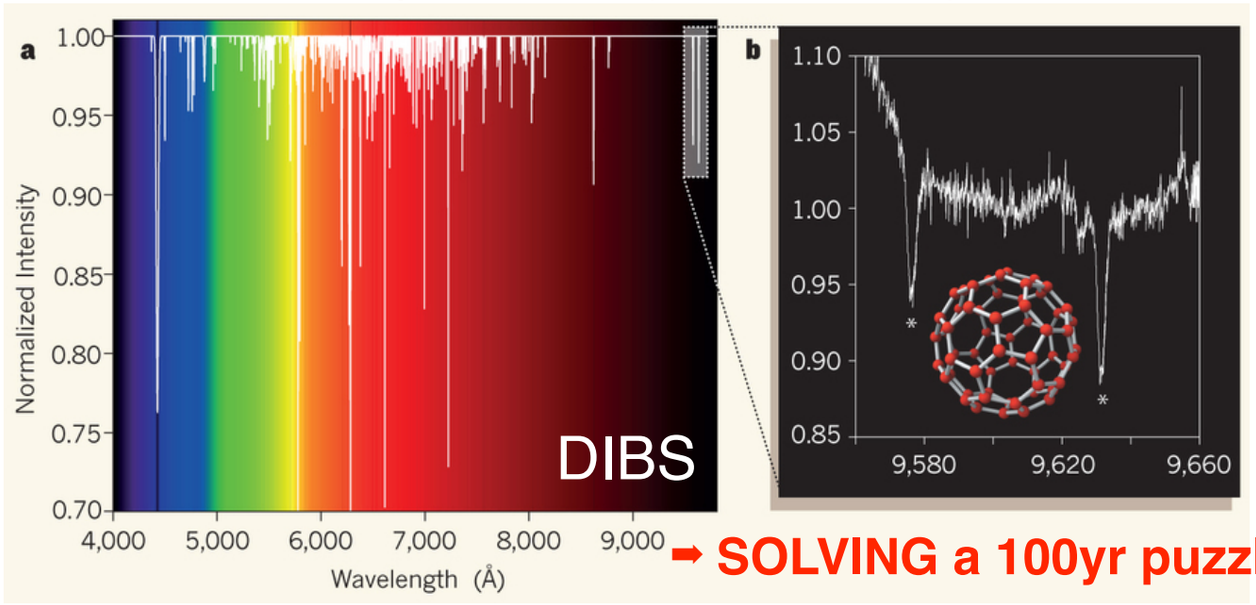


Fullerenes Everywhere

Cami, Bernard-Salas et al. (2010, Science)



Campbell et al. (2015, Nature)



➡ **SOLVING a 100yr puzzle**

Figure: Ehrenfreund & Foing (2015, Nature)

post-AGBs, PNe, HII regions, Reflection Nebulae, Stars, YSOs

JWST

Will detect fullerenes in many environments: establish its role in circumstellar and interstellar media

How are they formed / excited?

How do large organics form?

➡ Do large molecules arise from **Bottom-Up** or **Top-Down** chemistry?

Fullerene are located in a **ring** around the central star!

Cami et al. (in prep.)

JWST: Physical conditions at fullerene location (across nebula) to establish its formation/excitation & link to other dust features

Carbon-dust evolution?

