Modélisation de l'évolution des grains de poussière dans la nébuleuse de la Tête de Cheval

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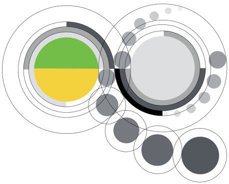
Présentation labEX P2IO

Vendredi 19 octobre 2018

- THEMIS
- Dust modelling with DustPDR
- Dust modelling with CRT
- Conclusion

The Heterogeneous dust Evolution Model for Interstellar Solids



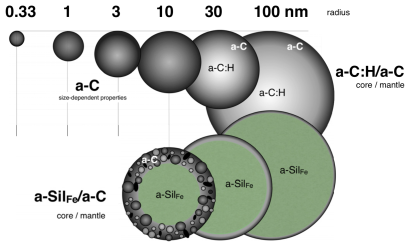
For local physical conditions, THEMIS provides :

- Dust structure;
- Dust composition;
- Dust Evolution.

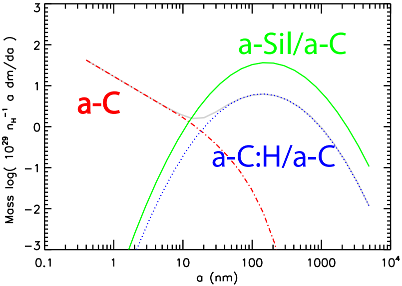
THEMIS is built on laboratory-measured properties of :

- H-poor (a-C) hydrogenated amorphous carbon materials;
- H-rich (a-C:H) hydrogenated amorphous carbon materials;
- Collectively H-poor and H-rich (a-C(:H)) materials;
- Amorphous olivine-type and pyroxene-type silicates with iron and iron-sulfide nano-inclusions (a-Sil(Fe-FeS));

The THEMIS dust model for the diffuse ISM



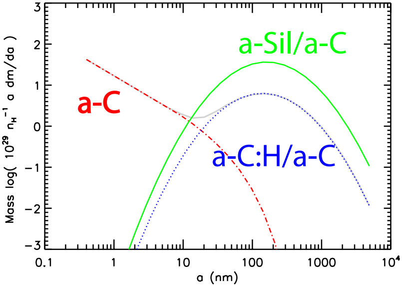
Diffuse dust model population.



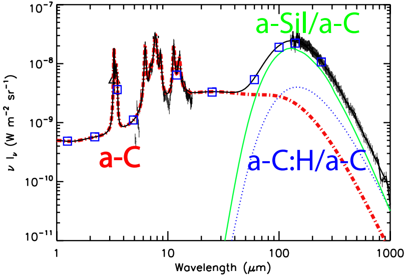
Diffuse dust grain distribution (Jones et al. 2013)

- Power-law distribution of a-C nano-particles ($a <$ 20nm);
- Log normal distribution of large a-C:H grains ($a \sim$ 160 nm) with a-C mantles;
- Log normal distribution of large a-Sil(Fe,Fes) grains ($a \sim$ 140 nm) with a-C mantles.

The THEMIS dust model for the diffuse ISM



Diffuse dust grain distribution.

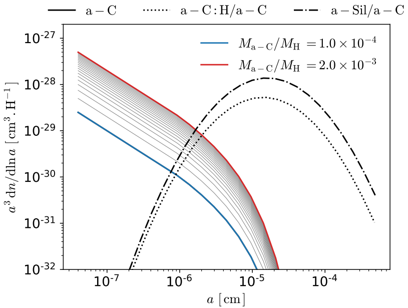


Diffuse grain dust emission (Jones et al. 2013)

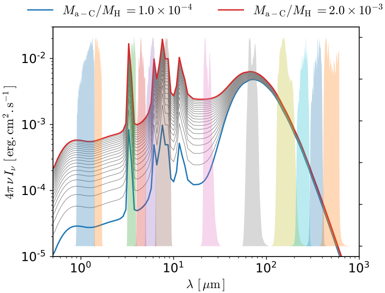
Contribution of different dust types to the total emission :

- Near and mid-IR emission : a-C nano-particles;
- Far infrared emission : a-Sil(Fe,Fes) grains with a-C mantles.

