



ICED: IAS/CEA evolution of Dust

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Laboratoire de Physique des Solides



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Overview

- Project objectives.
- What is Interstellar Dust (ISD)?
- The crucial role of Nearby Galaxies.
- IMEGIN (NIKA2) & DustPedia.
- Modelling ISD evolution.
- Summary.





Main goal : constraining the evolution of Interstellar Dust grains in different environments.



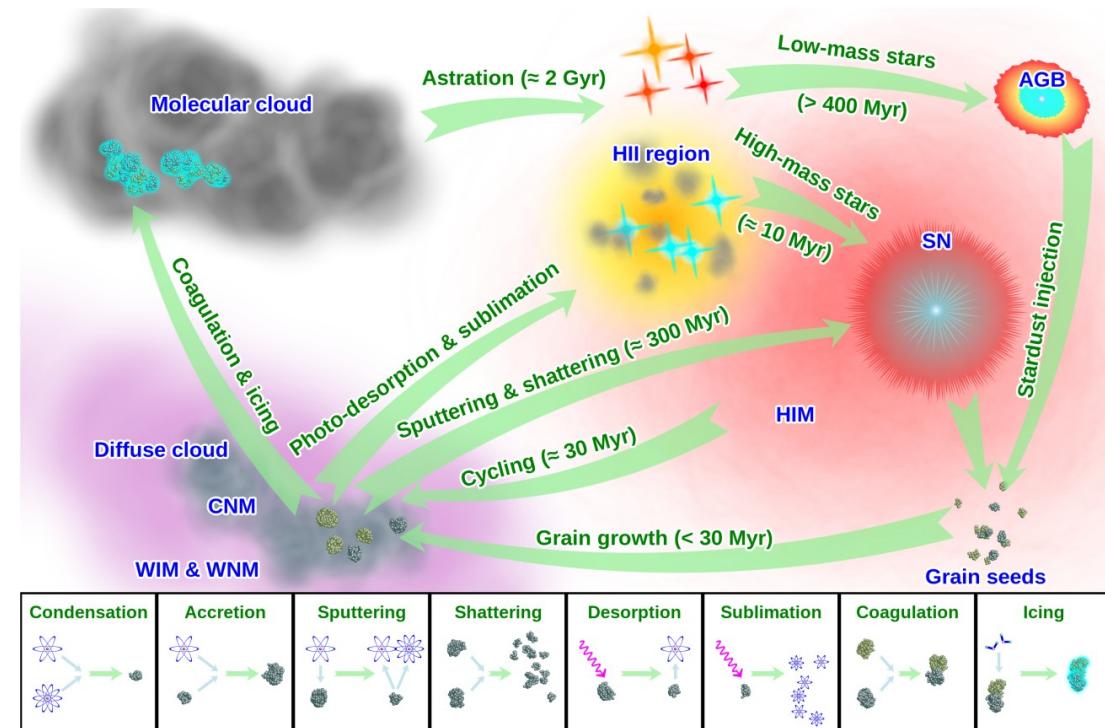
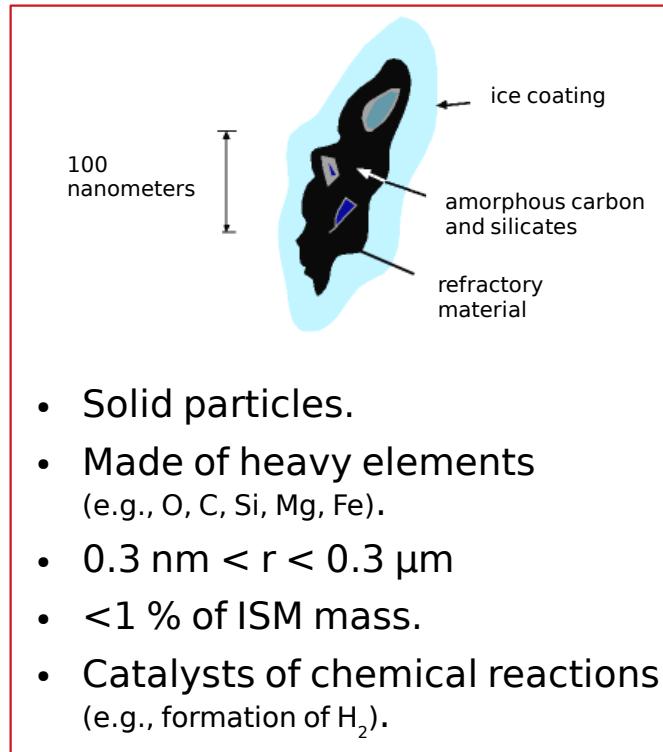
Tools :