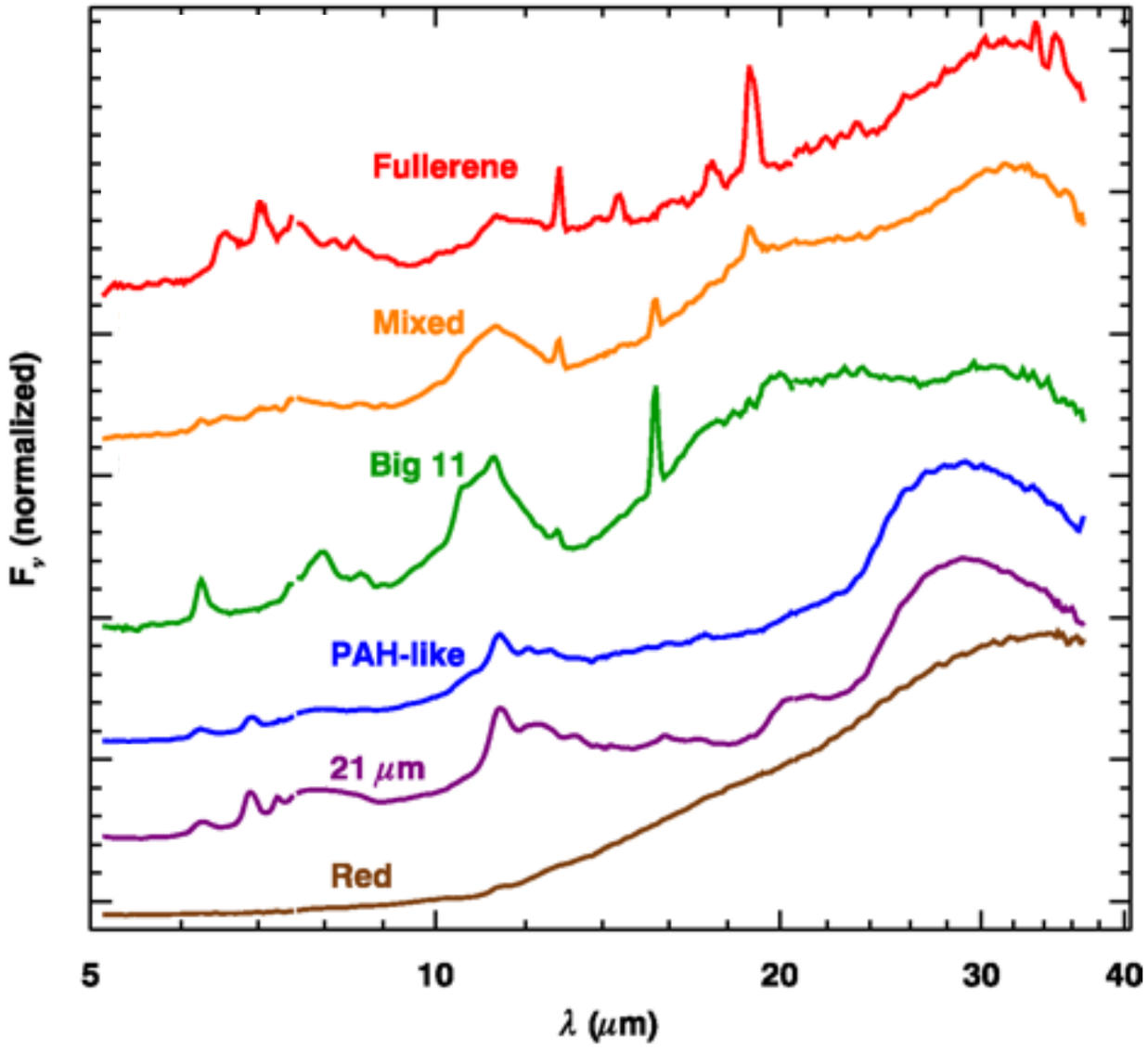
➡ Low metallicity favours production of **carbon rich dust** by AGB stars