Influence of M_{a-C}/M_H on modelled dust emission



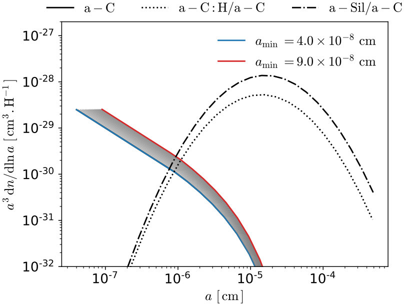
Diffuse dust grain distribution.



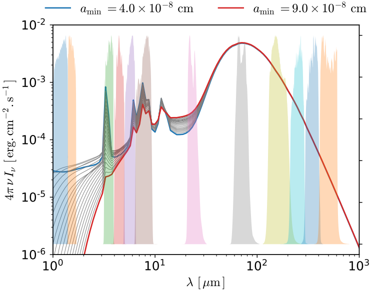
Diffuse grain dust emission.

- Decrease of dust emission in near and mid-IR with $a_{\mathrm{min,a-C}}$ ↑;
- Increase of dust emission in far-IR with $a_{\mathrm{min,a-C}}$ ↓.

Influence of $a_{\mathrm{min,a-C}}$ on modelled dust emission



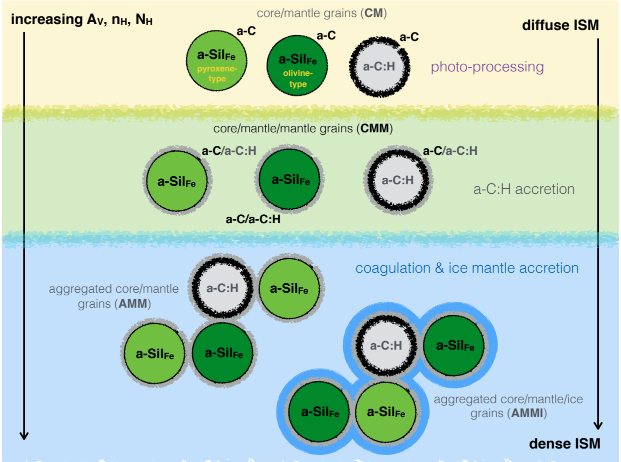
Diffuse dust grain distribution.



Diffuse grain dust emission.

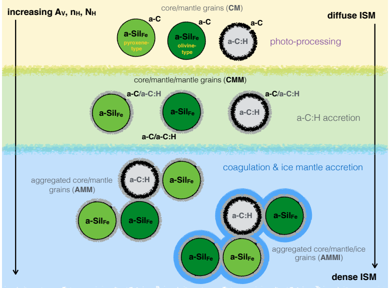
- Decrease of dust emission in near and mid-IR with $a_{\mathrm{min,a-C}} \uparrow$;
- Increase of dust emission in far-IR with $a_{\mathrm{min,a-C}} \downarrow$.

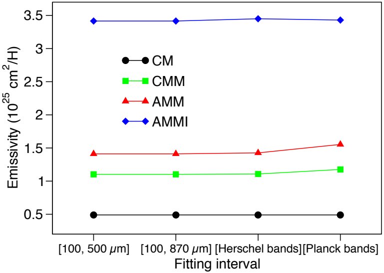
Scenario of dust evolution from diffuse to denser regions



Representation of dust evolution in *(Jones et al. 2017)*

Scenario of dust evolution in denser regions





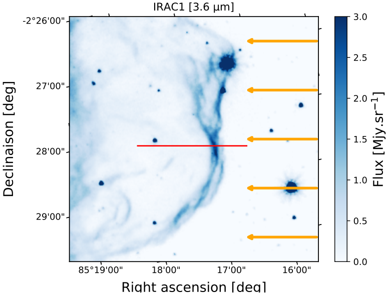
Dust evolution scenario (Jones et al. 2013). Model dust emission (Köhler et al. 2015)

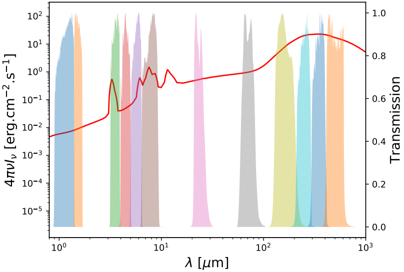
- CM : Core-mantle grains;
- CMM : CM + a-C:H mantle;
- AMM : Aggregates consisting of CMM grains.
- AMMI : Aggregates consisting of CMM grains with an additional ice mantle.