- Spatially-resolved modelling of optical/near-IR-to-cm Spectral Energy Distributions of nearby galaxies .
- The data used are part of the European consortium of the **NIKA2 Guaranteed Time program, IMEGIN** (P.I. Madden), currently acquiring 1 and 2 mm continuum maps of nearby galaxies at the IRAM-30m telescope.
- NIKA2 data complemented by the multi-wavelength images of the **DustPedia** sample.
- SED modelling performed with the **THEMIS** dust evolution model (Jones et al., 2017) within the hierarchical Bayesian SED fitting code **HerBIE** (Galliano, 2018).



- What is Interstellar Dust (ISD) ?

Dust grains and their lifecycle

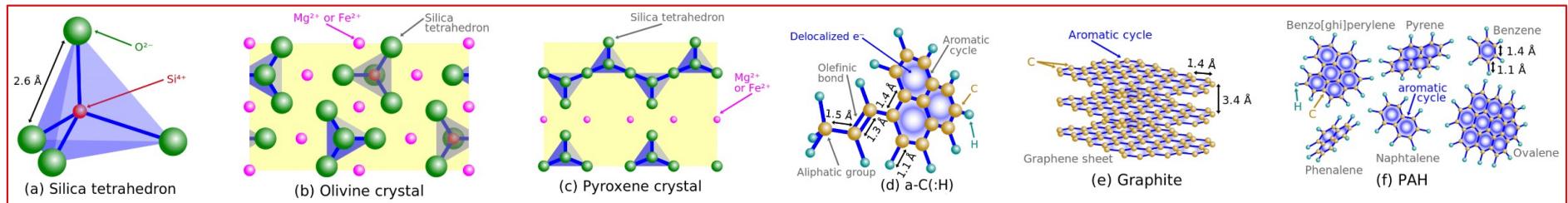


credit : F. Galliano

- What is Interstellar Dust (ISD) ?

