Projet P2IO JWST
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Nano carbon dust emission in proto-planetary disks: the aliphatic-aromatic components

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Nano carbon dust emission in proto-planetary disks: the aliphatic-aromatic components

Dust plays a role in:

- The formation of molecules
- The thermal balance: gas heating / cooling
- Disk dynamics: structure and formation of planets

These roles depend on its properties and therefore on its composition.

Outline

- Dust in interstellar and circumstellar media
- Its composition and signatures
- Proto-planetary disk and how to probe it

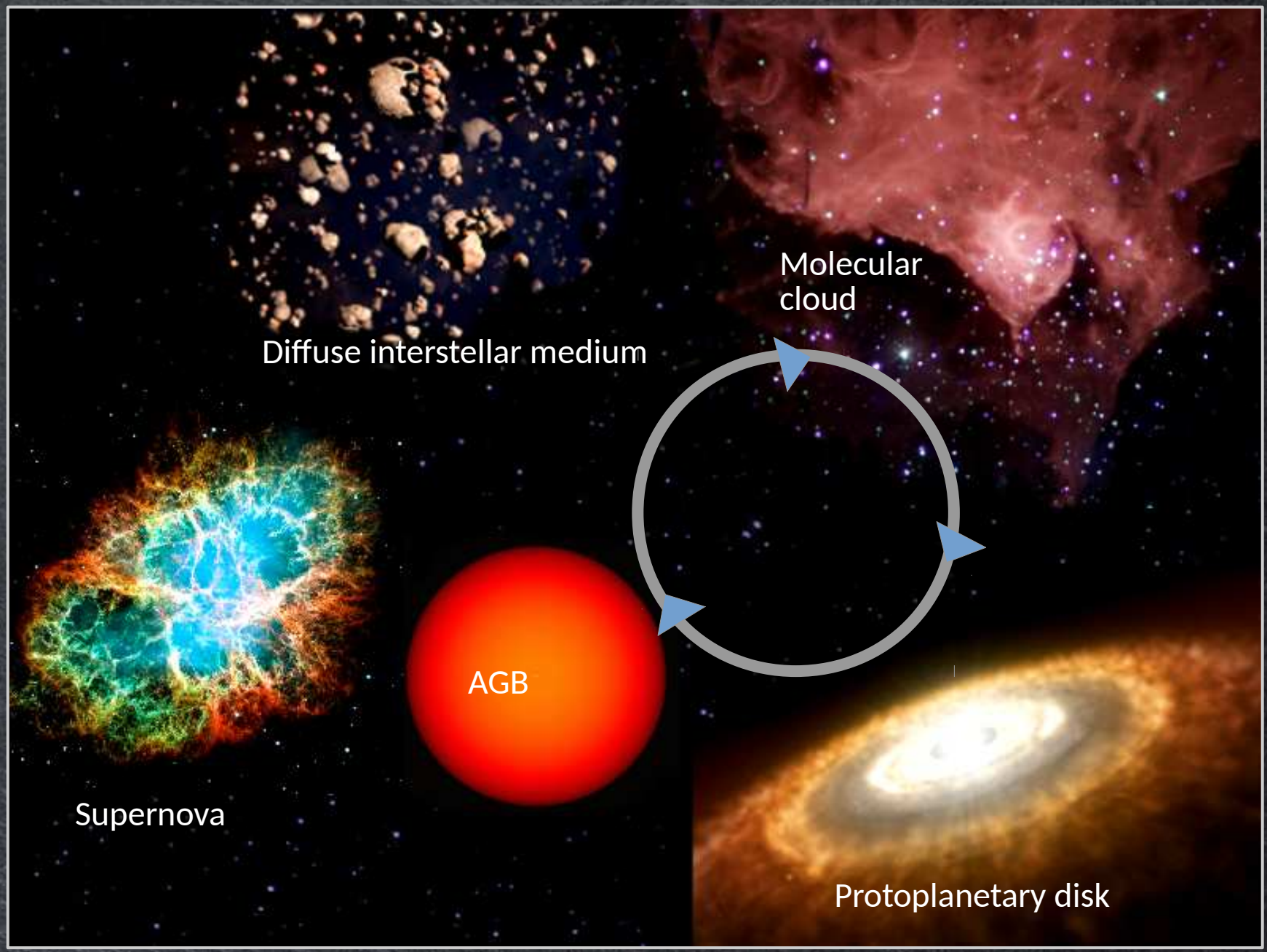
- Observation and decomposition

- Results : dust properties at the disk surface

- Comparison with the THEMIS model

- Summary
- Outlook

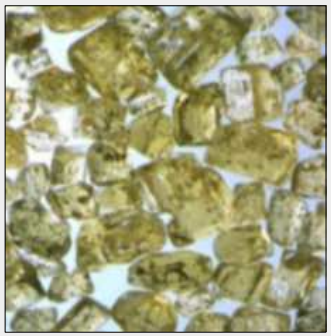
Gas and Dust - The Dust cycle in the Galaxy



What is interstellar dust made of?

« refractory » solids

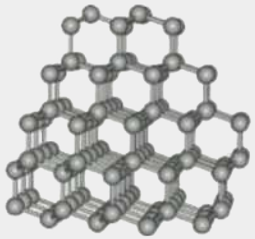
« volatile » solids



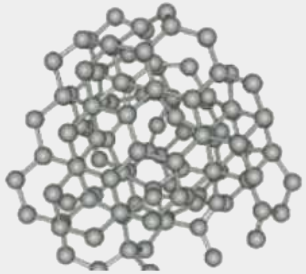
Silicates

Carbonaceous materials

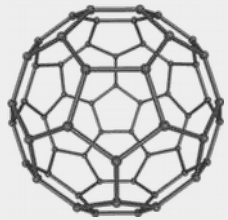
Ice mantle



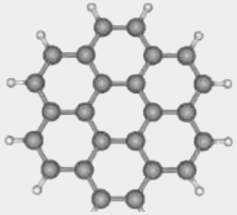
Nano-diamonds



a-C(:H)

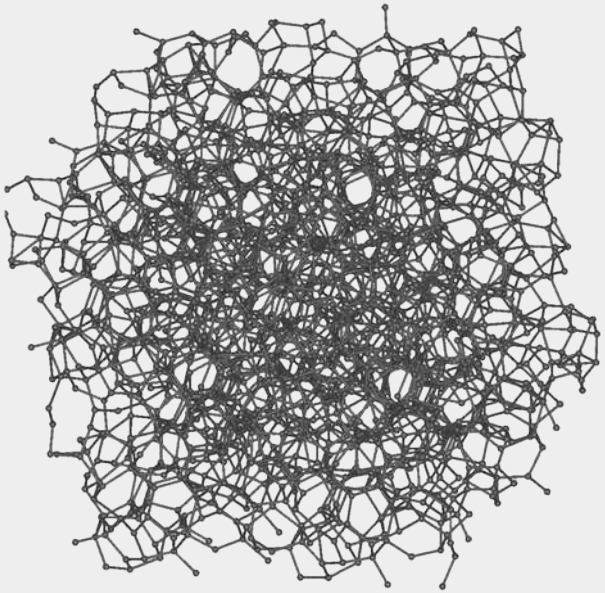


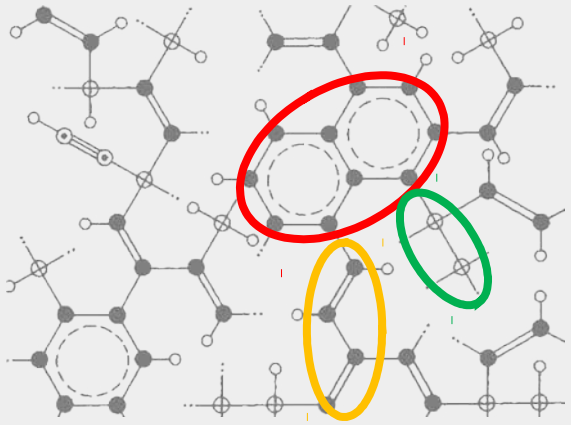
Fullerenes



PAH

What is carbonaceous dust made of?



