Self-consistent modelling of dust growth from the diffuse to dense ISM

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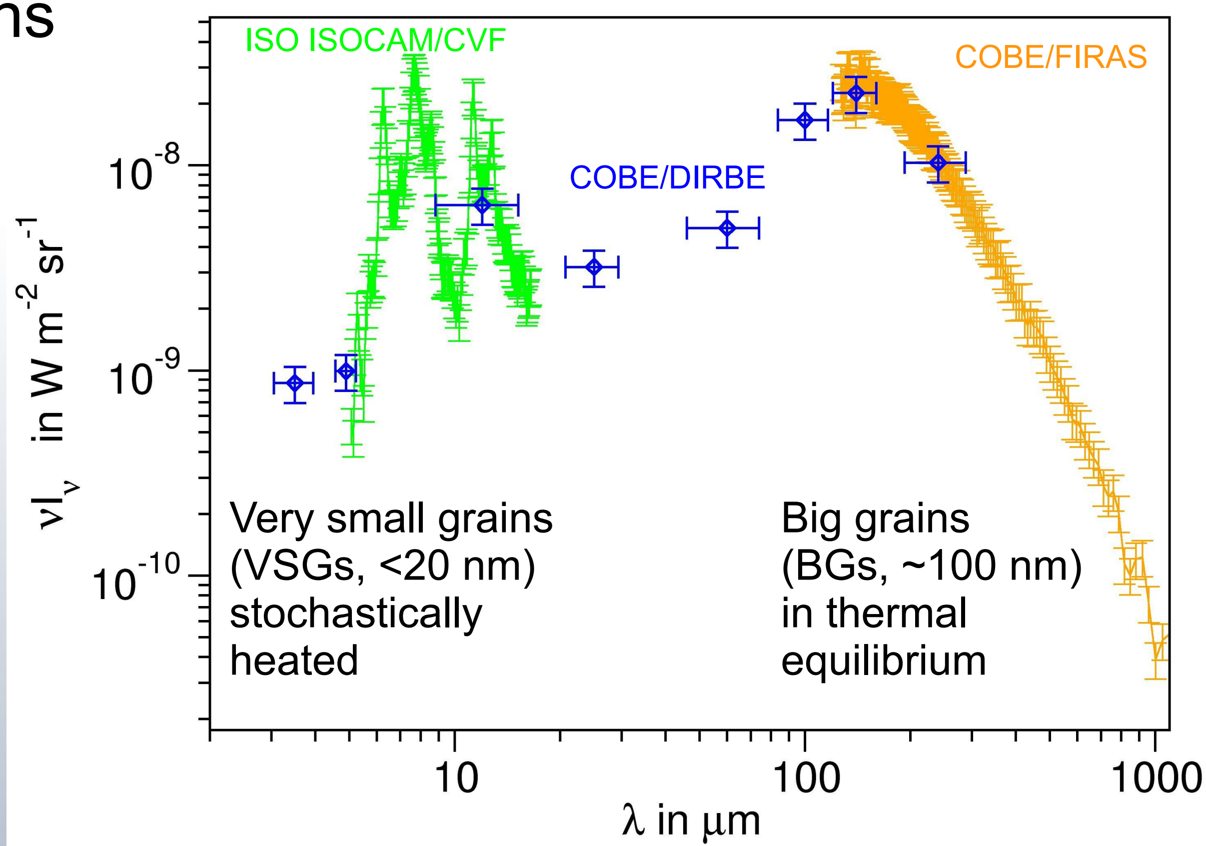
Dust in the diffuse ISM

Pre-Herschel/Planck observations



Modified blackbody fit gives

T_{obs} = 17.5 K

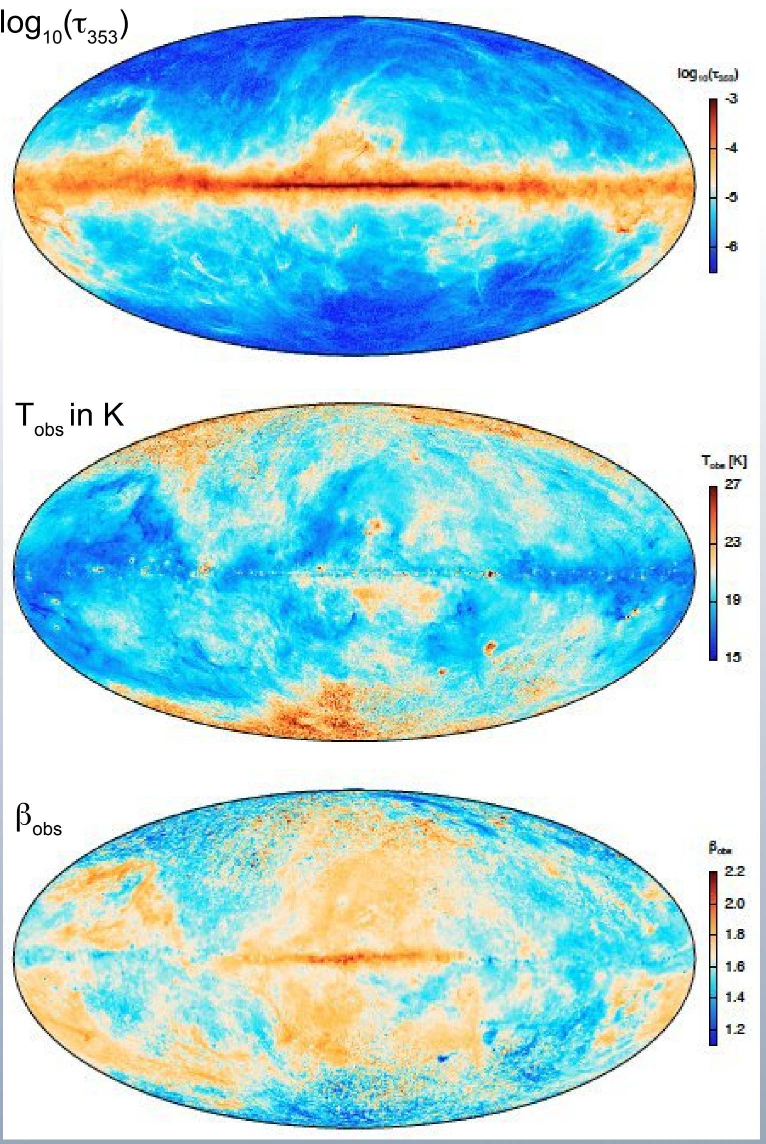
β = 2

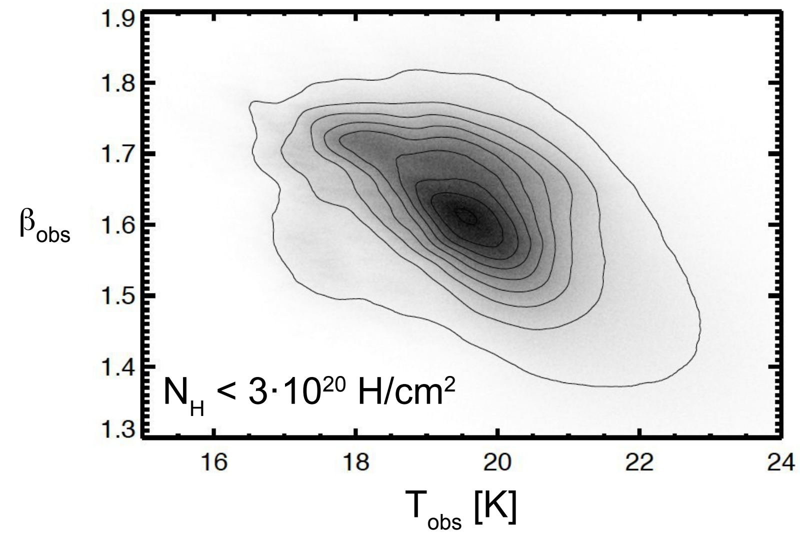
$\varepsilon_{250\mu m} = 1 \cdot 10^{-25}$ cm^2 (Boulanger et al., 1996)

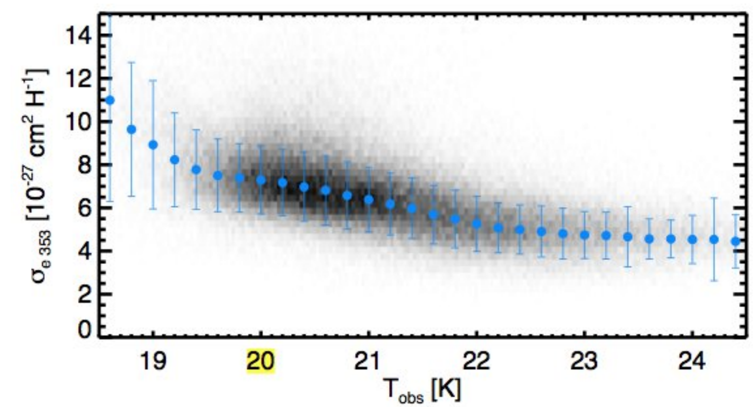
Pre-Herschel/Planck it was assumed that T and β are rather constant in the diffuse ISM.