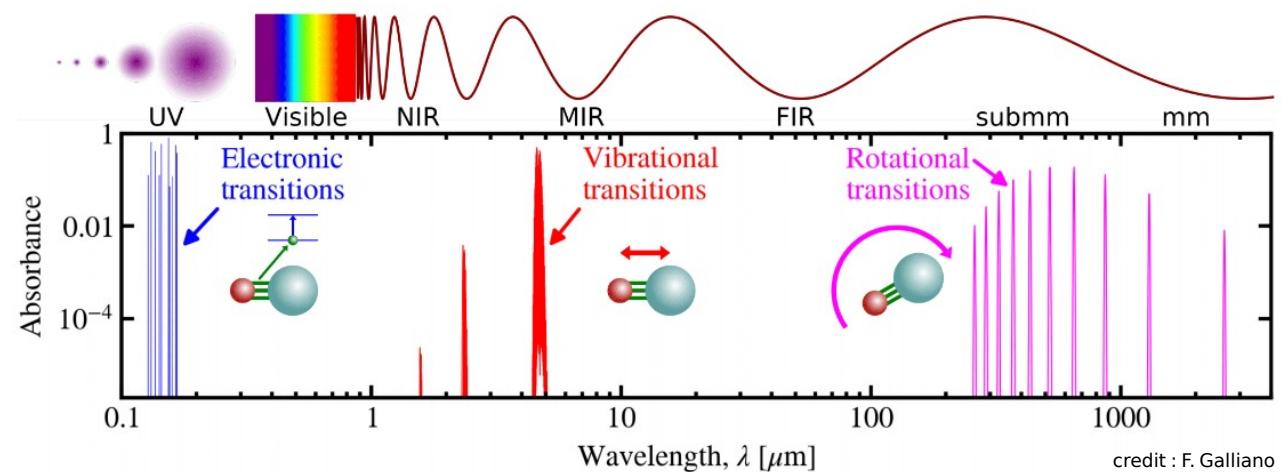


ISD candidates



Dust grains show their nature by interacting with light.

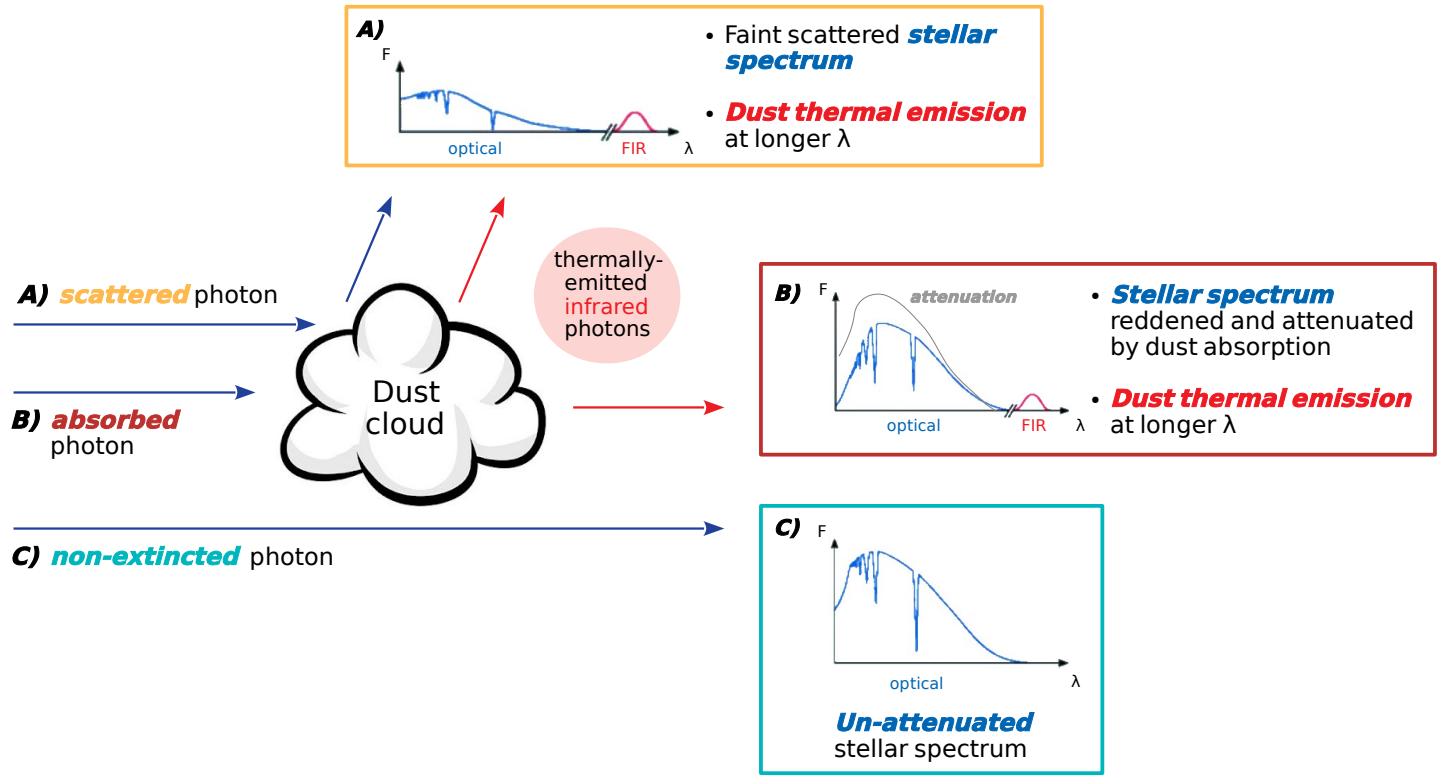
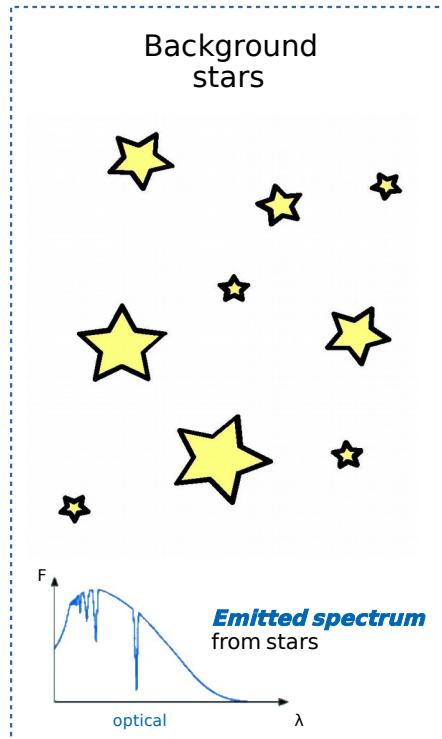
The most relevant transitions are in the **MIR** and associated with the ***stretching or bending of a bond***.