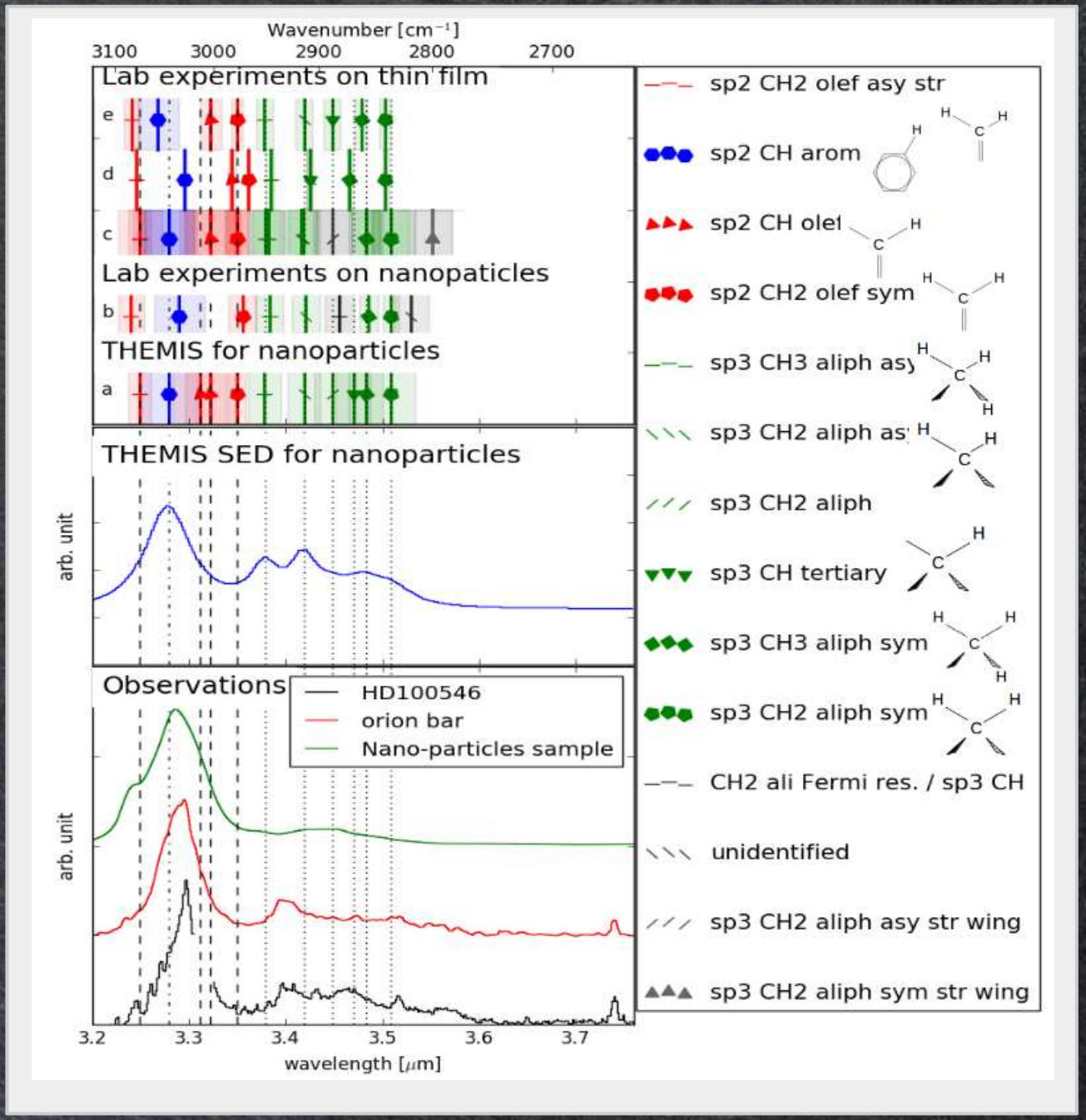


Aromatics

Aliphatics

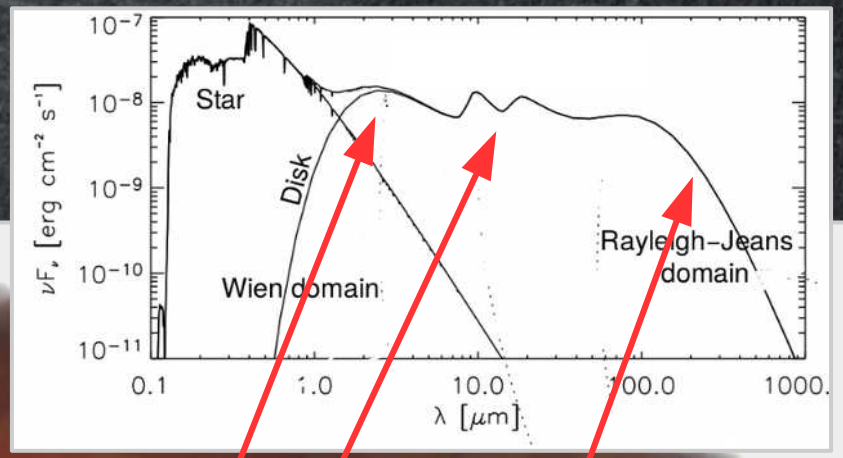
Olefinics

Dust signatures in the 3-4 µm-range

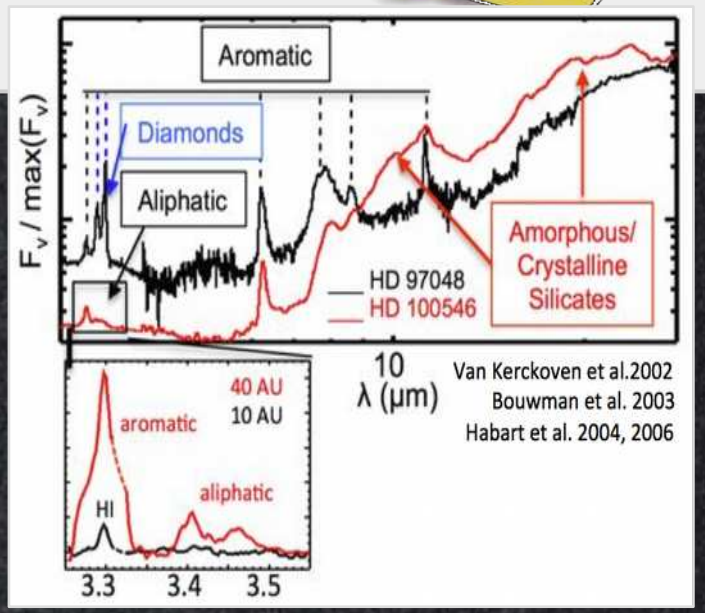


Proto-planetary disk and how to probe it

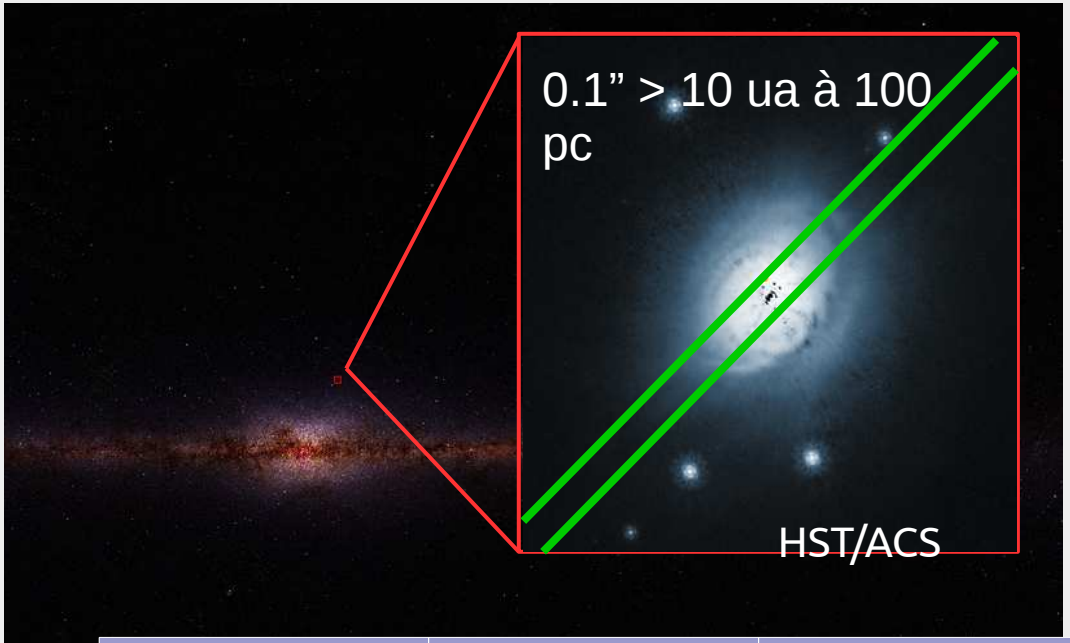
- Made of gas and dust (90/10)
- Orbiting the central star
- More or less flared



- Hot surface VS cold interior
- Small grains of dust coupled to gas and present at the surface
- Large grains settle in the median plane