A well-known PDR : The Horsehead Nebula

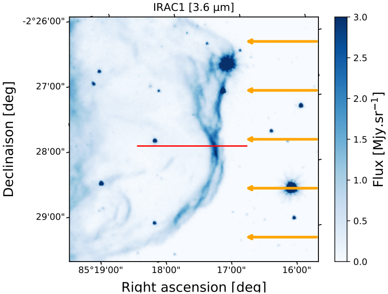
Observations from Hubble, Spitzer and Herschel :

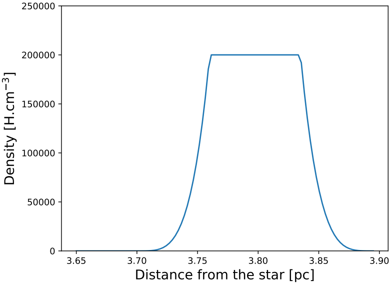
- 12 photometric bands [μm] : 1.15, 1.54, 3.6, 4.5, 5.8, 8, 24, 70, 160, 250, 350, 500.
- ⚠ : Possibly gas contribution in HST bands.





Physical conditions inside the Horsehead Nebula

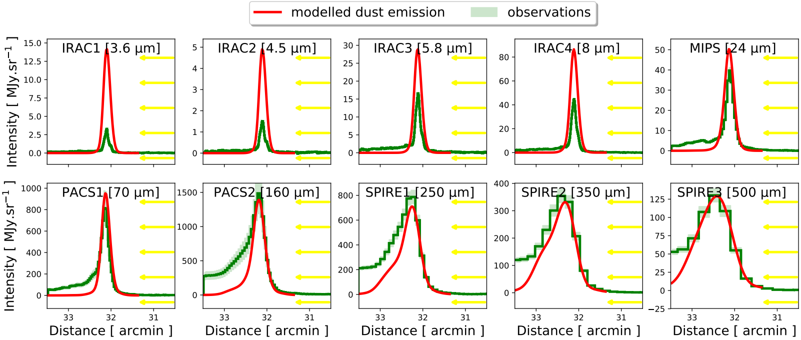




Physical conditions required to compute radiative transfer :

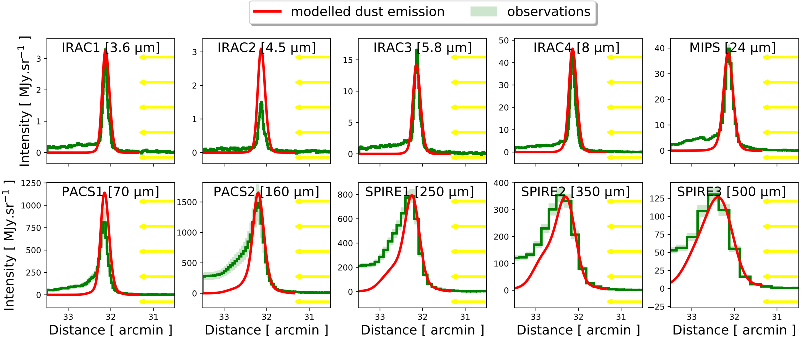
- Density profile of atomic hydrogen from Habart et al. 2006;
- Length of the PDR along the line of sight : 0.1 pc.