- What is Interstellar Dust (ISD) ?



Extinction

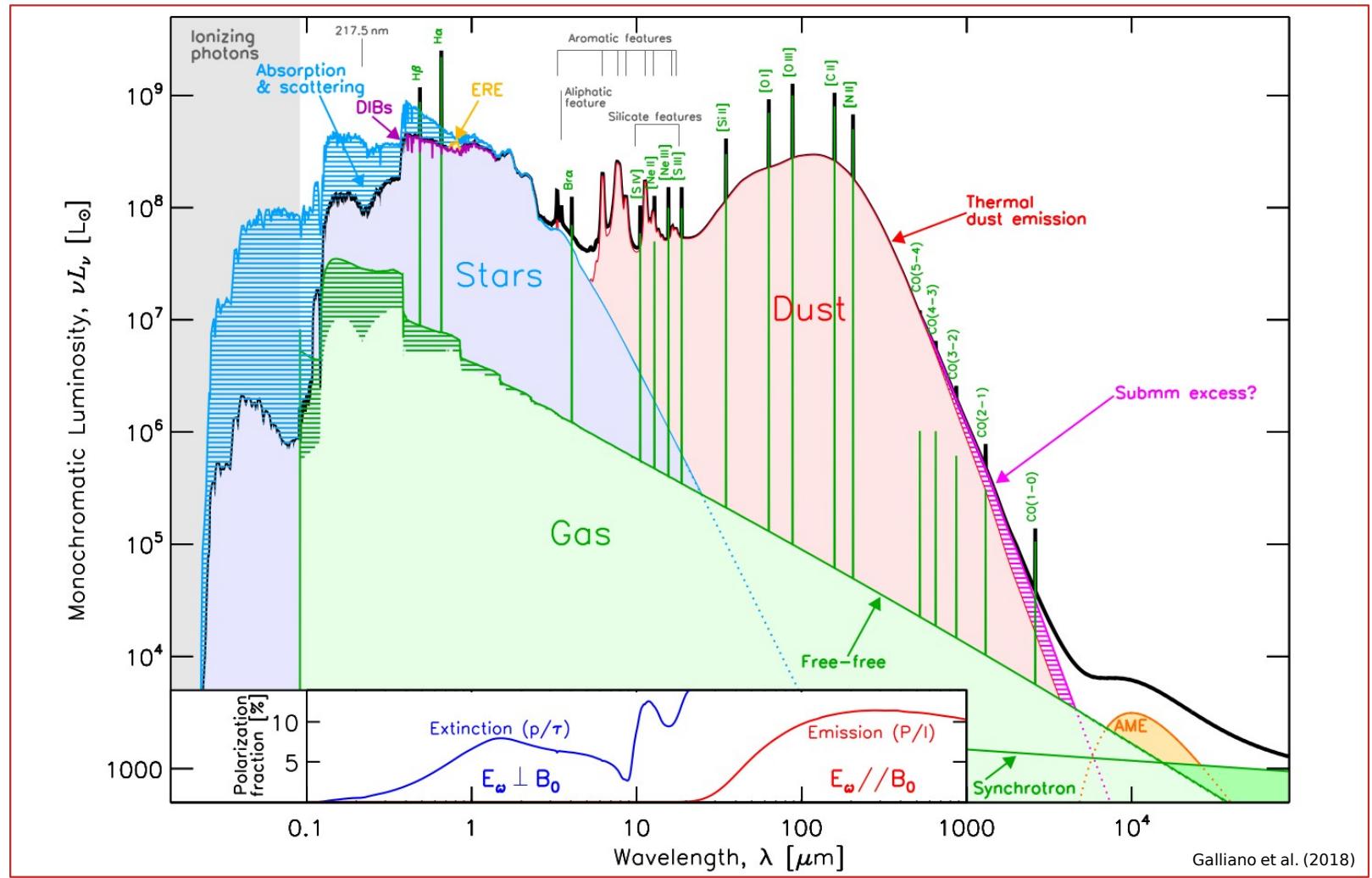




- The crucial role of Nearby Galaxies.

SED of a typical late-type galaxy.

- Dust absorbs and reradiates ~30% of stellar power in the IR.
- Essential for ***star formation***.
- Responsible for the ***heating of gas*** in neutral atomic medium (photoelectric effect).
- Polarized extinction and emission** by elongated grains (magnetic field).





- The crucial role of Nearby Galaxies.

Most of our knowledge of ISD properties comes from studies of the **Milky Way**.

(Draine 2003a)



Small range of environmental conditions

- Confusion along the sightline.
- No massive star forming regions.
- Narrow radial metallicity gradient.
- Passive SMBH.



Milky Way



faced-on spiral galaxy

M99 - NGC4254



Blue Dwarf Irr galaxy

DDO 68

credit : ESO ; NASA/ESA



Nearby galaxies (< 100 Mpc) provides unique constraints on ISD properties.

- Faced-on galaxies → **clearer sightlines** .
- SSC in Blue Dwarfs ; bright AGNs ; low Z objects → probe ISD in **extreme conditions** .
- Intermediate step towards understanding ISD and ISM in **distant galaxies** .

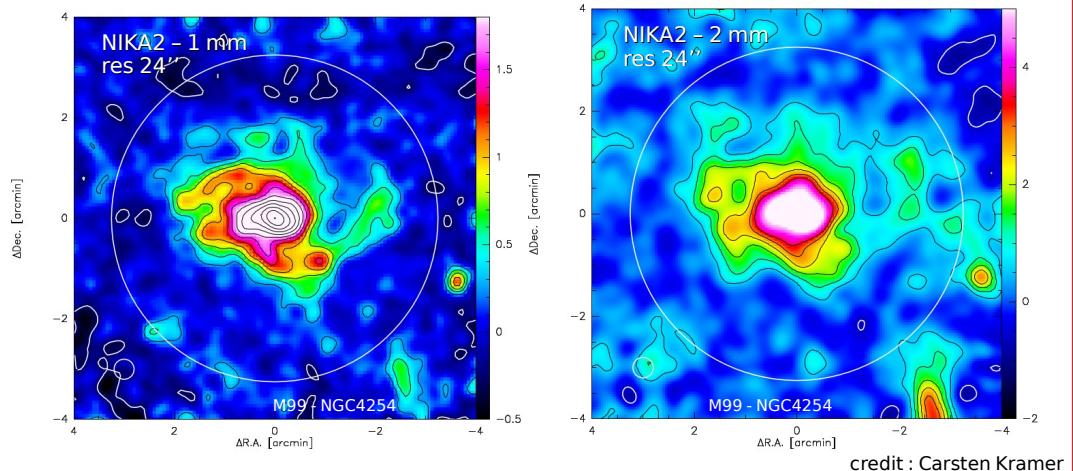
- IMEGIN (NIKA2) & DustPedia.