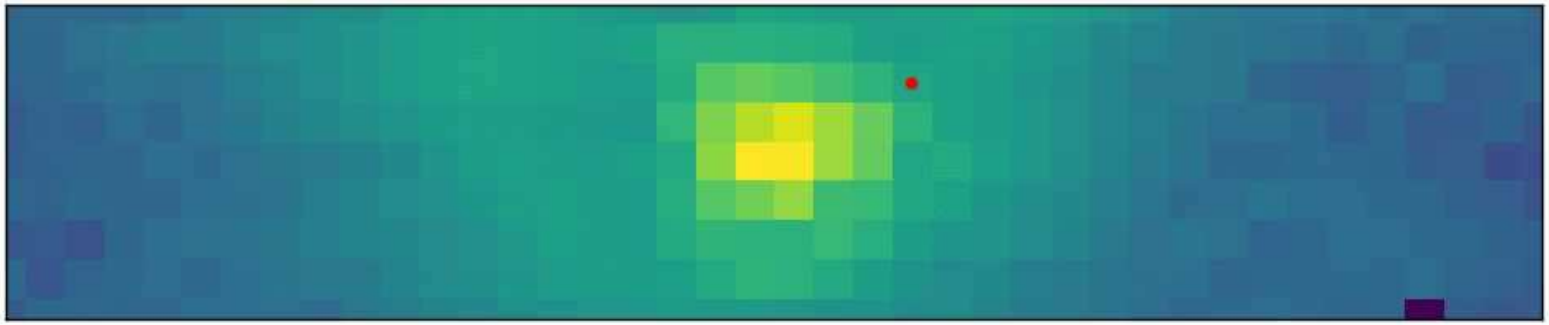


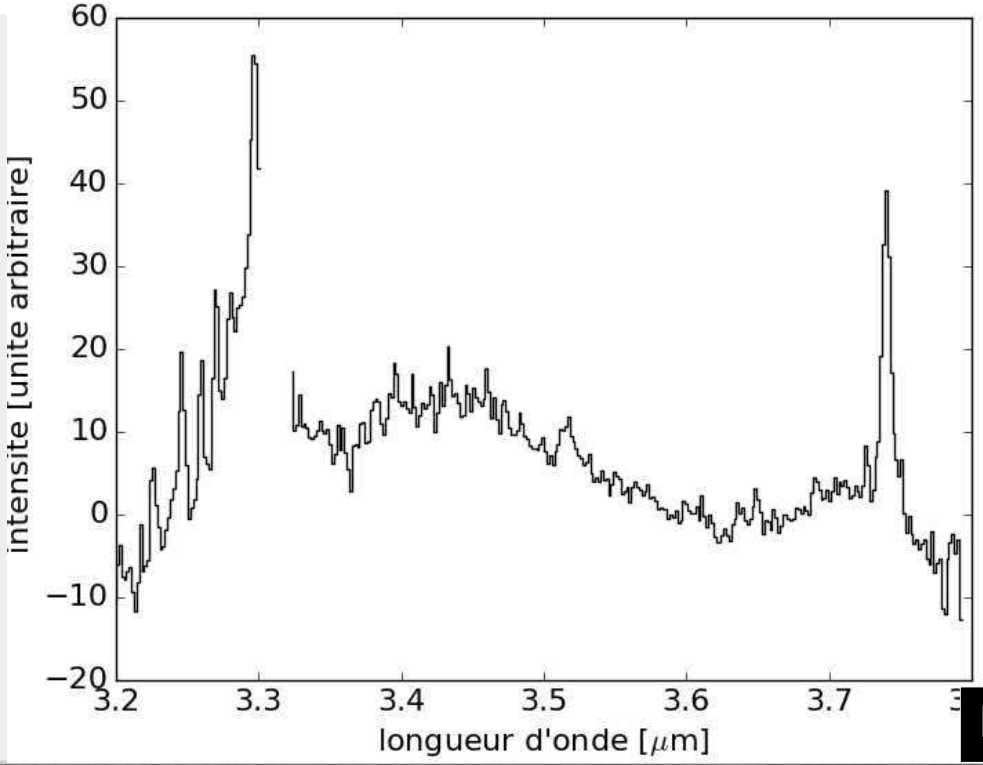
Observations



	HD 100546	HD 100453	HD 169142	HD 179218
Temp. [K]	10500	7600	8250	9640
Lum. [L⊙]	32	10	8.55	182
Mass [M⊙]	2.4	1.8	1.7	3.7
Age [Myr]	> 10	15	6	1
Distance [pc]	103	114	145	254
G_0 at 50 au	4.2×10^6	2.4×10^5	3.4×10^5	1.6×10^7