Dust in the diffuse ISM

Planck All Sky Survey







$<\beta_{obs}> = 1.62$

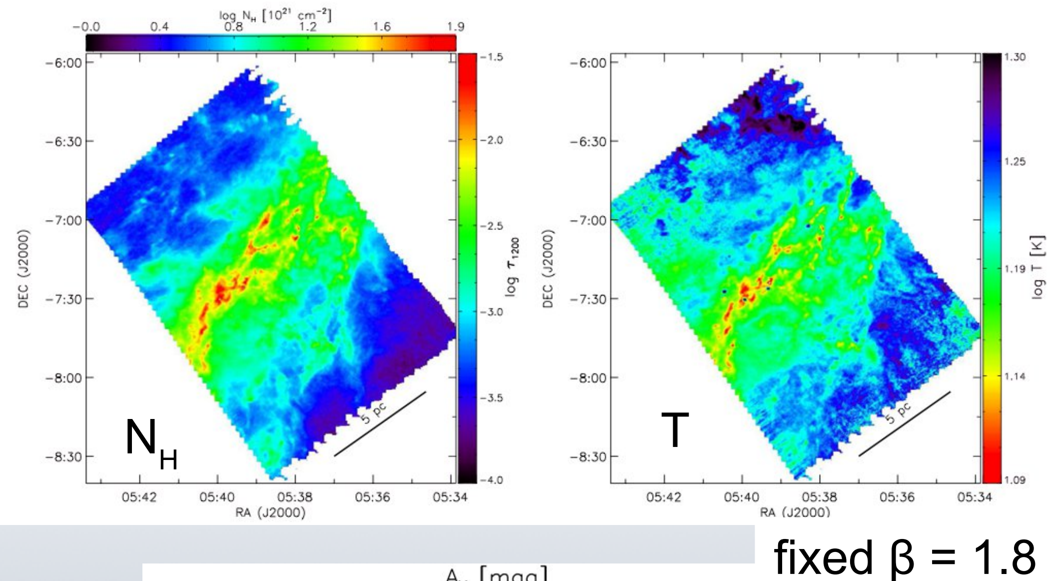
$<T_{obs}> = 19.7$ K

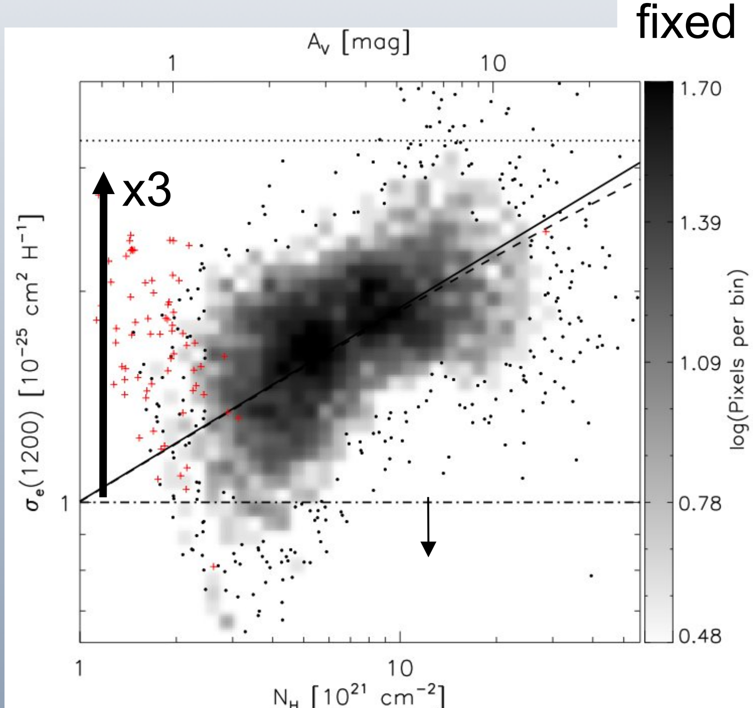
$<\varepsilon_{250\mu m}> = 0.49\cdot10^{-25}$ cm^2

Planck Collaboration: All-sky model of thermal dust emission, 2014

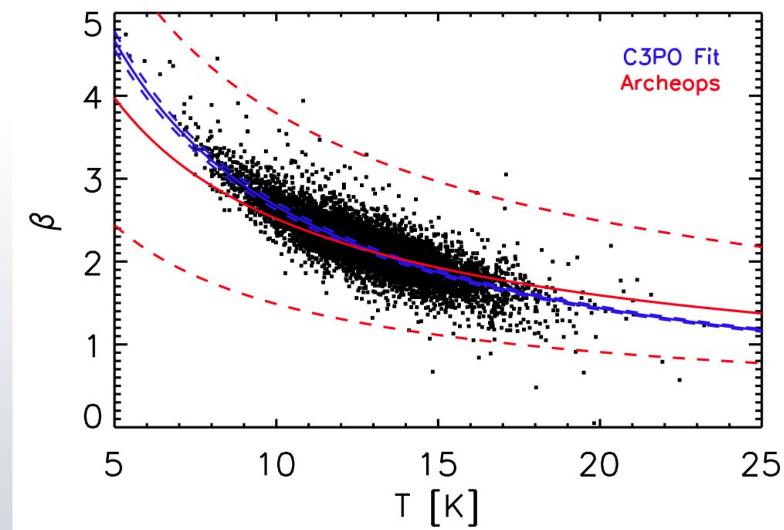
Dust in the denser ISM

Orion A molecular cloud (Roy et al. 2013)





Planck Collaboration, XXIII: The first all-sky survey of Galactic cold clumps. 2011



Dust in the denser ISM

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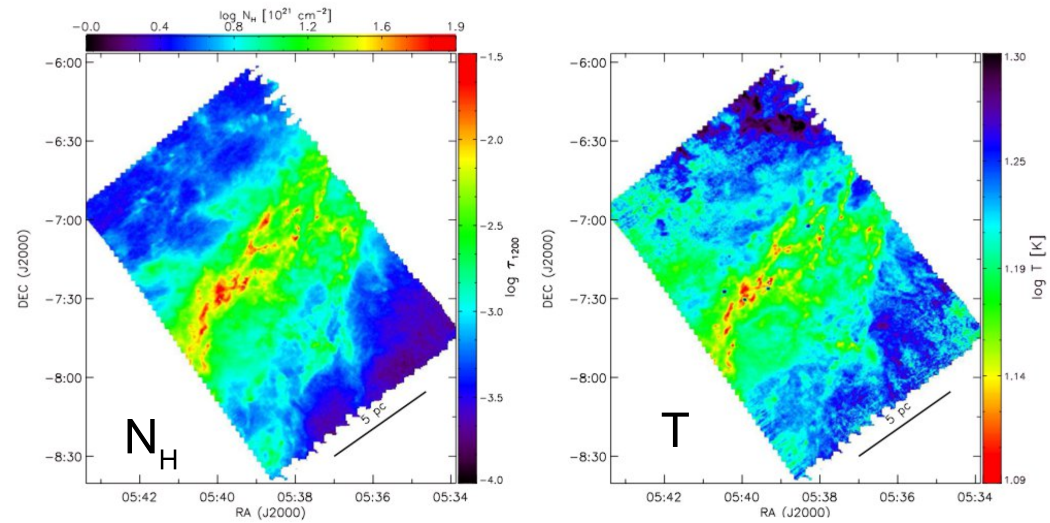
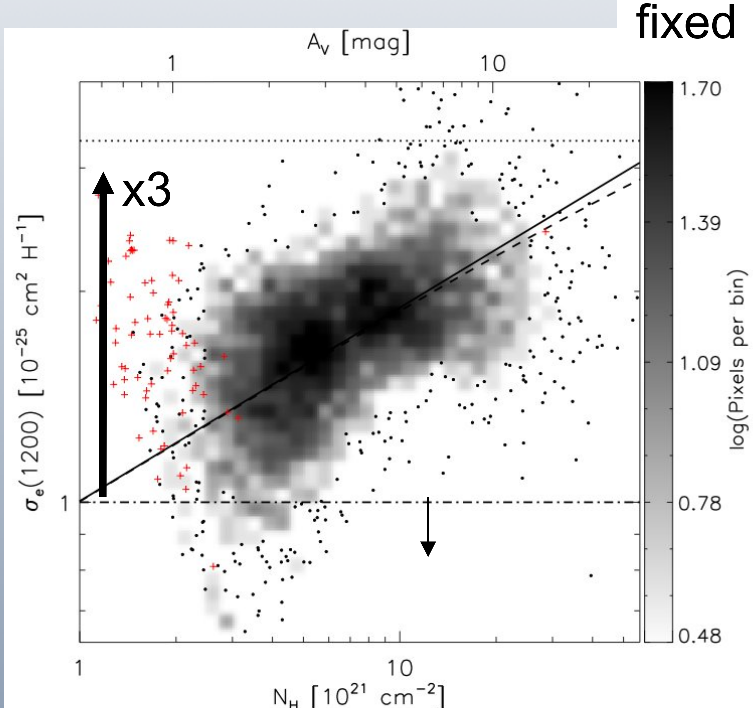