- Very diverse chemistry
- There are observational links between features

We need a consistent picture for carbon-dust chemistry

JWST

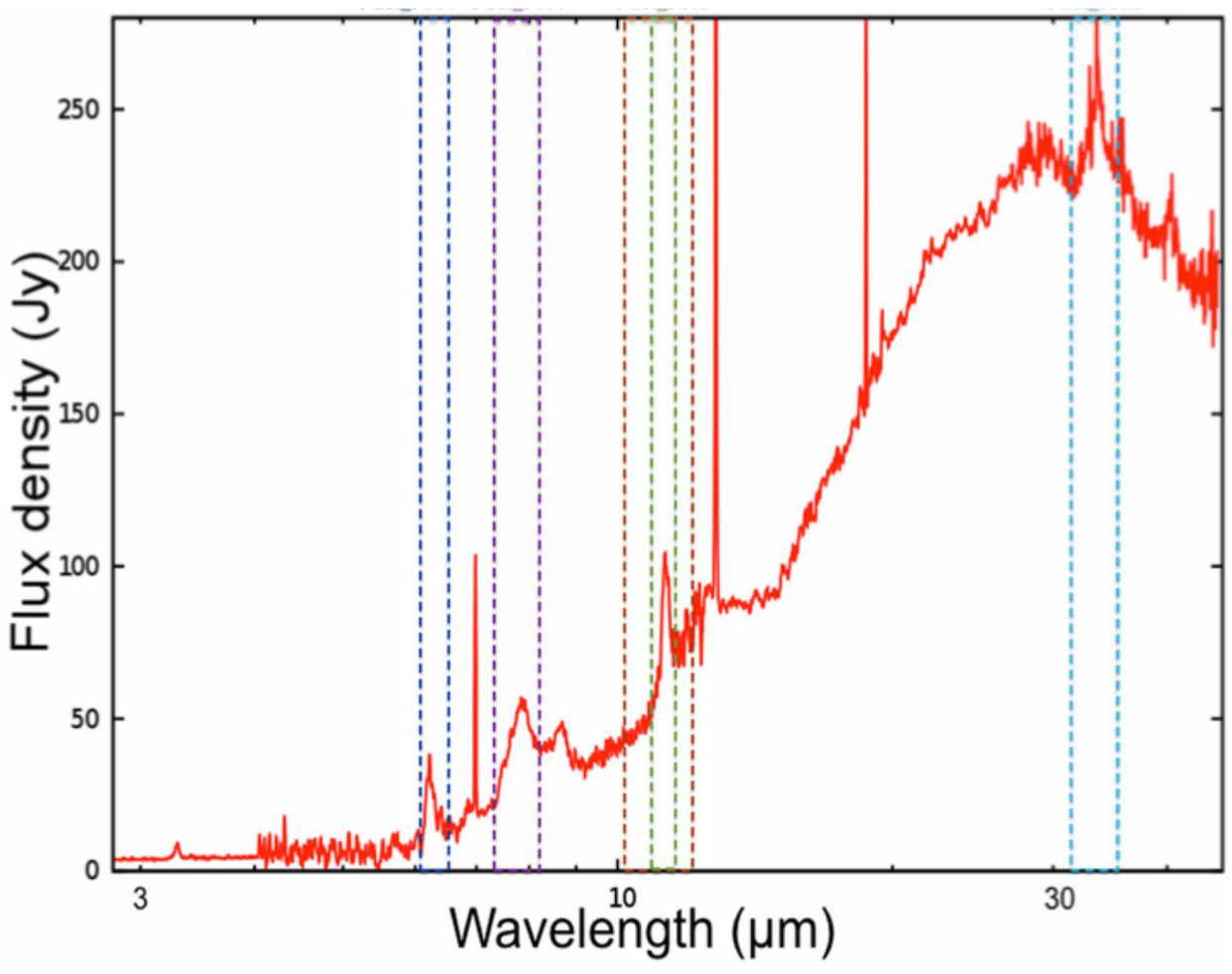
- Replicate LMC/SMC studies in a wide parameter space (**Local Group**)
- Homogeneous study of dust composition vs metallicity (M33…)
- High resolution to exploit diagnostic information from blended bands
- Access 3um region: aliphatic/aromatic



Sloan et al. (2014)

Origin of dual Chemistry?