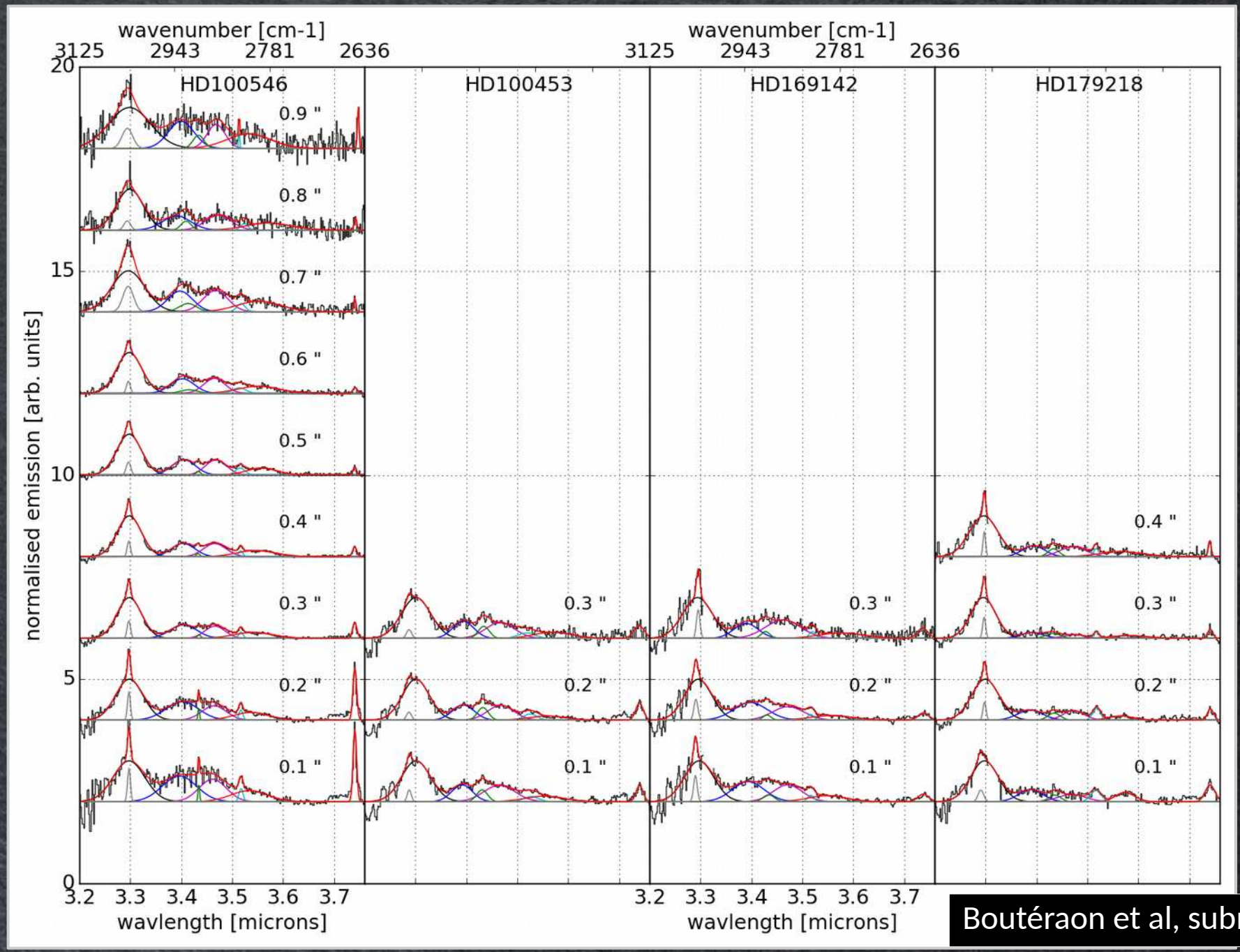
Observations





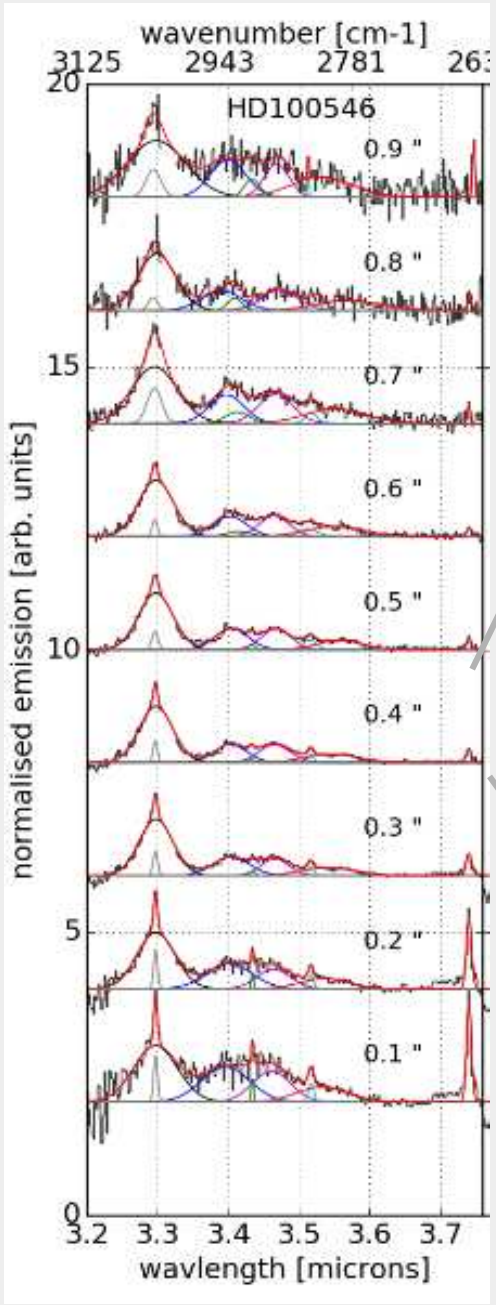
Boutéraon et al, submitted

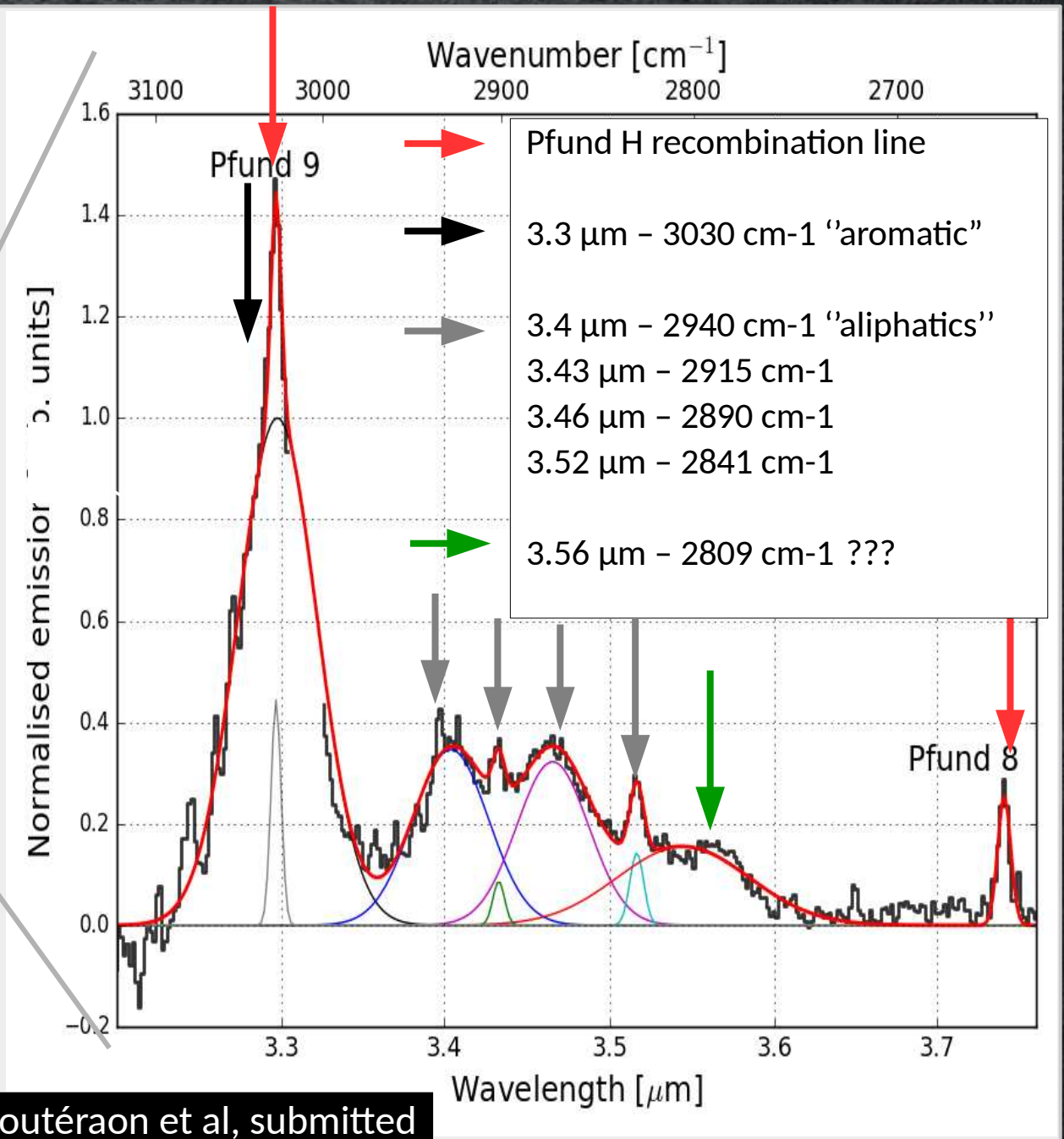
Disk observations - Spatial mean of spectra



Boutéraon et al, submitted

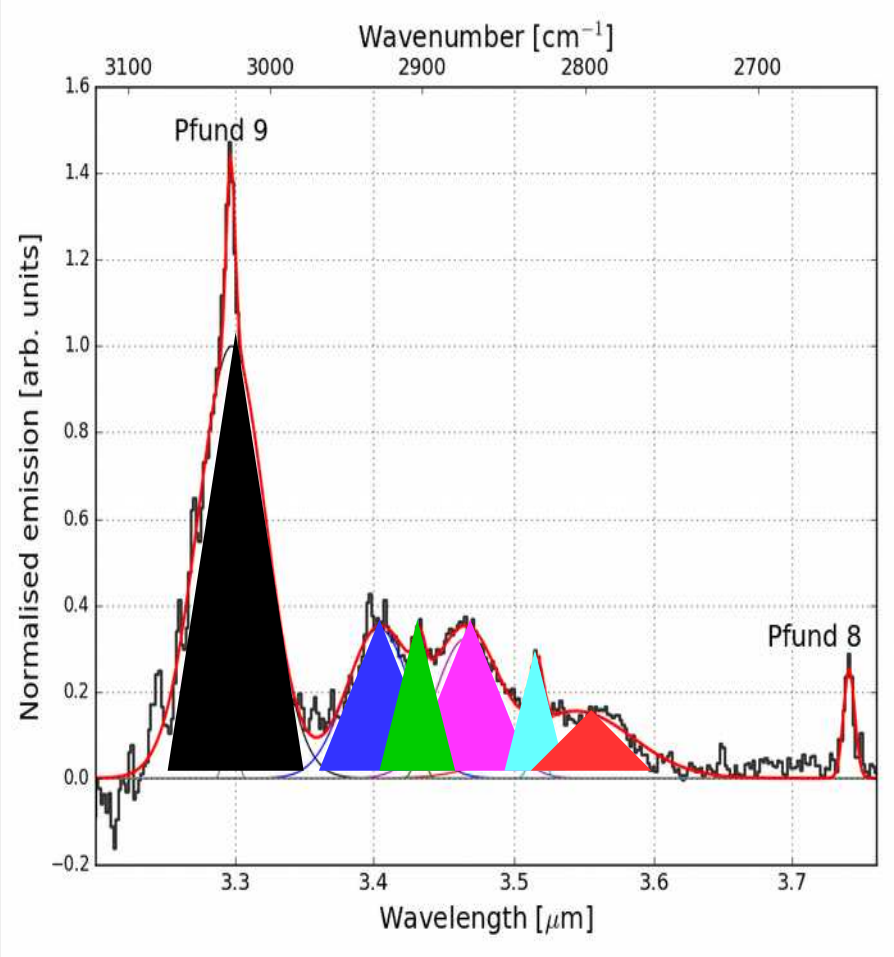
Identification of signatures and decomposition