fixed β = 1.8



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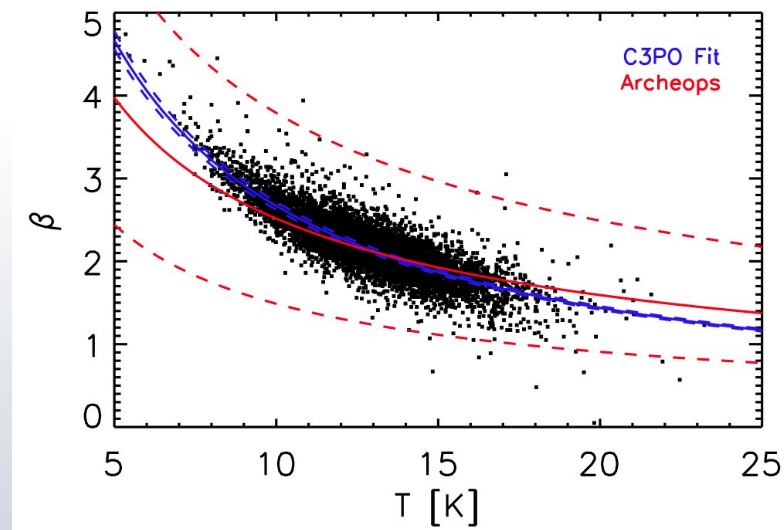

Why?

- Radiative transfer effects
- Fitting procedure
- Calibration, PSF
- Changing dust properties

Dust modelling

- Derive dust optical properties
  - Material composition
  - Grain shape and structure
  - Size distribution

  Mie (BHMIE, BHCOAT, Bohren & Huffman 1983)

  DDA (Draine 1988, Draine & Flatau 2010)
- Derive SED and extinction
  - Radiation field
  - Geometry
  - Density distribution

  DustEM (Compiegne et al. 2011)

  CRT radiative transfer code (Juvela 2005, Ysard et al. 2012)
- Compare directly to observations or derive β and T

  Modified black body: Wavelength range, fitting procedure

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→ Dust model with realistic dust grains

→ Dust evolution: changes dust properties and size distribution

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  - Radiation field
  - Geometry
  - Density distribution

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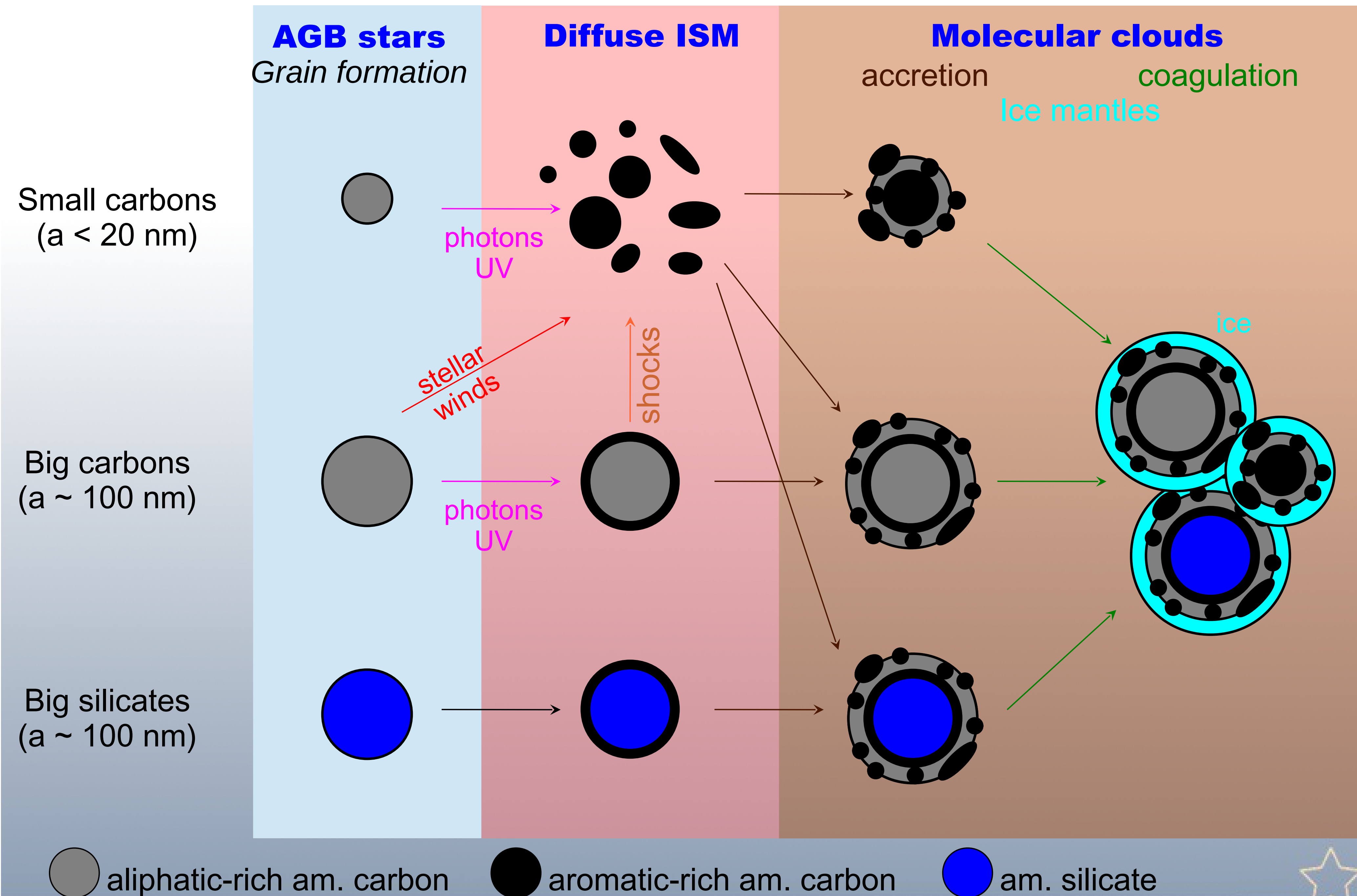
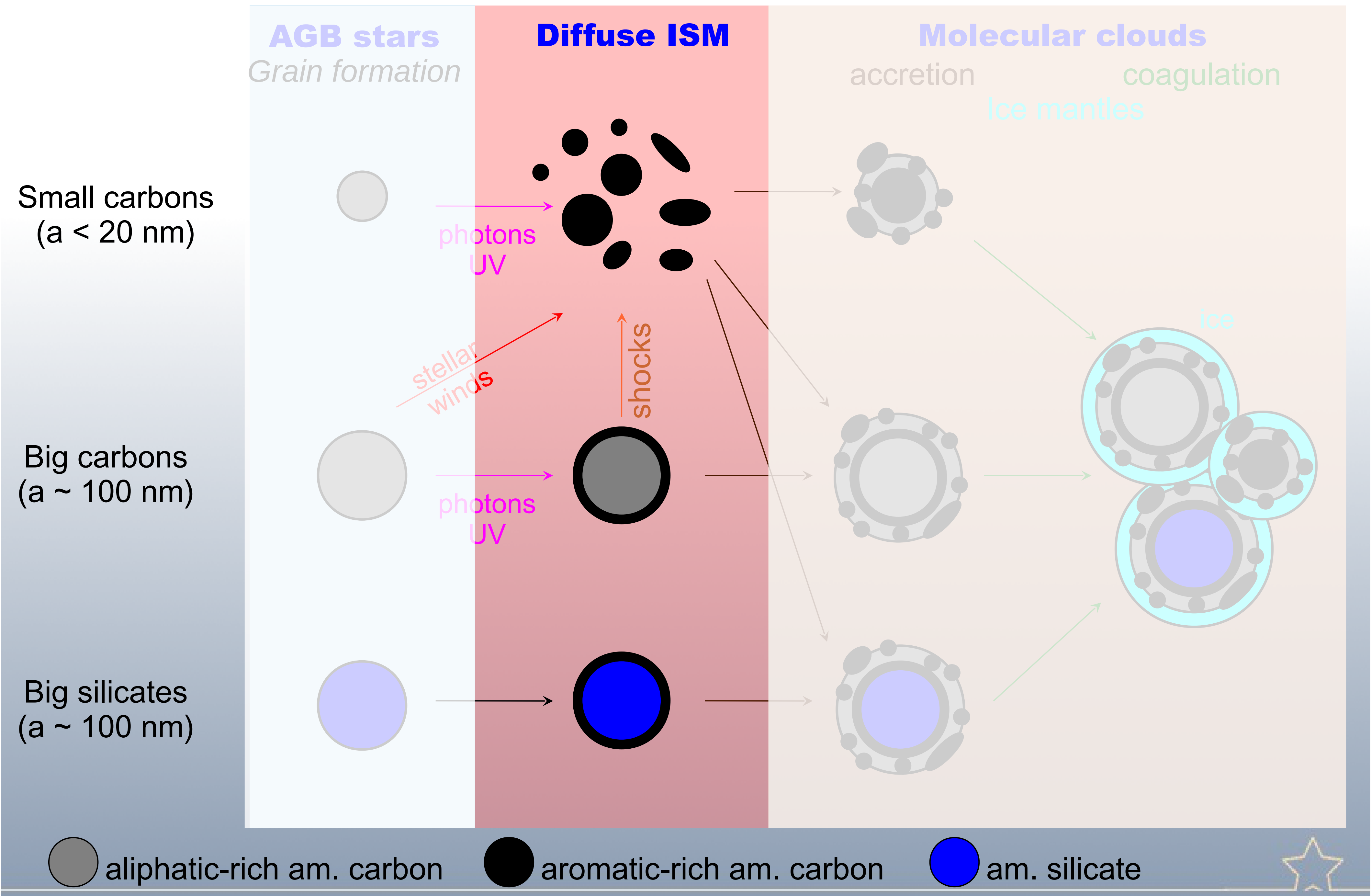
Dust evolution