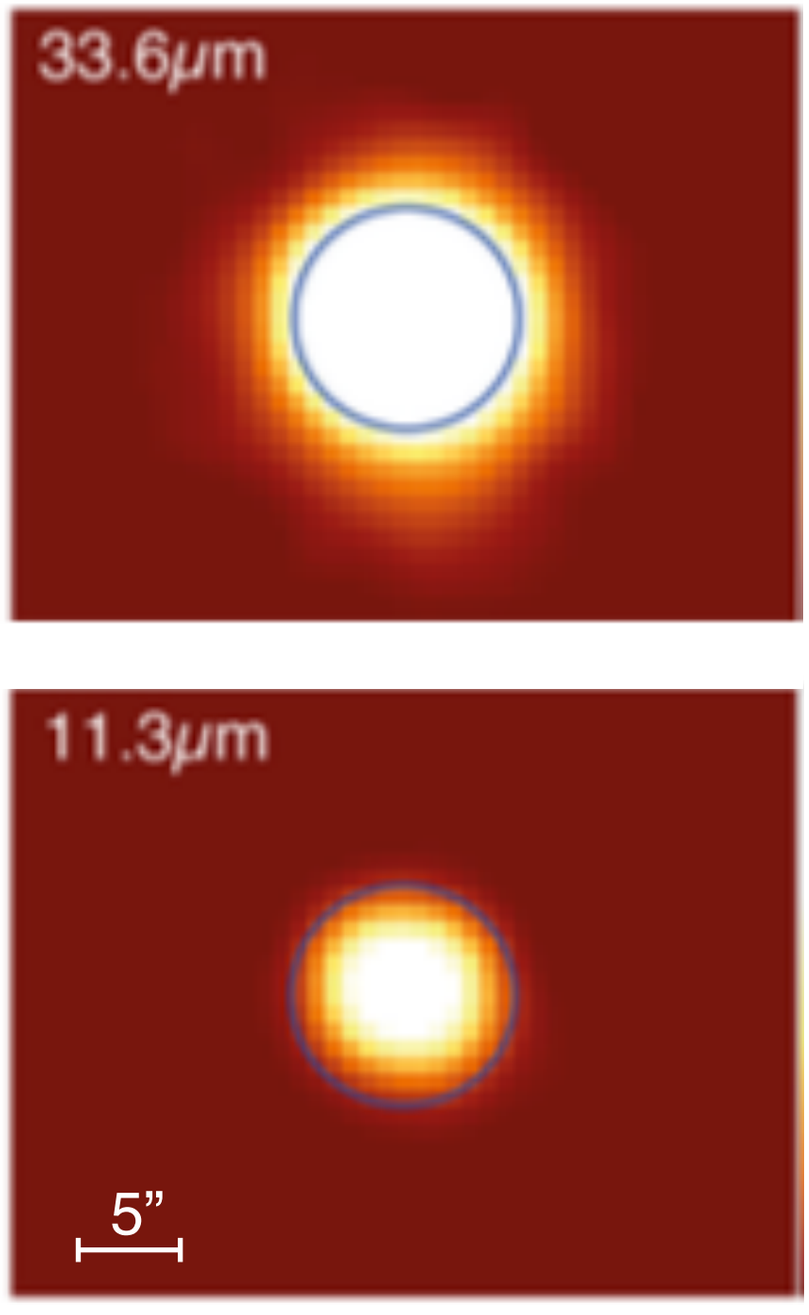
Emergence of a carbon star (BD+30 3639)



But filter at crystalline feature also contains dust

JWST: Spatially resolve carbon-rich (PAHs) and oxygen-rich (silicates 20, 22, 28um) dust to establish their origin

SOFIA



Guzman-Ramirez et al. (2015)