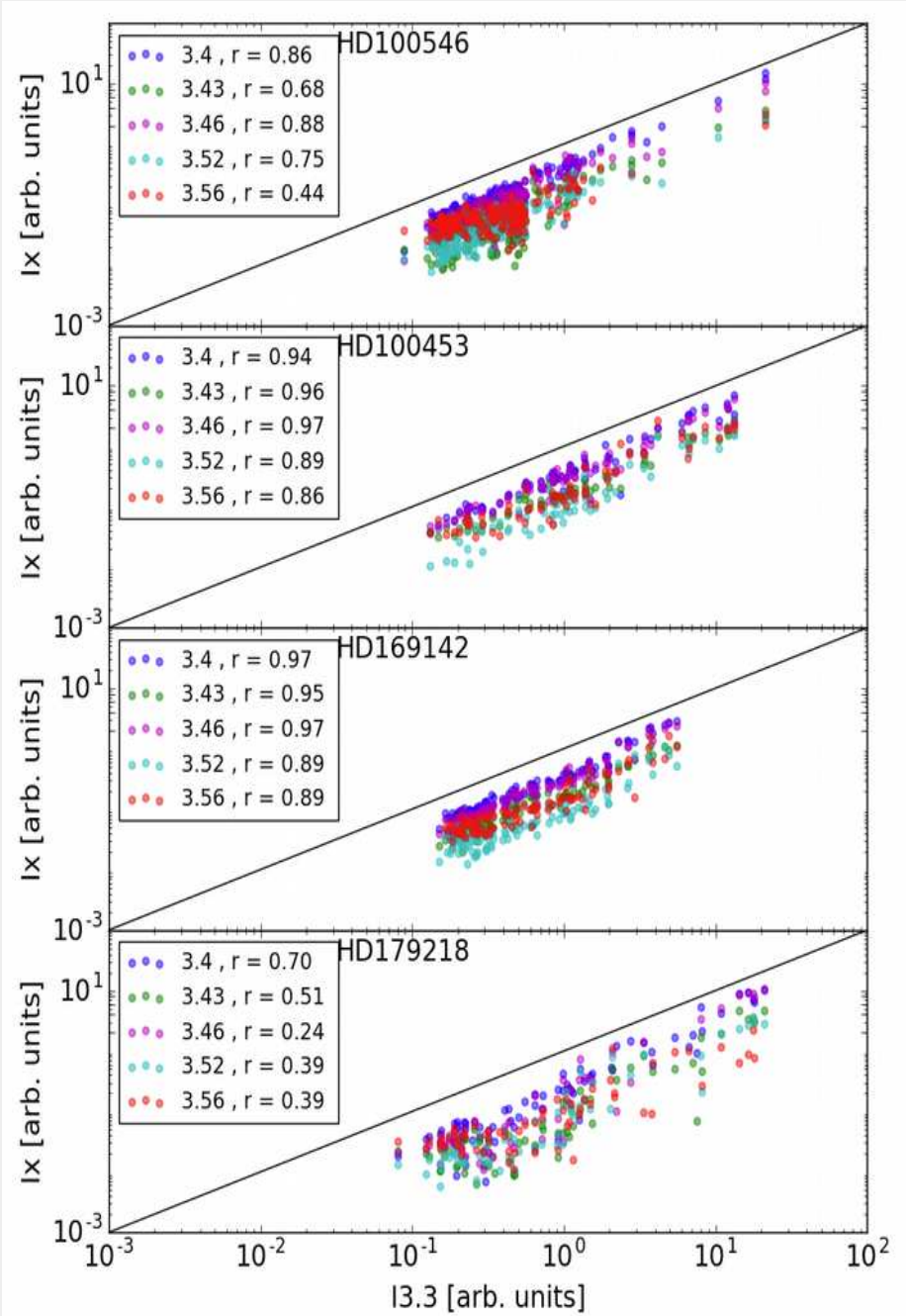




Boutéraon et al, submitted

Results - Signature correlation

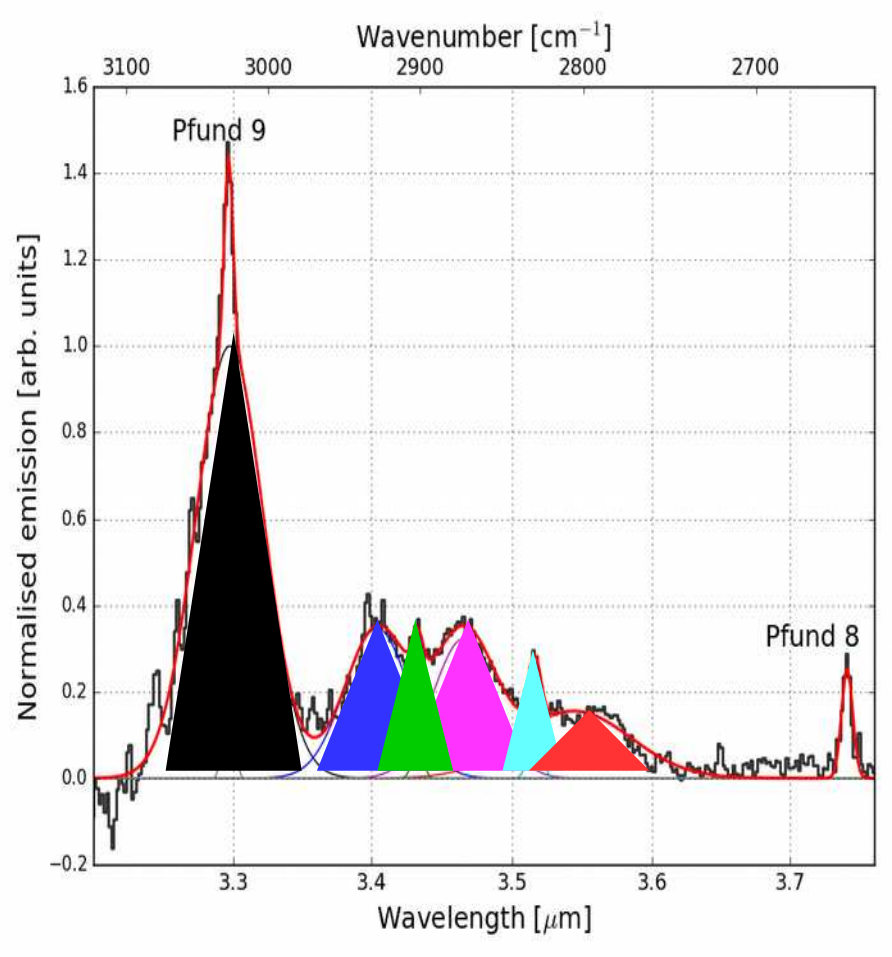


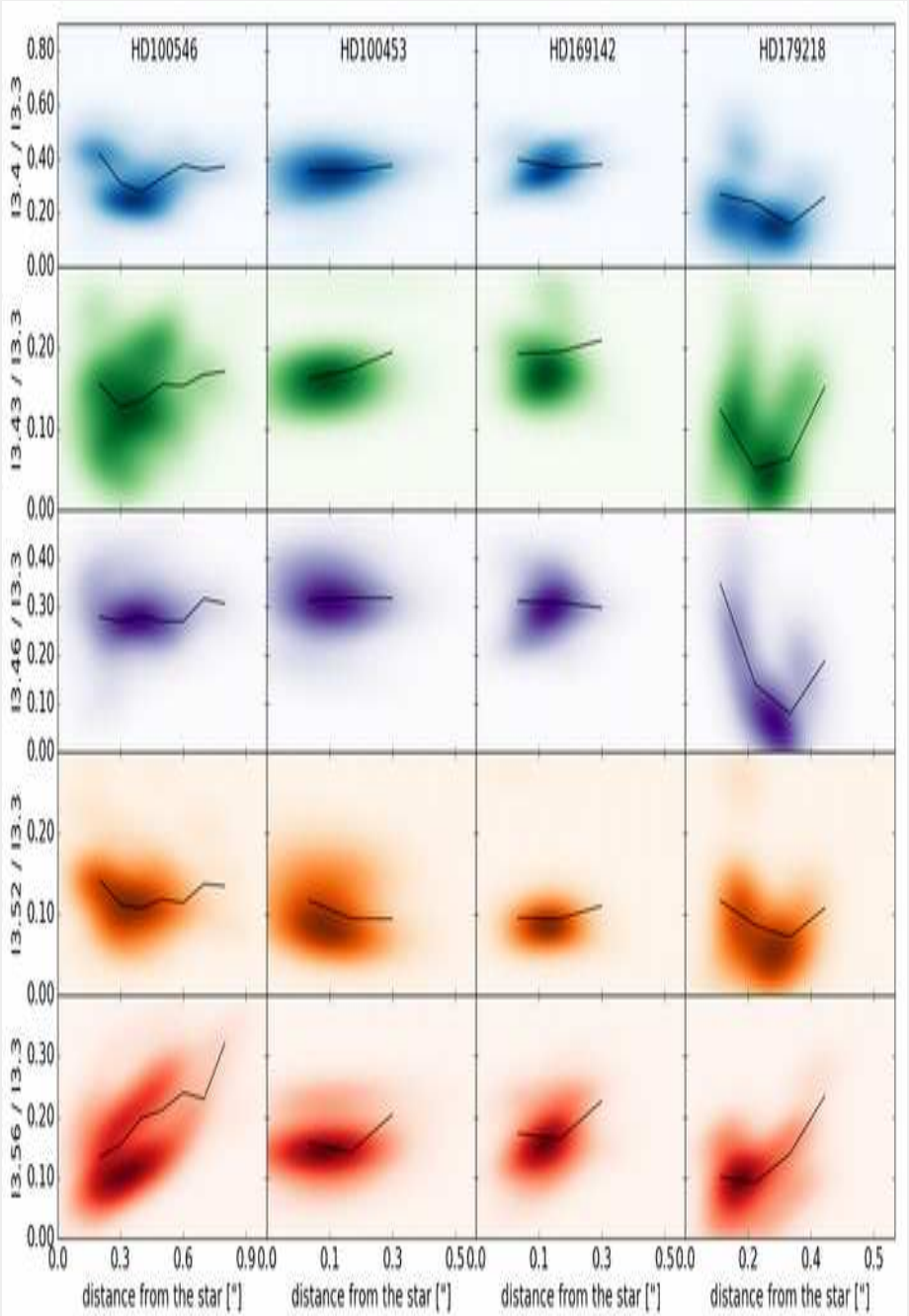


Good correlation of signatures
> unique kind of carriers
> similar composition according to the radiation field

Boutéraon et al, submitted

Results - Band ratios according to the distance



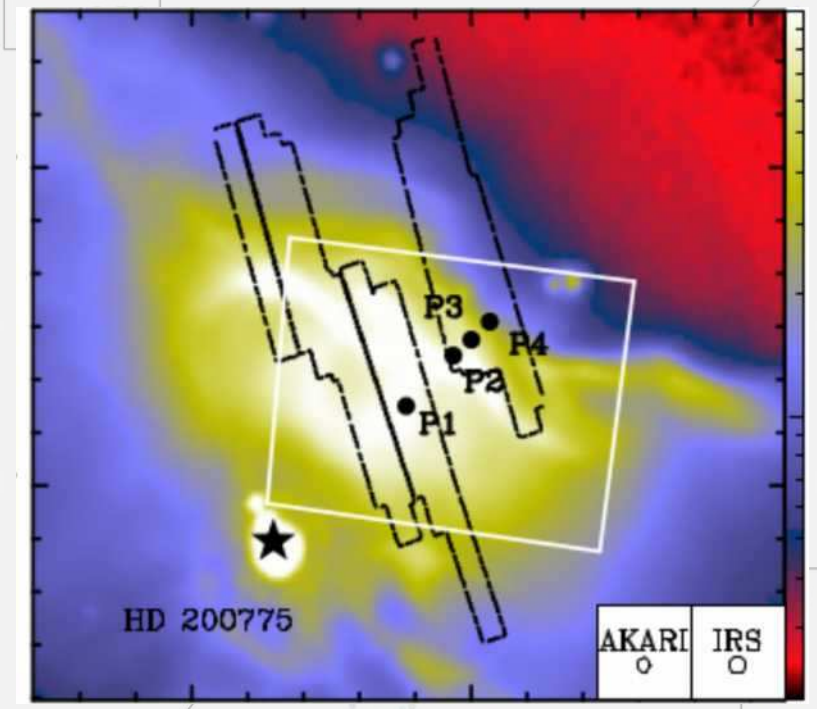