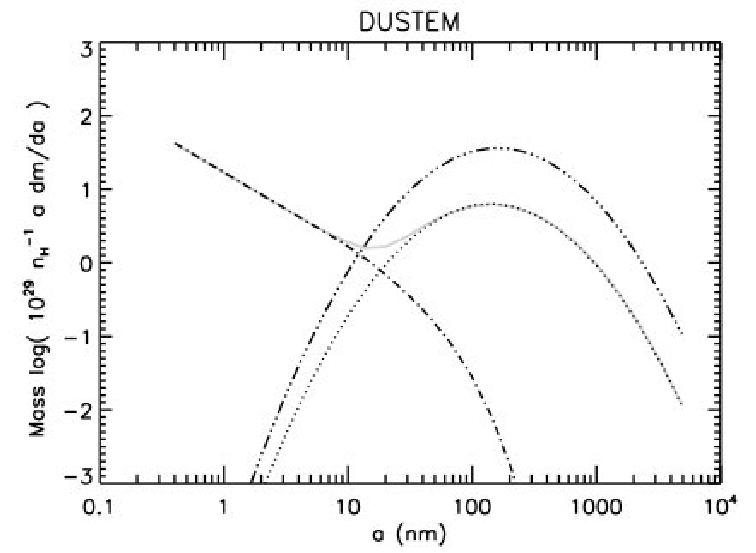
Dust evolution



Dust in the diffuse ISM

Diffuse ISM dust model with **realistic dust materials**
(Jones et al. 2013, Köhler et al. 2014)

- VSGs of aromatic-rich amorphous carbon (<20 nm)
- VSGs and BGs of aliphatic-rich amorphous carbon with mantle of aromatic-rich amorphous carbon (>20 nm)
- BGs of amorphous silicate with Fe/FeS nano-inclusions with mantle of aromatic-rich amorphous carbon



Jones et al. 2013

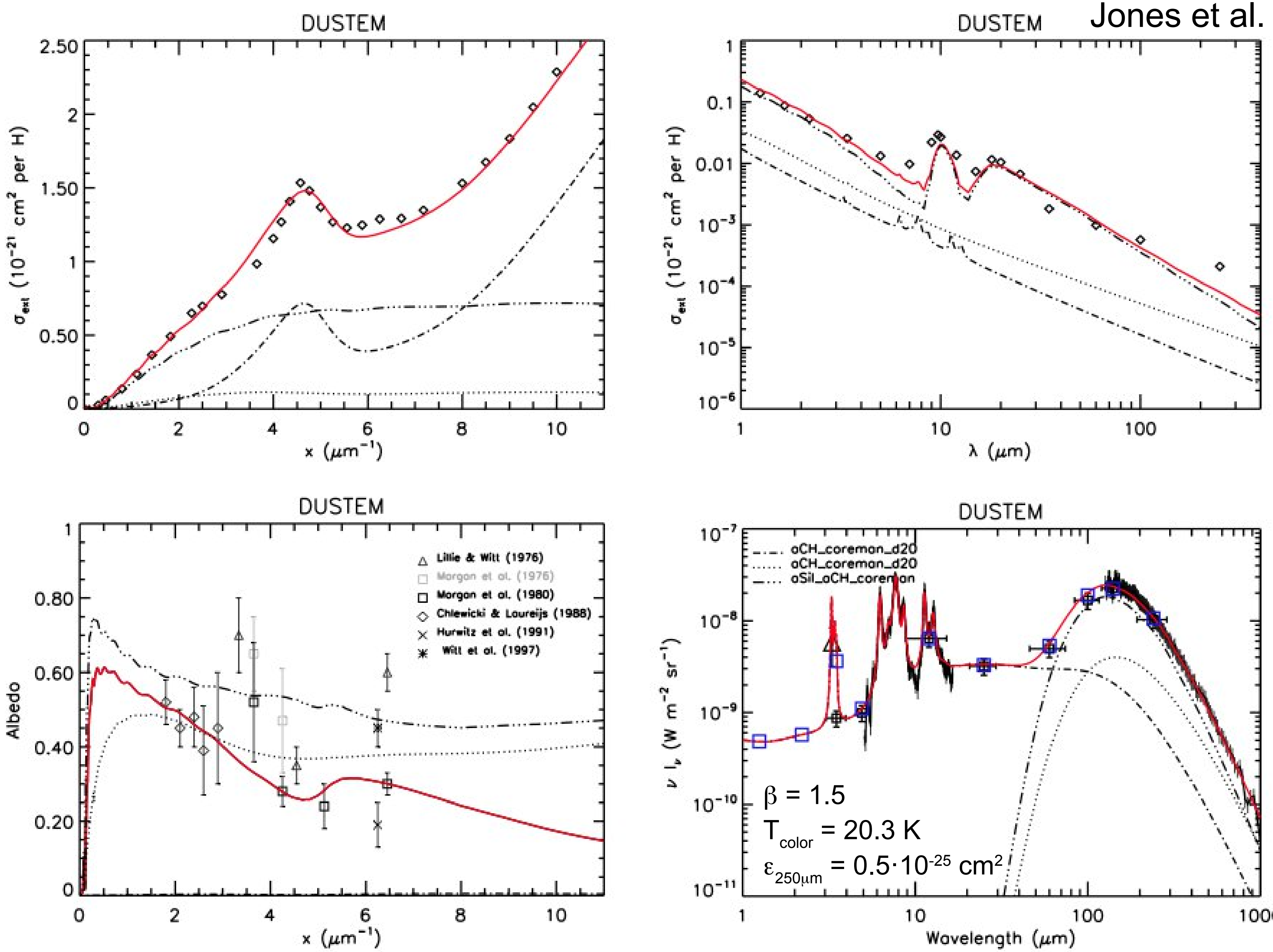
Optical constants:

am. silicate: Scott & Duley 1996
inclusions: Fe: Ordal et al. 1985,1988
FeS: Pollack et al. 1994