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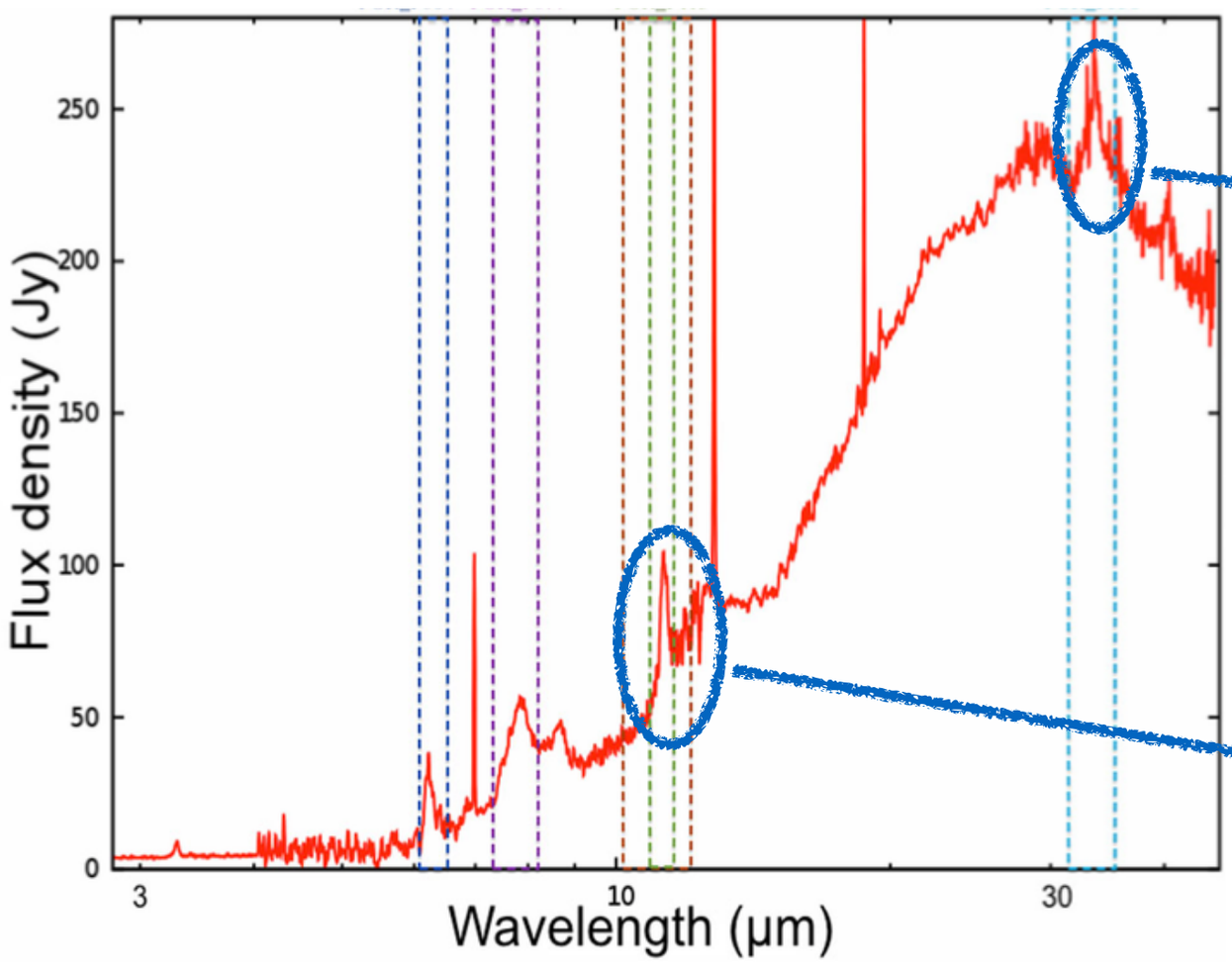

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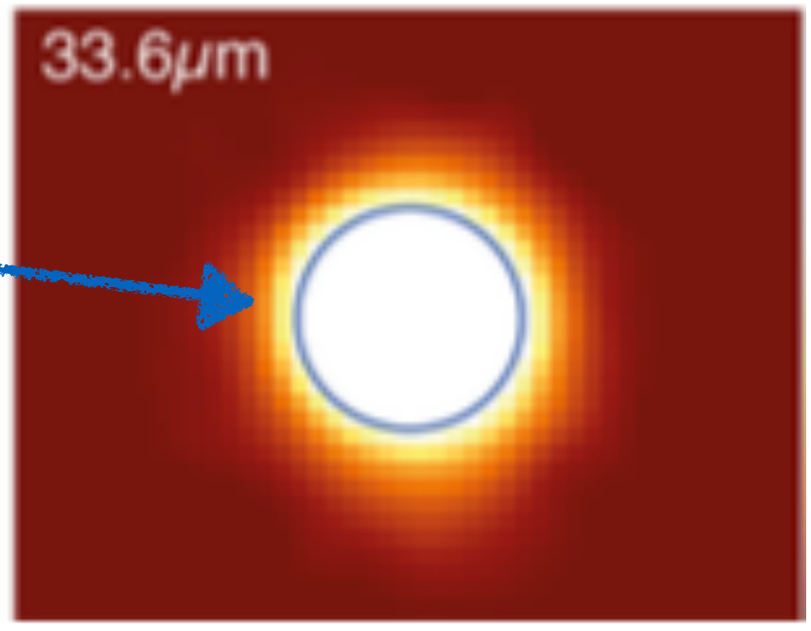