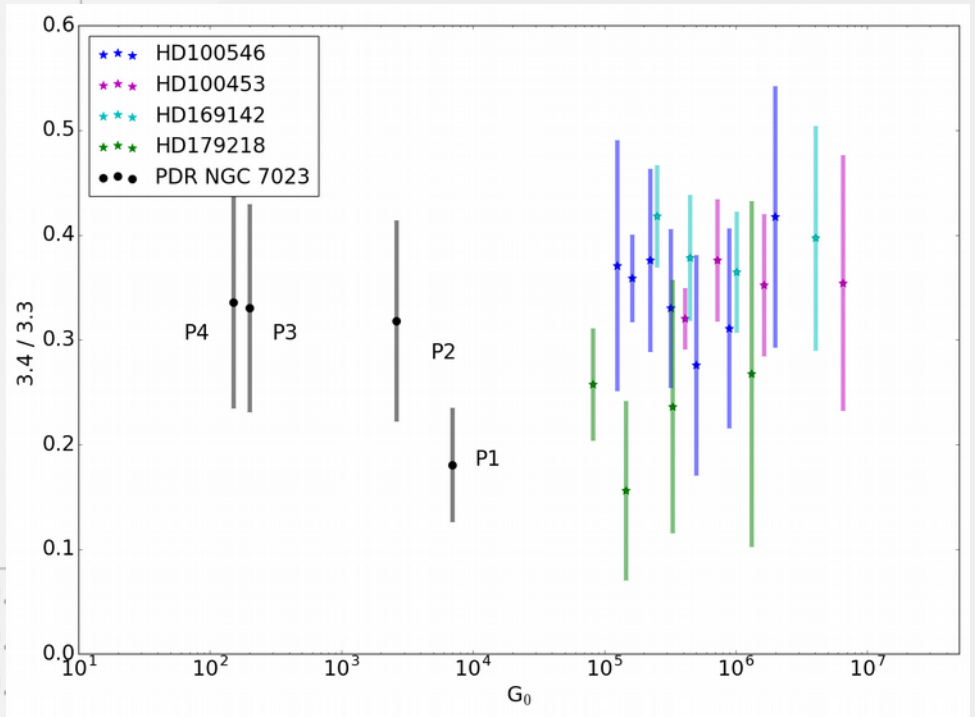
Good correlation of signatures
> unique kind of carriers
> similar composition according to the distance

Boutéraon et al, submitted

Results - Band ratios according to G0 / nH

Comparaison avec les zones irradiées du milieu interstellaire



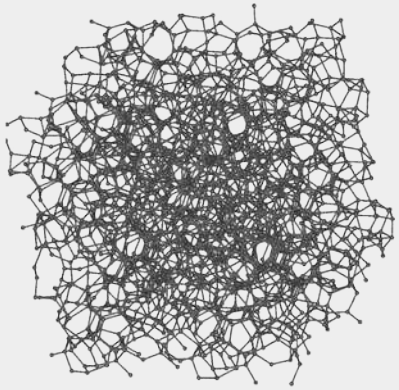


Pilleri et al 2015

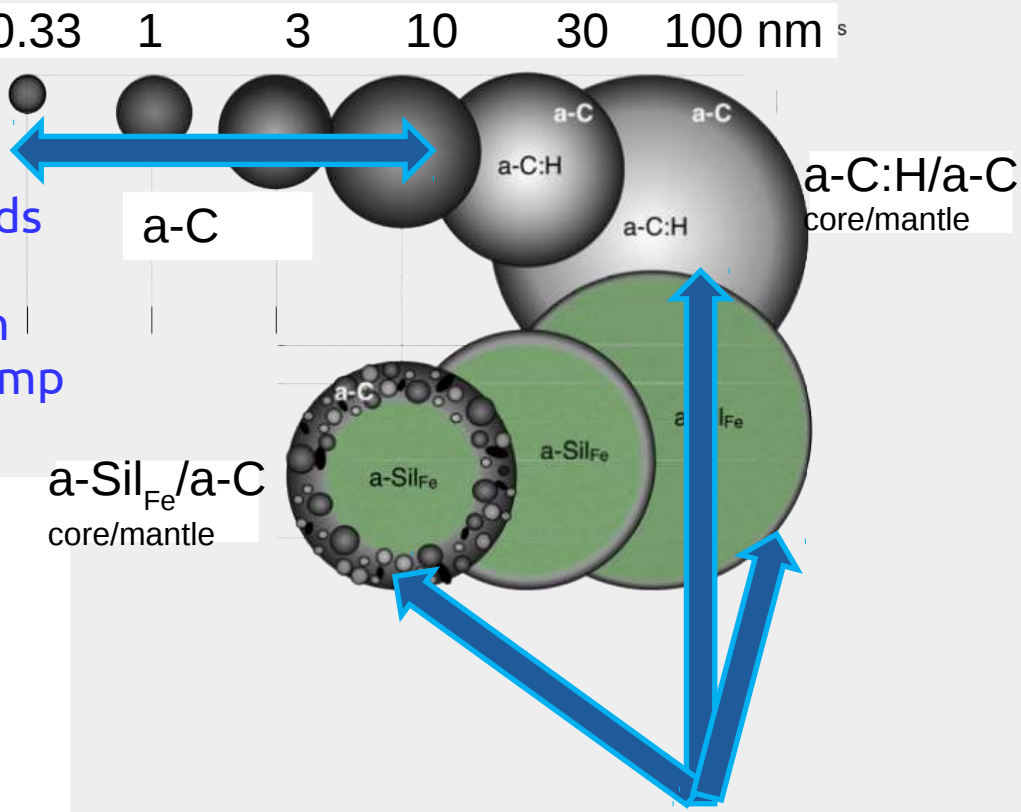
The 3.4 / 3.3 ratio to probe the evolution of matter with physical conditions