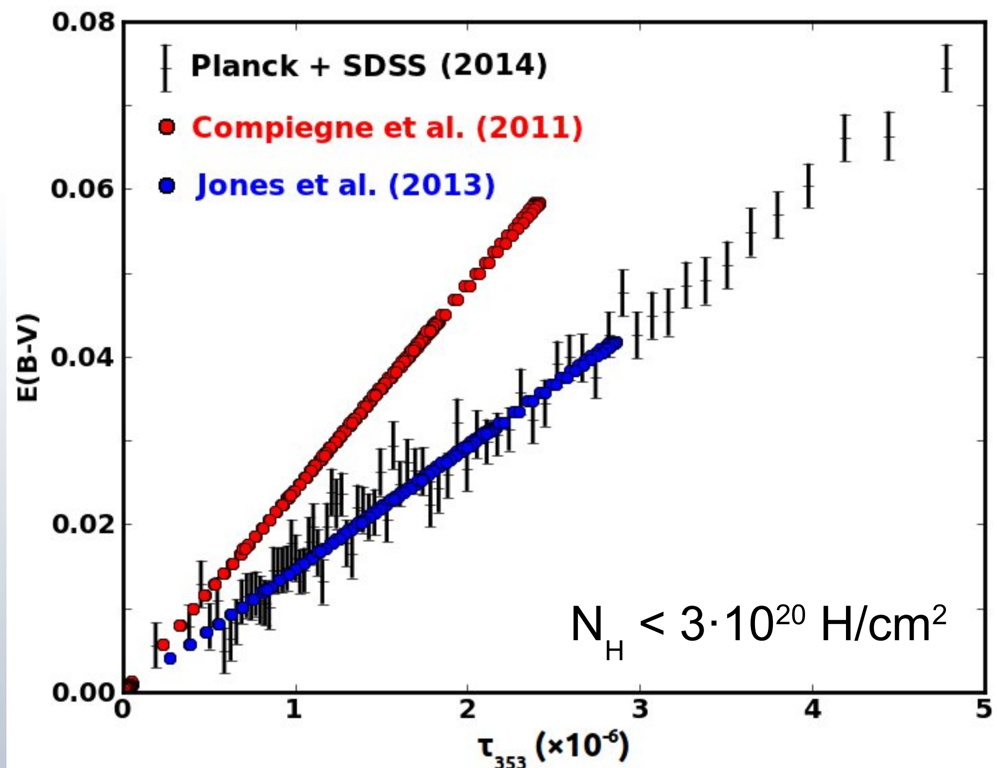
am. carbon: Jones et al. 2012

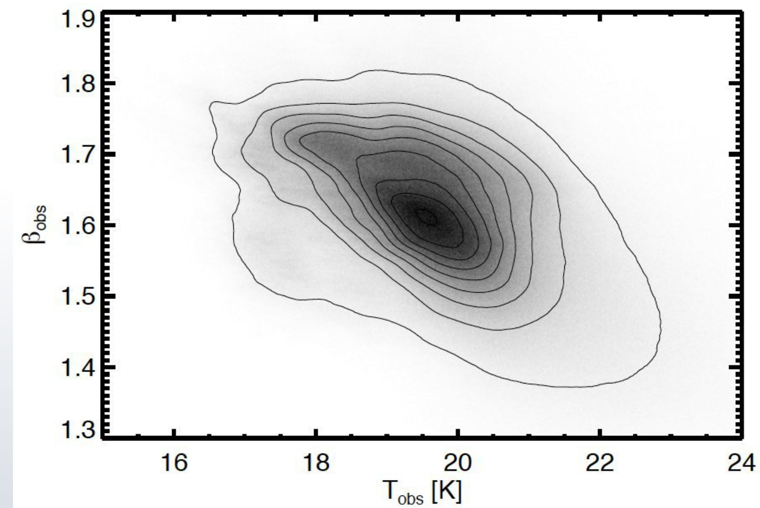
Dust in the diffuse ISM

Jones et al. 2013



Dust in the diffuse ISM

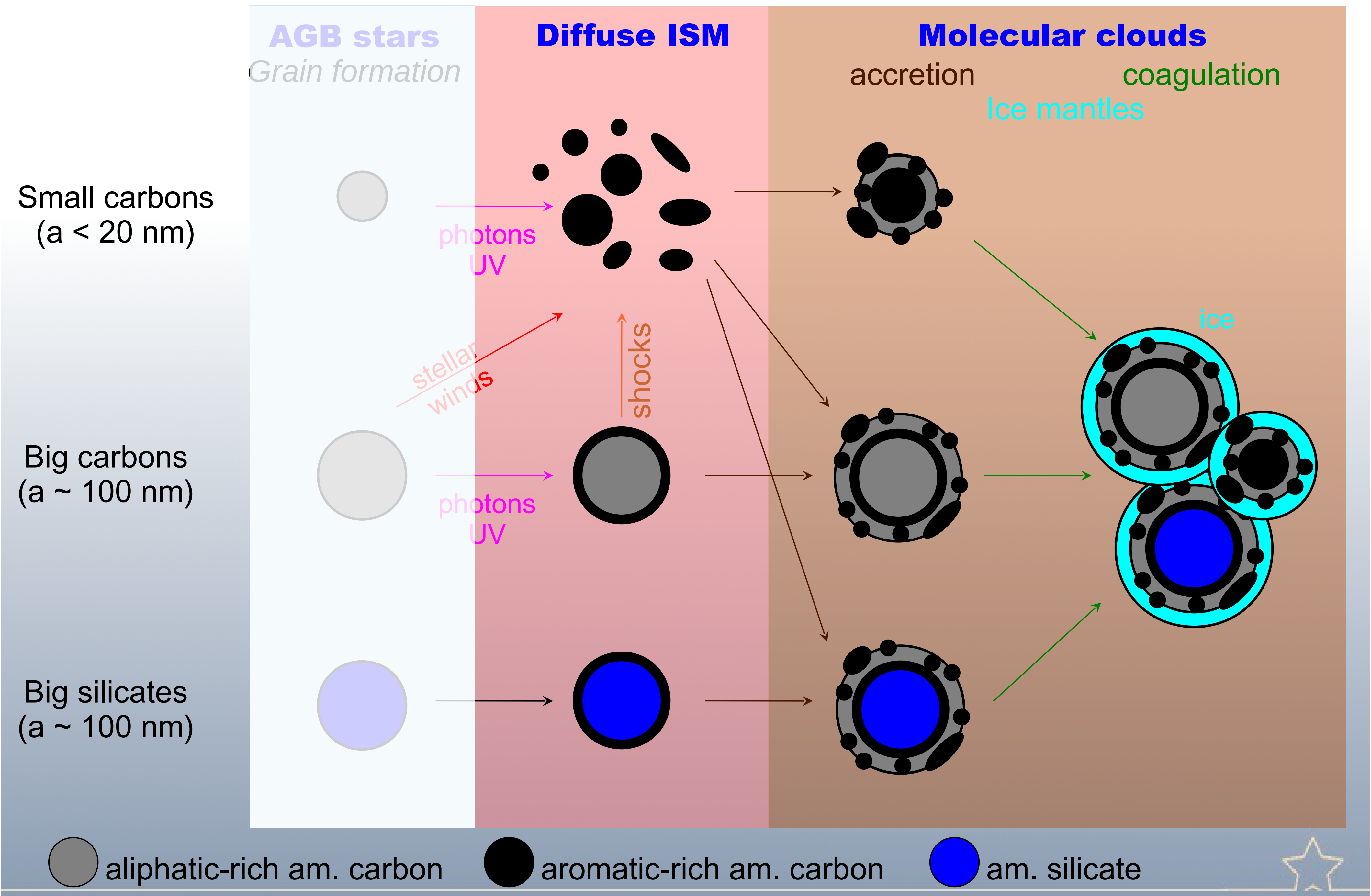




Talk by Lapo Fanciullo

Poster by Nathalie Ysard

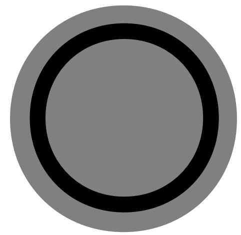