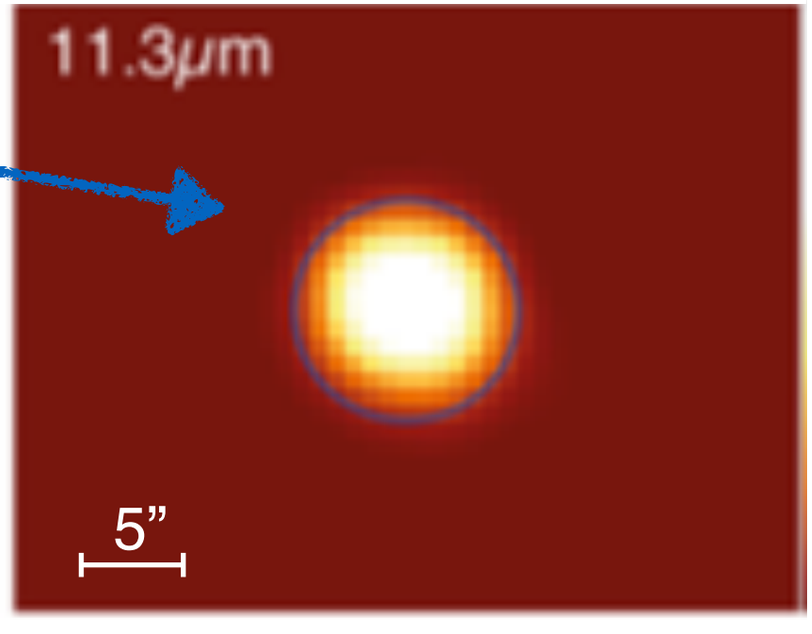

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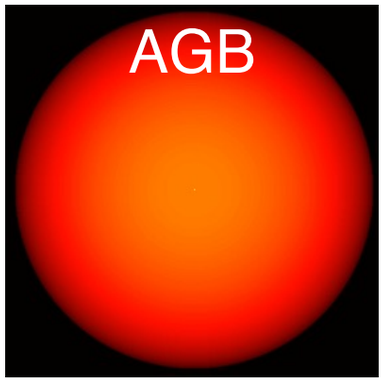
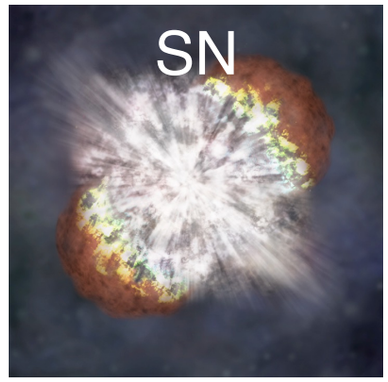
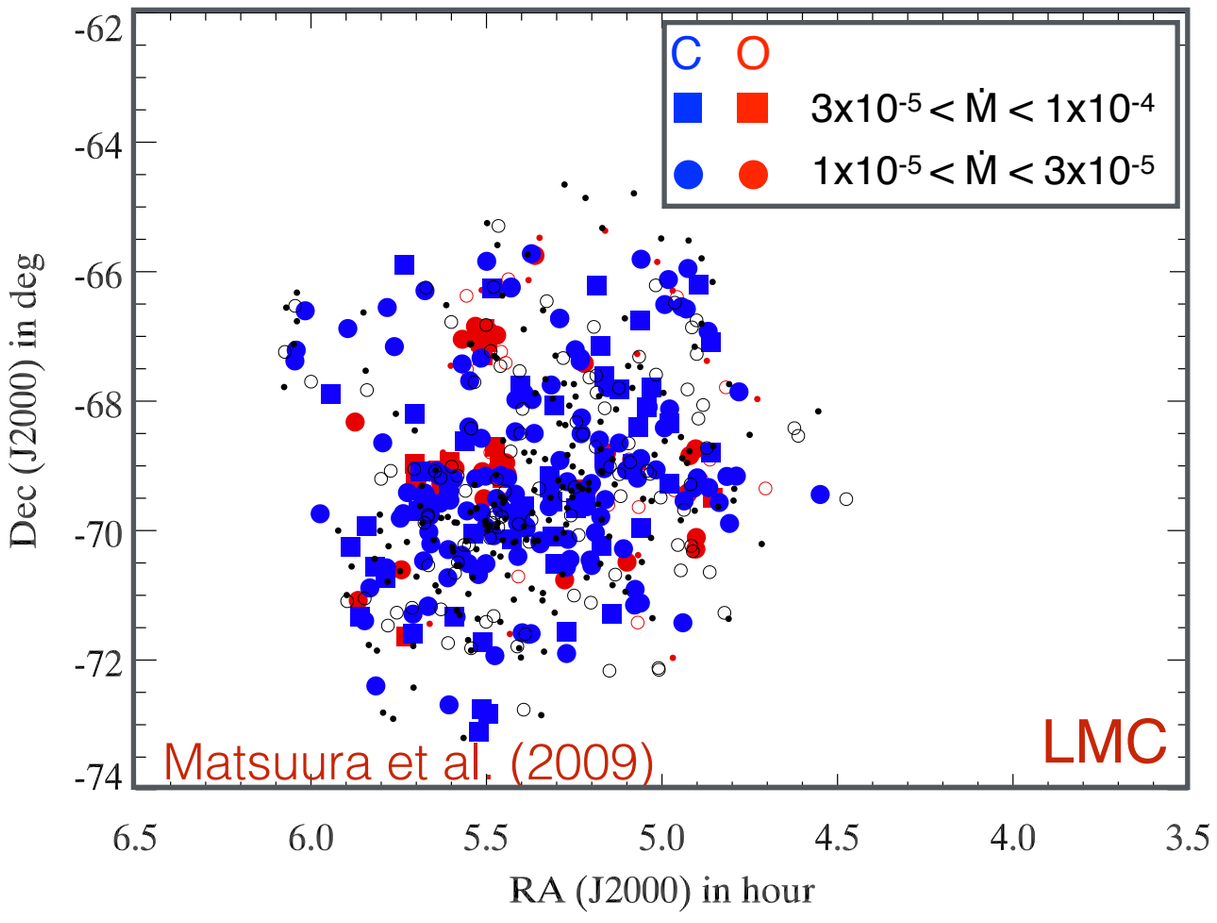


Dust production?





AGBs dominate dust production in the Milky Way (Gehrz 1989)

Spitzer: 1st dust production census from evolved stars in a galaxy (LMC): AGB dust << ISM dust

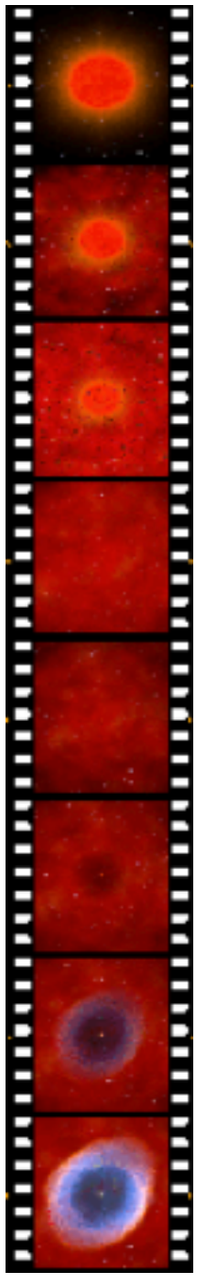
See also Zhukovska+2013, Boyer+2012/15

M. Boyer DUSTiNGS
Poster #SMP12

JWST

- Comprehensive survey of AGB dust production at different metallicities in Local Group
- Spatial distribution of dust sources in galaxies & compare to ISM dust
- Characterise dust produced by evolved stars at high-z by looking at dwarf irregulars

Summary: JWST



Understanding of the carbon-chemistry in evolved stars

- ☑ PAH evolution
- ☑ Fullerenes
- ☑ Double Chemistry
- ☑ Organic diversity
- ☑ Effects of metallicity
- ☑ Dust Production