Boutéraon et al, submitted

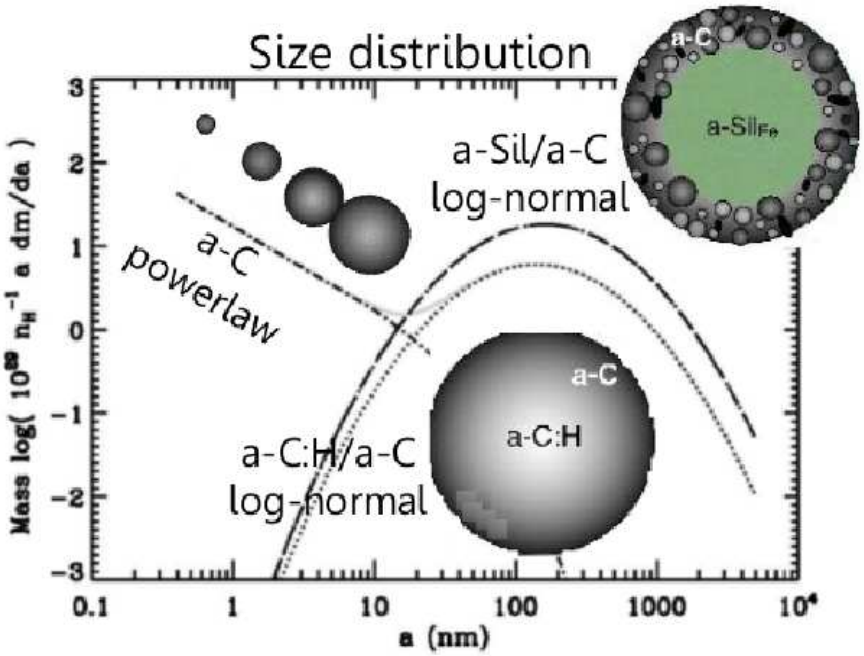
THEMIS: The Heterogeneous dust Evolution Model for Interstellar Solids



A model for the diffuse ISM



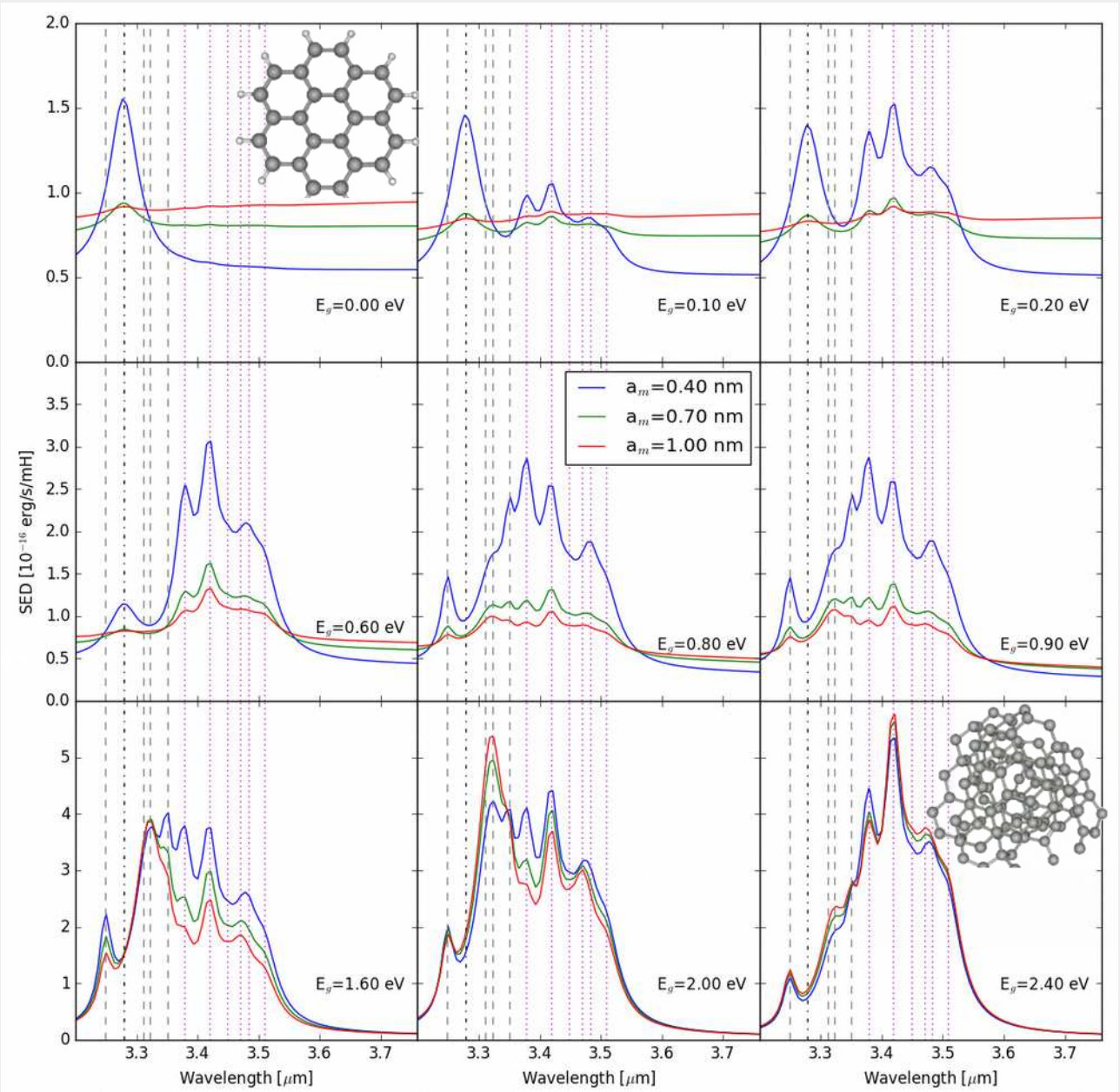
IR emission bands
MIR emission
FUV extinction
UV extinction bump