DustPDR results with dust from diffuse medium



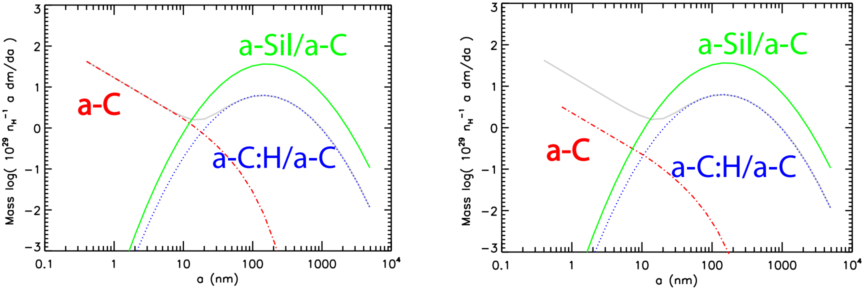
- $l_{\rm PDR}$=0.28 pc required for far-infrared.
- Dust emission overestimate in near and mid-infrared.

DustPDR results with modified dust from diffuse medium



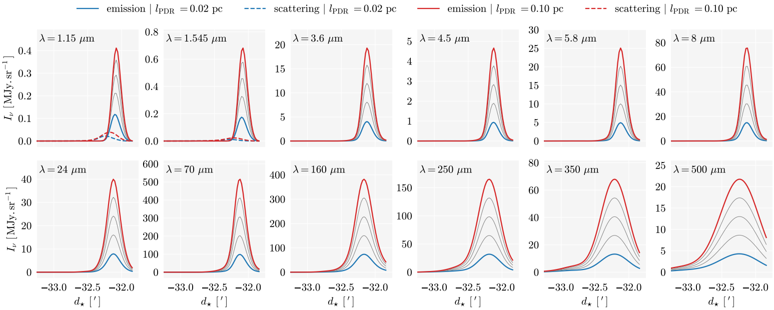
- Increase of $a_{\mathrm{min,a-C}}$ from $4{\times}10^{-8}$ to $5.75{\times}10^{-8}$ cm;
- Decrease of $\mathrm{M_{a-C}/M_H}$ from 17 $\times 10^{-4}$ to 7 $\times 10^{-4}$.
- $l_{\mathrm{PDR}} = 0.28$ pc

Discussion about DustPDR results



- ✓ $a_{\mathrm{min,a-C}}$ ↑ and ✓ $\mathrm{M_{a-C}/M_H}$ ↓: the small grains have not yet had time to form OR they cannot exist because of UV photodestruction;
- ✗ l_{PDR} =0.28 pc → $N_{\mathrm{H}} \sim 10^{23}$ H.cm^{-2} too high !

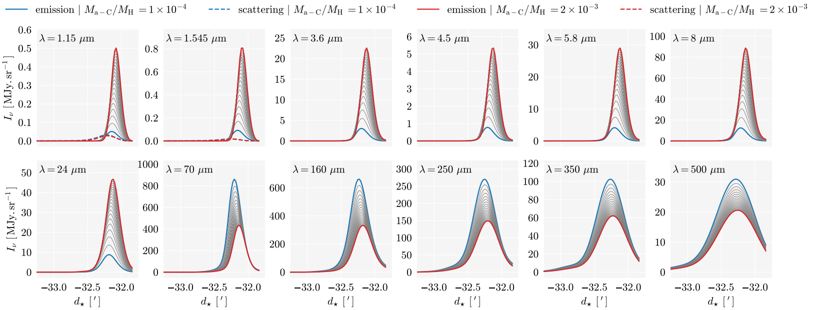
CRT results : Influence of $l_{\rm PDR}$ on dust emission and scattering



$$\mathrm{M_{a-C}/M_H} = 0.14\times10^{-2} \text{ - } a_{\rm min,a-C} = 4.00\times10^{-8}\ \mathrm{cm}$$

- Dust emission and scattering increase with $l_{\rm PDR}$;
- Dust emission increases linearly with $l_{\rm PDR}$ in all bands.