IMEGIN : Interpreting the Millimetre EMission of Galaxies (NIKA2)

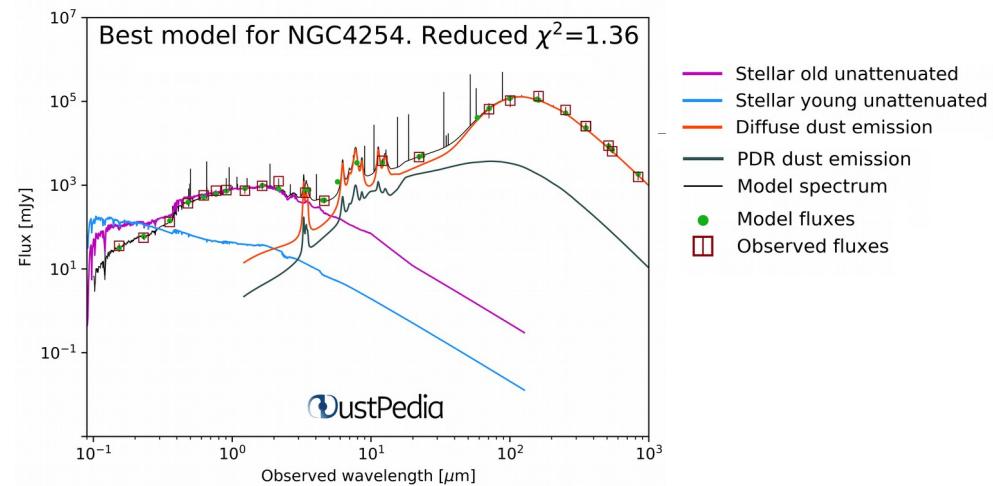
PI: Madden

- ISD, free-free and synchrotron emission in spatially-resolved galaxy SEDs.
- Dust-to-gas mass ratio within galaxies.
- Dust millimeter opacity.
- Sub-millimeter excess in galaxies.



DustPedia archive contains 875 nearby galaxies.

Data are from GALEX, SDSS, DSS, 2MASS, WISE, Spitzer, Herschel, and Planck surveys.