IR absorption bands
visible/MIR extinction
FUV extinction
FIR/submm emission

Jones+ 2017
Köhler, Jones & Ysard 2014

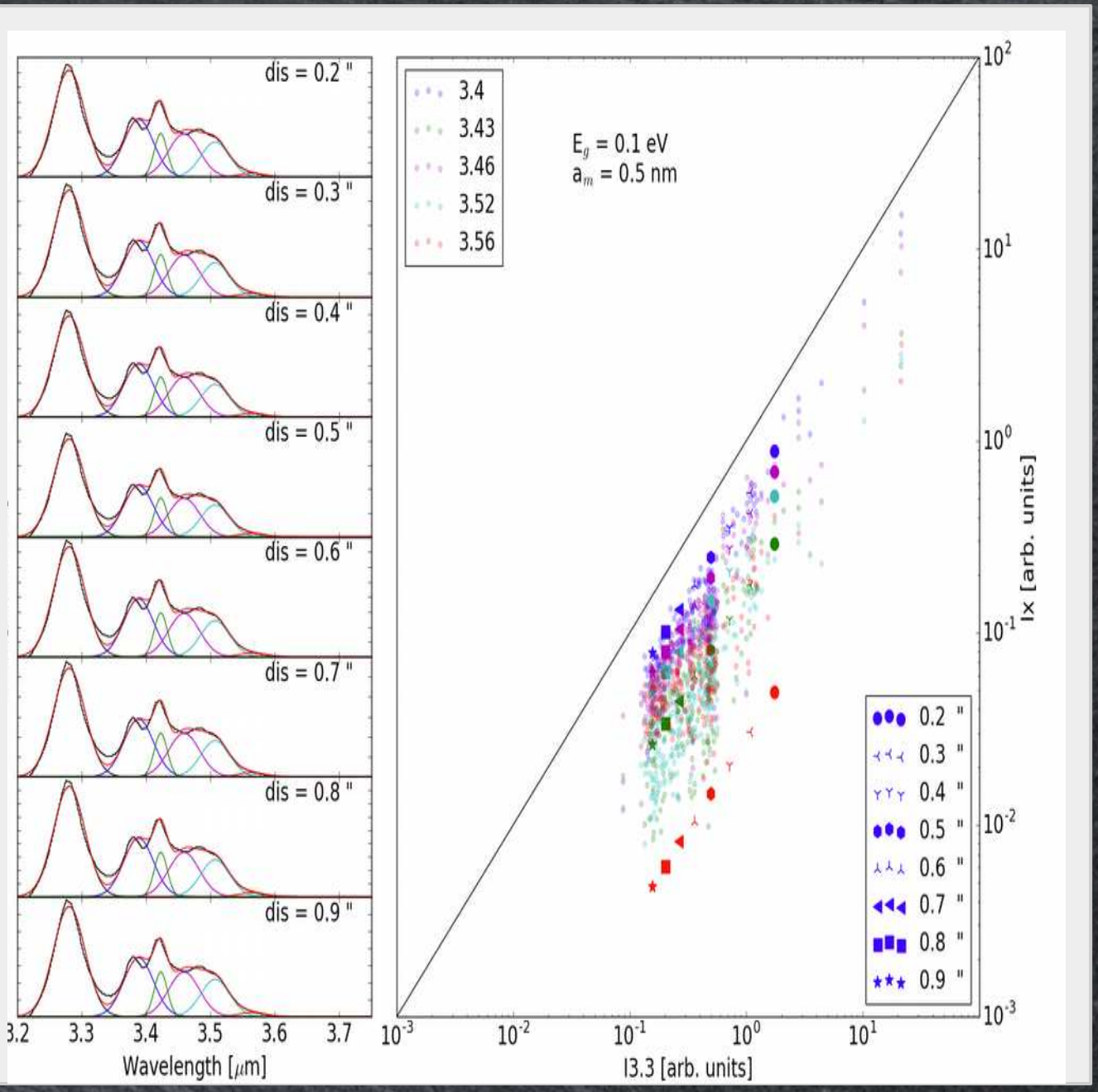
SED with THEMIS : from aromatics to aliphatics



- Signatures vary a lot with the composition (i.e. the band gap)
- For aromatics, the band to continuum ratio decreases with the size

> Spectrum gives both indications on the grain composition and the upper limit of smallest grain size

Results - Comparison with THEMIS



Application of the same decomposition method to spectra simulated by THEMIS.

> Values of the intensity ratios are well reproduced

> Highly aromatic grains with an aliphatic component

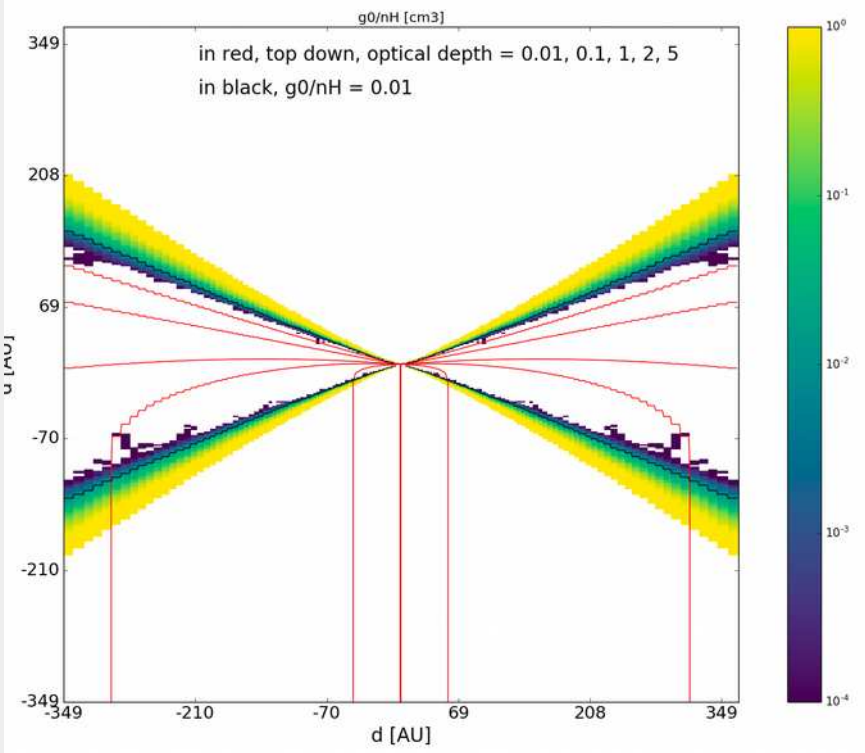
> The smallest grains around 0.5 nm

Boutéraon et al, submitted

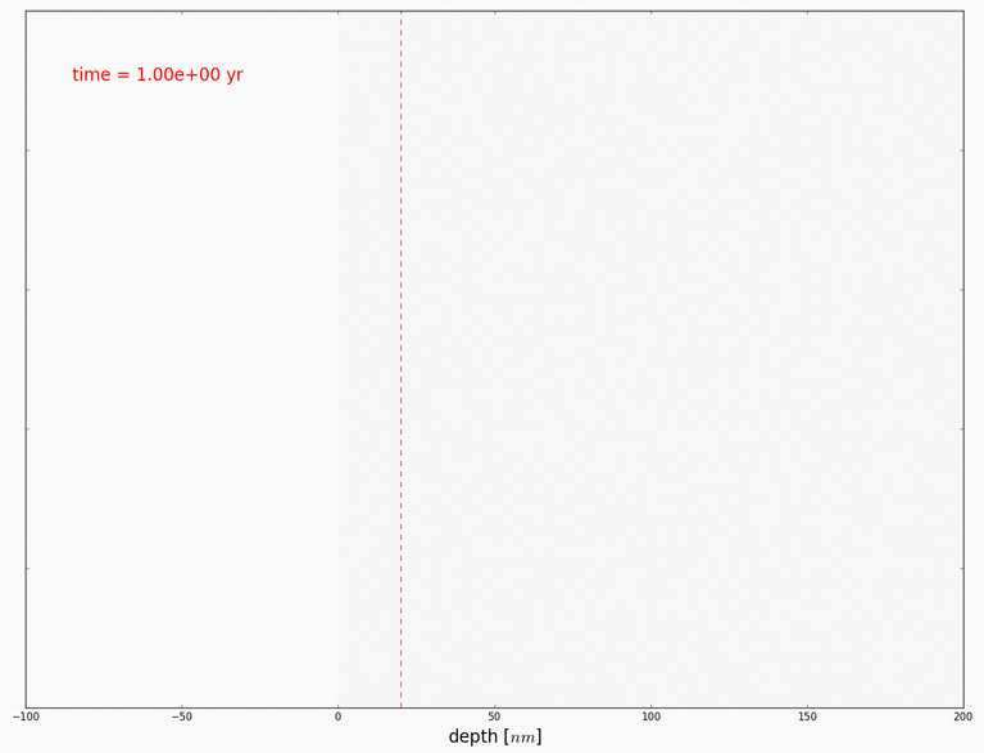
Summary

- This work shows the presence of features related to aromatic and aliphatic materials in disks around Herbig stars
- These features are observed in a wide spatial range of the disks (from about ∼10 to 100 au), even if the most inner parts of these disks remain inaccessible to our observations.
- Correlation between aliphatic/aromatic features in various conditions signs for carriers of same nature stochastically heated nano-grains of mixed aromatic and aliphatic composition.
- Our analysis provides evidence for their presence at the disk surface and in the inner cavity.
- No strong variations in band ratios according to the distance to the star are observed. This suggests that it could have a continuous replenishment at the disk surface which are PDR-like
- The THEMIS model, a valuable and pertinent approach to understand the dust evolution in disks

Outlook



Modelling the disk with Polaris/THEMIS
> work with R. Brauer
> physical conditions in the disk
> constrained by previous results
> JWST,VLT/MATISSE



Grain processing time
> grain composition
> optical properties
> constraints on disk physical conditions
> evolution of the grain size distribution