Dust evolution

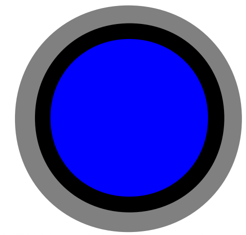


Dust growth

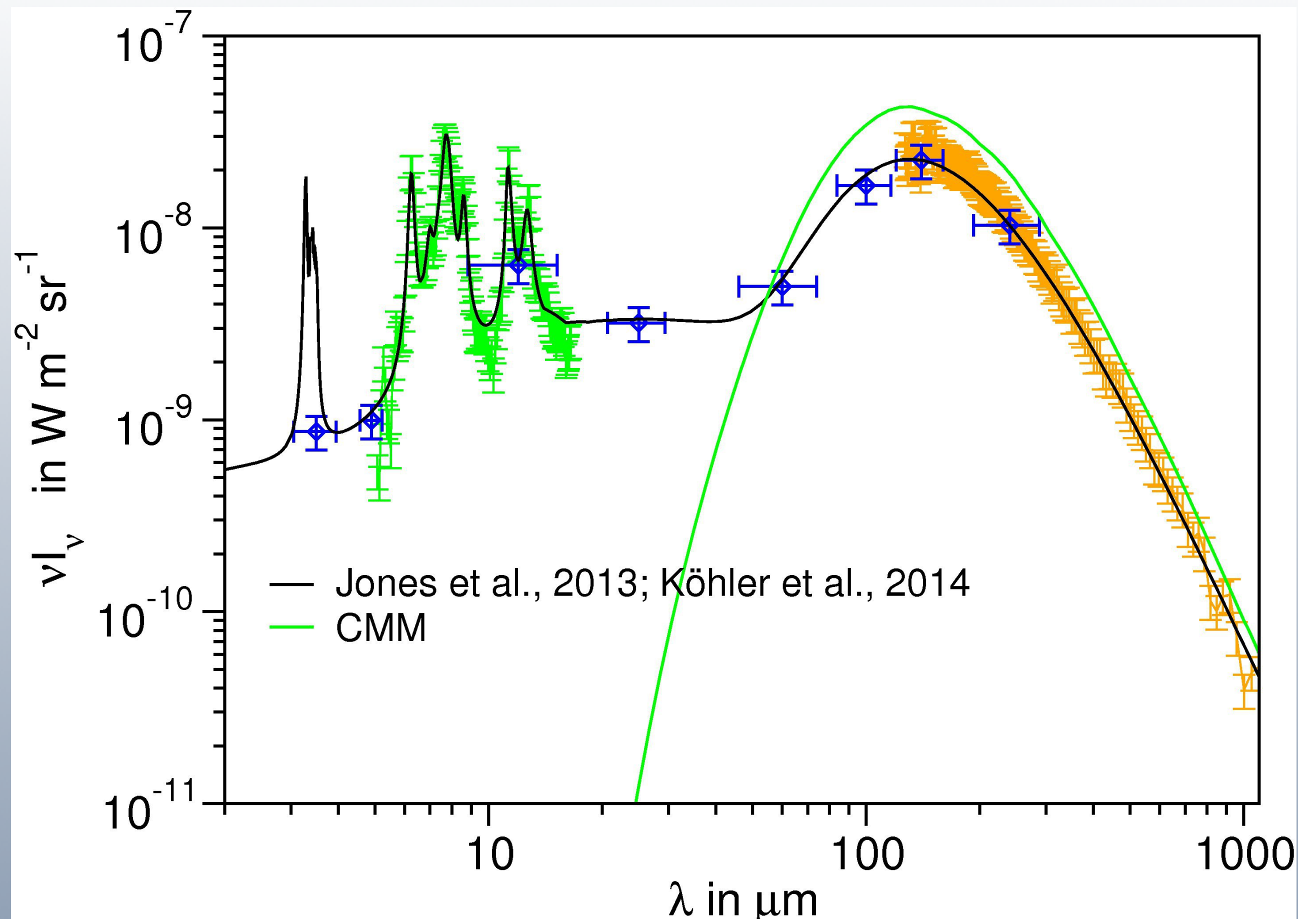
Accretion

aliphatic-rich am. carbon
aromatic-rich am. carbon
aliphatic-rich am. carbon





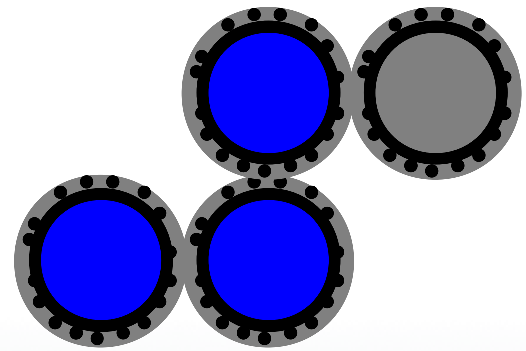
aliphatic-rich am. carbon
aromatic-rich am. carbon
am. silicate + Fe inclusions