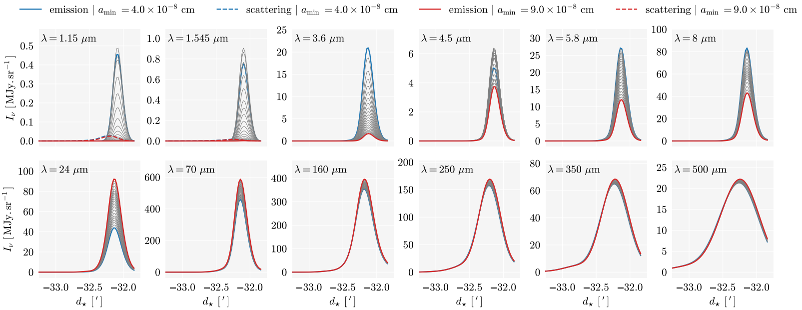
CRT results : influence of M_{a-C}/M_H on dust emission and scattering



$a_{\min,a-C} = 4.\times10^{-8}$ - $l_{PDR} = 0.1$ pc

- No influence of $a_{\min,a-C}$ on dust scattering;
- Dust emission increases linearly with M_{a-C}/M_H in NIR;
- Dust emission decreases with M_{a-C}/M_H increase in FIR.

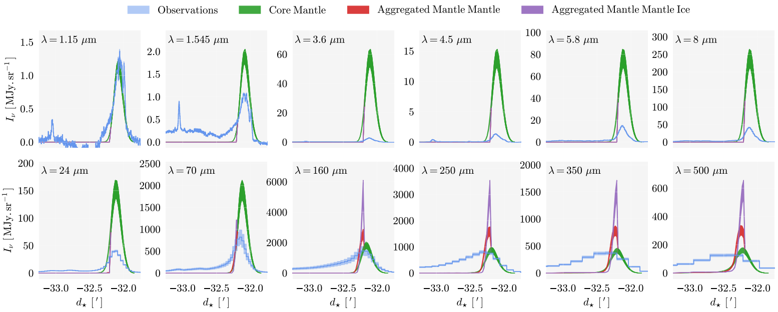
CRT results : influence of $a_{\mathrm{min,a-C}}$ on dust emission and scattering



$\mathrm{M_{a-C}/M_H} = 0.14\times10^{-2}$ - $l_{\mathrm{PDR}} = 0.1$ pc

- No influence of $a_{\mathrm{min,a-C}}$ on dust scattering;
- No influence of $a_{\mathrm{min,a-C}}$ on dust emission in FIR;
- Dust emission decreases non-linearly with $a_{\mathrm{min,a-C}} \uparrow$ in NIR.

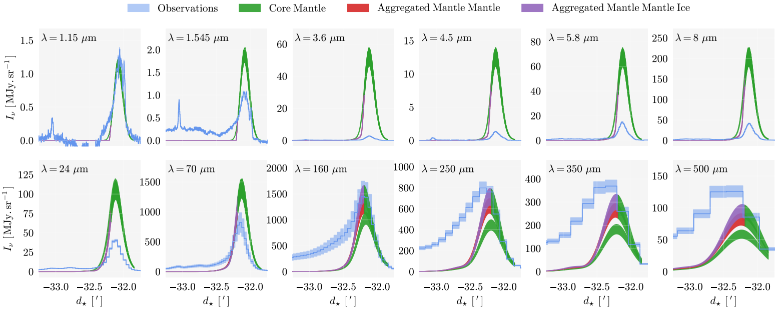
CRT results : Influence of AMM and AMMI grains



Profiles not convolved with PSFs - $l_{\mathrm{PDR}} \in [0.22, 0.30]$ pc

- CM grains where dust emits in NIR;
- AMM / AMMI where dust emits in FIR;

CRT results : Influence of AMM and AMMI grains



Profiles convolved with PSFs - $l_{PDR} \in [0.22, 0.30]$ pc

- AMM : dust emission increases by a factor of 1.5;
- AMMI : dust emission increases by a factor of 2;

Discussion and perspectives

Discussion

- a-C grains properties must change on the edge of the PDR to decrease NIR dust emission;
- Grains need to coagulate (AMM/AMMI) to increase FIR dust emission;
- l_{PDR} has to be bigger in the denser part of the PDR to increase FIR dust emission.

Perspectives

- More constraint on l_{PDR} and the density profile;
- Estimate gas emission on HST bands;