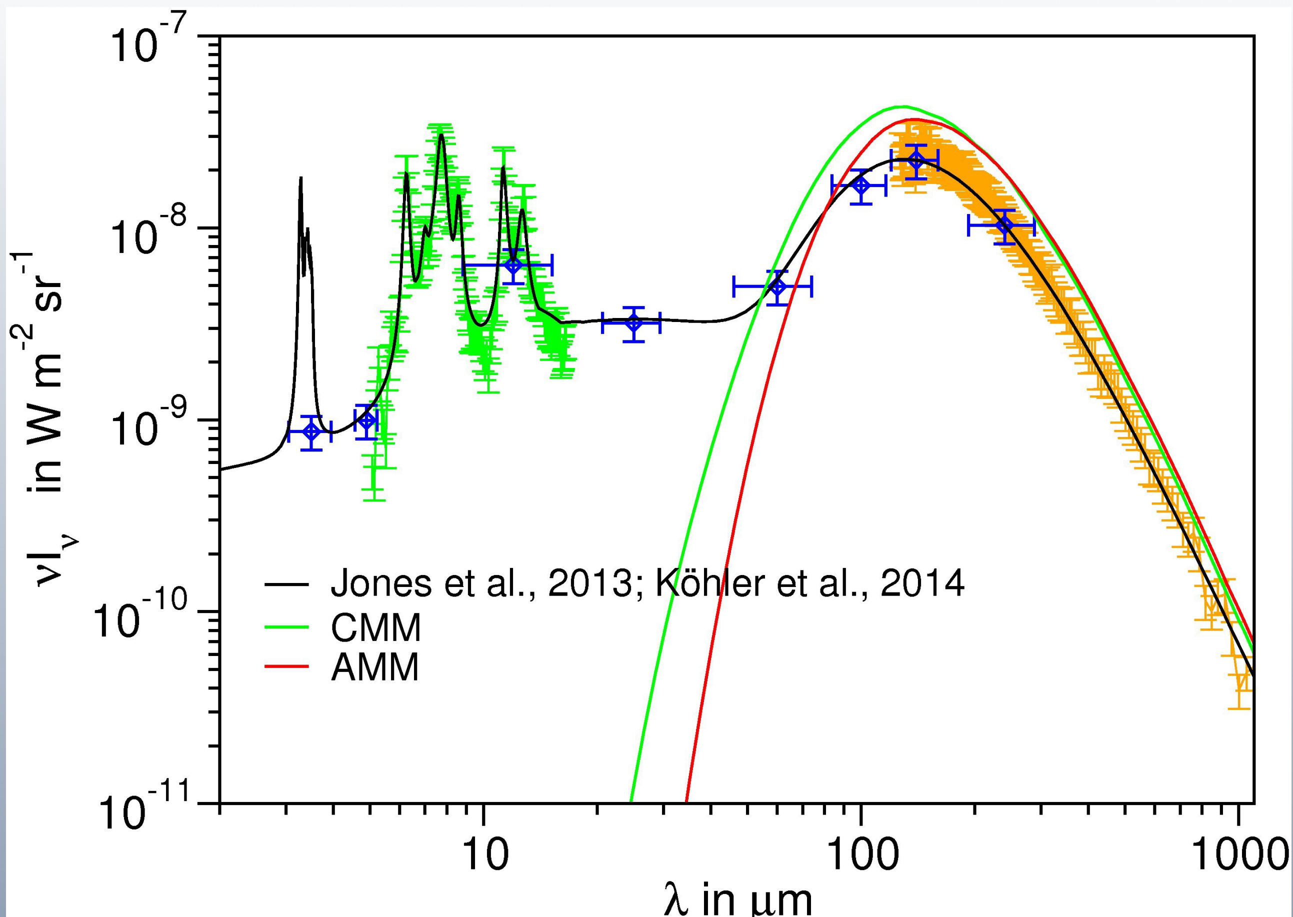


Dust growth

Accretion &

Coagulation of VSGs and BGs



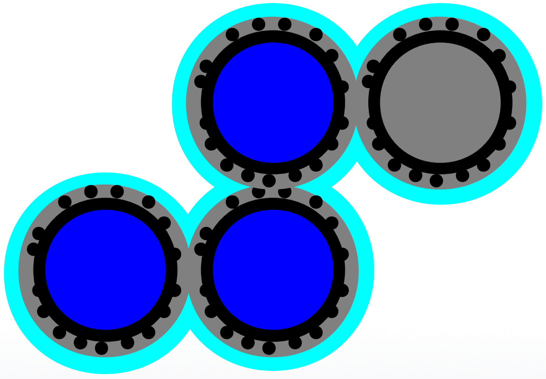


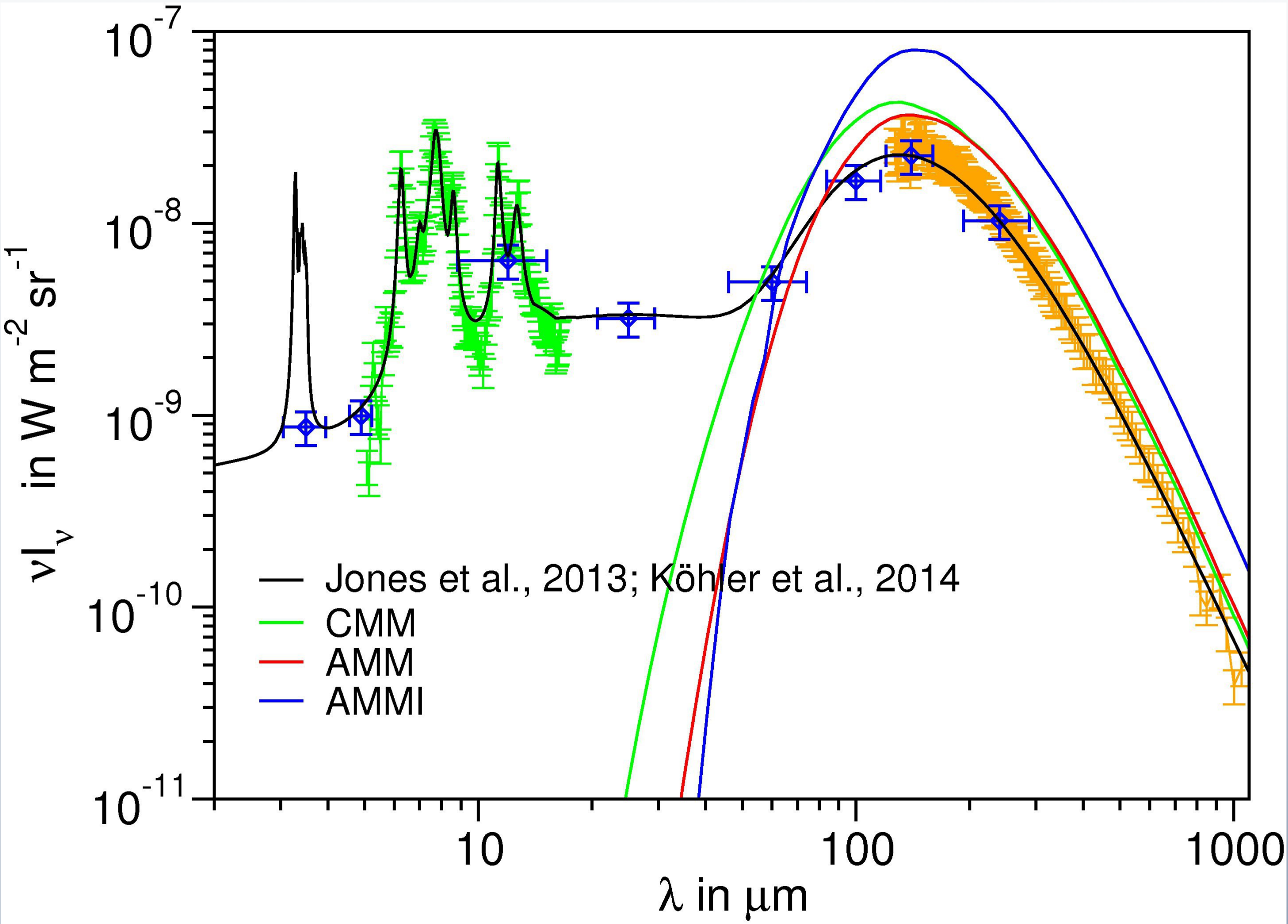
Dust growth

Accretion &

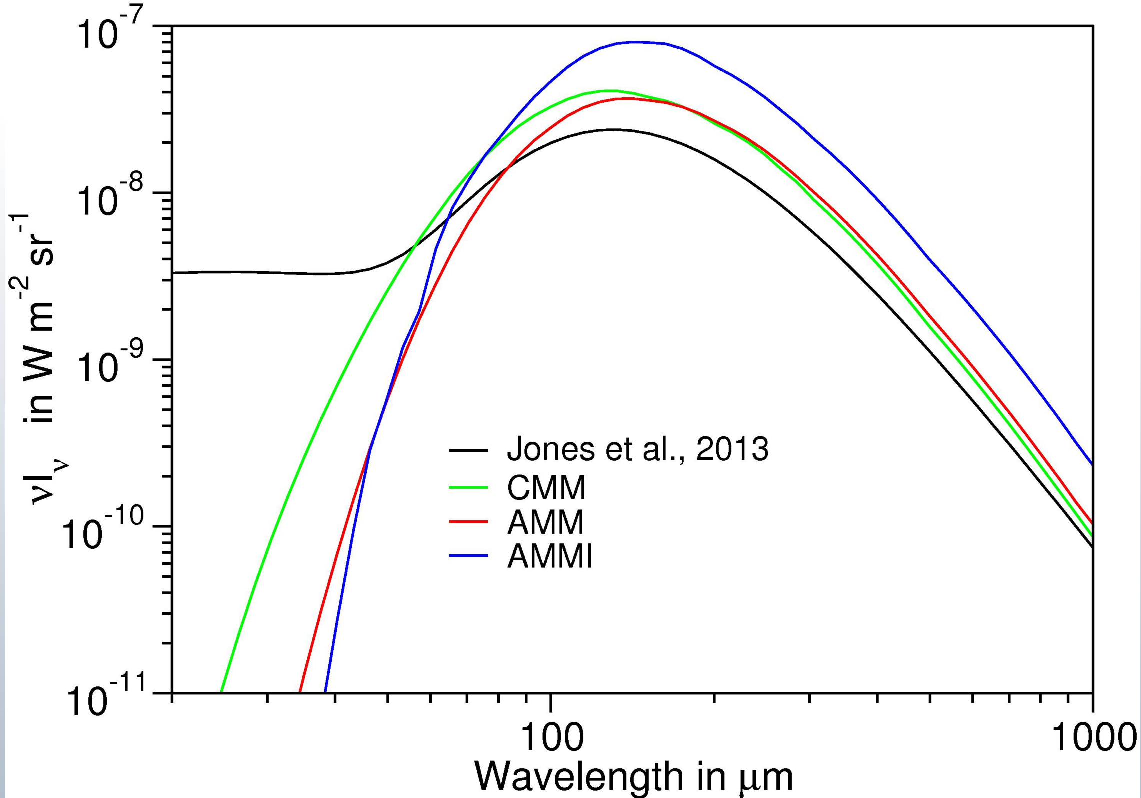
Coagulation of VSGs and BGs &

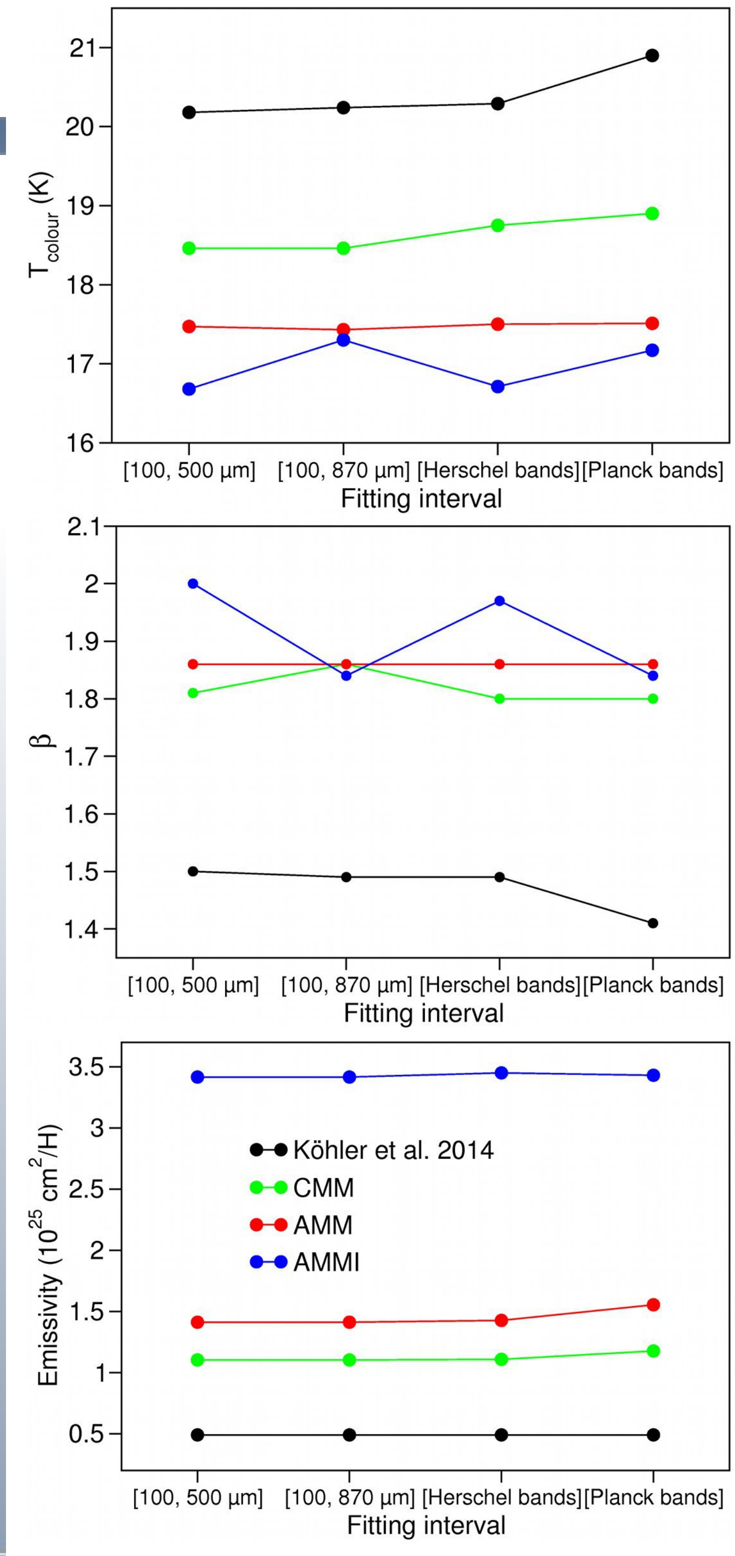
Accretion of ice mantles





Dust growth

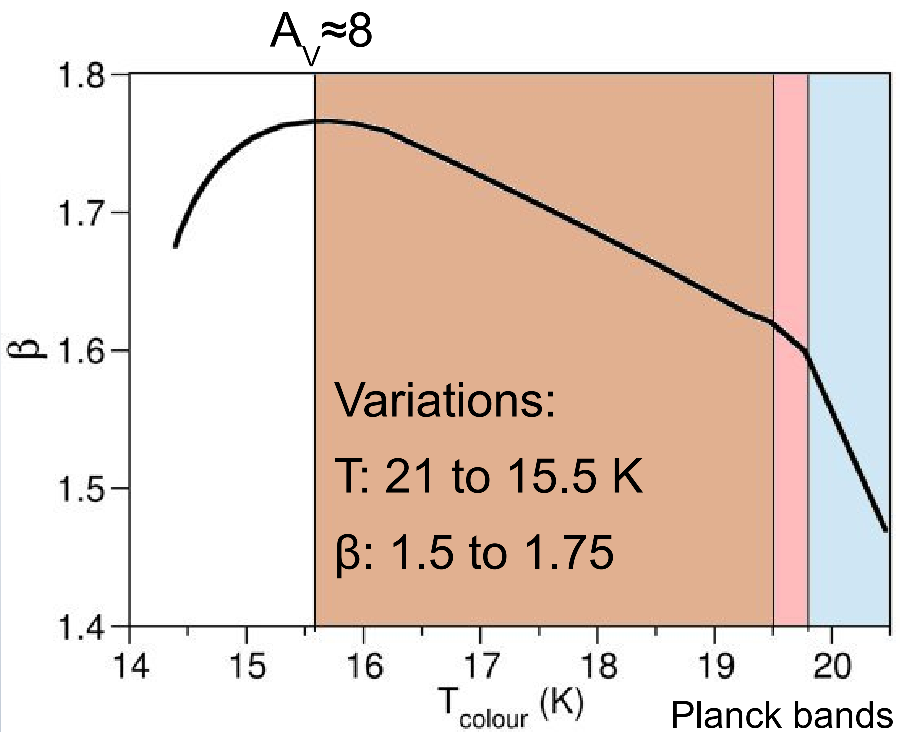


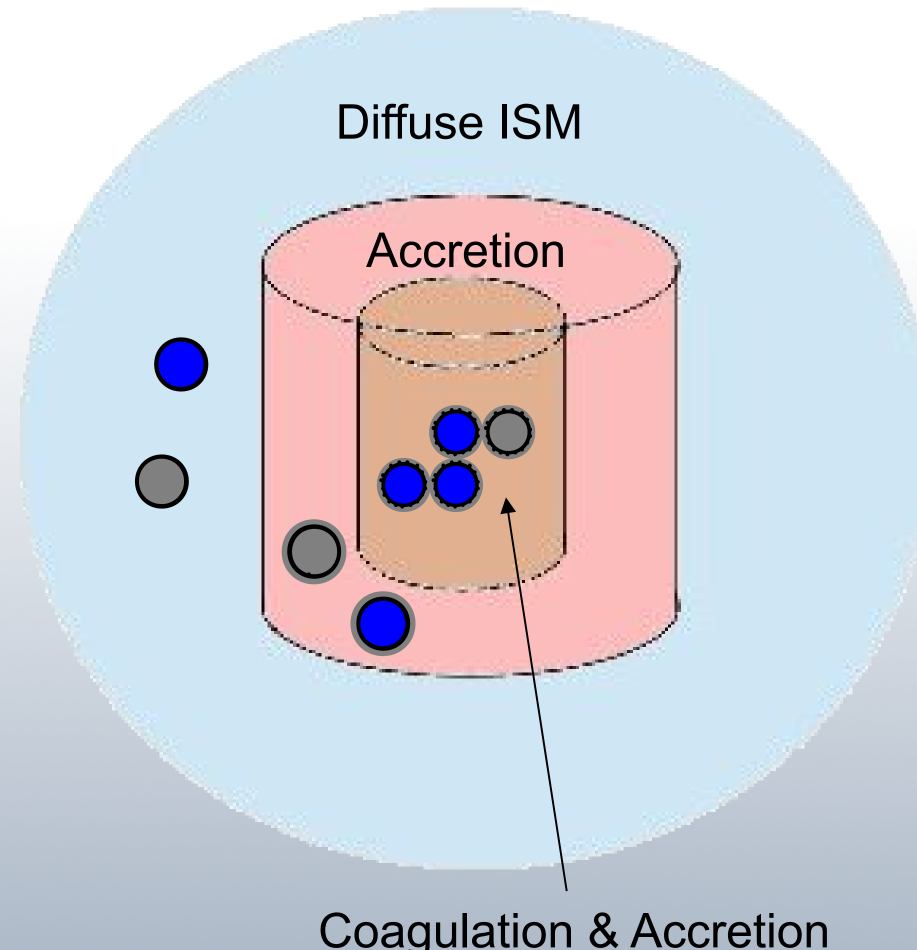


Köhler et al., (in prep.)

Dust evolution

DustEM + CRT





n_H: 100 to 10^6 cm^{-3}

A_V: 0.1 to 20

Summary

- Dust in the diffuse ISM
  - Individual small and large grains
  - Core-mantle grains
  - $\beta = 1.5$, $T_{color} = 20.3$ K, $\varepsilon_{250\mu m} = 0.5 \cdot 10^{-25}$ cm^2

in good agreement with observations of the diffuse ISM

- Dust in the denser ISM
  - Coagulation & Accretion: Aggregates with carbonaceous and ice mantles
  - Variations:
    - decrease in T to 17 K
    - increase in β to 1.9
    - increase in $\varepsilon_{250\ \mu m}$ by a factor of up to 3.5, with ice mantle up to 7

as observed in denser regions in the ISM