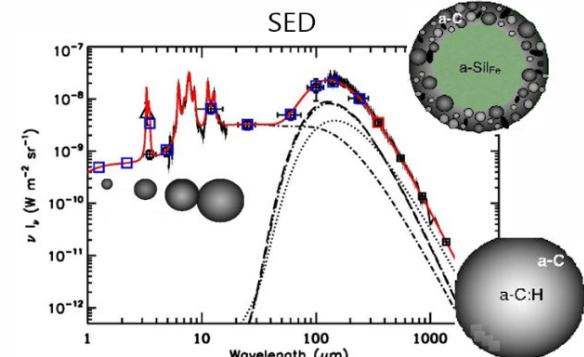
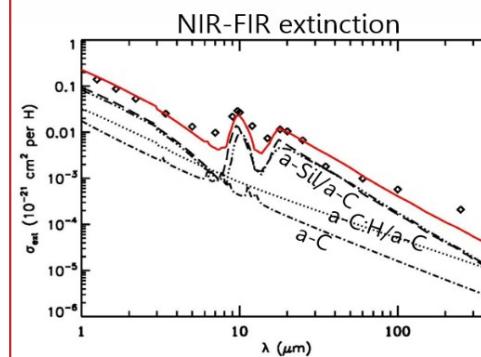
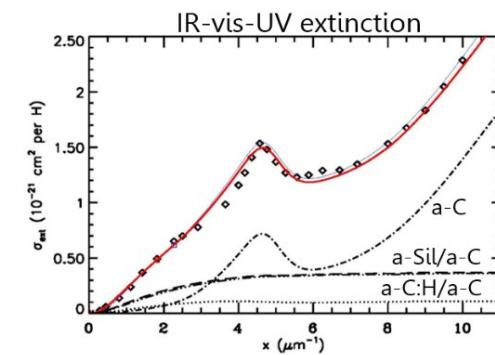
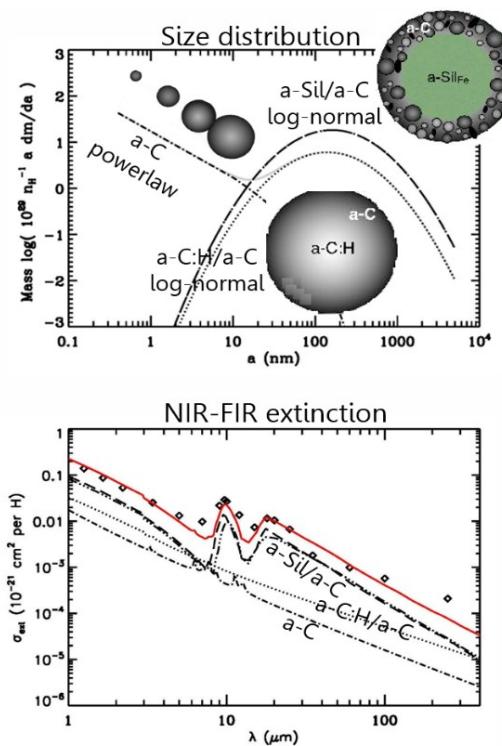
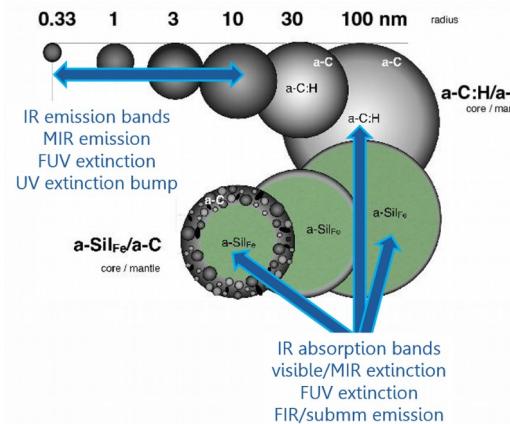


- Modelling ISD evolution.

THEMIS : The Heterogeneous dust Evolution Model for Interstellar Solids

- Anchored to the ***laboratory-measured properties*** of ISD analogues (i.e. amorphous hydrocarbons and silicates).

Optical properties
(e.g., refraction index).

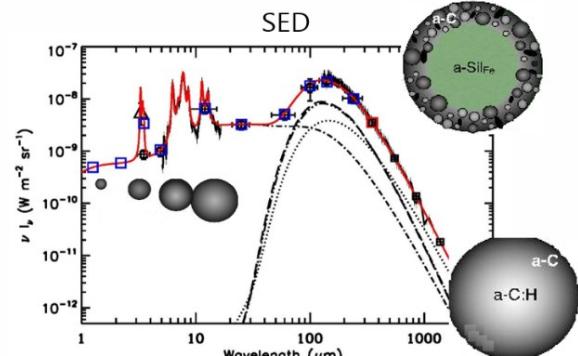
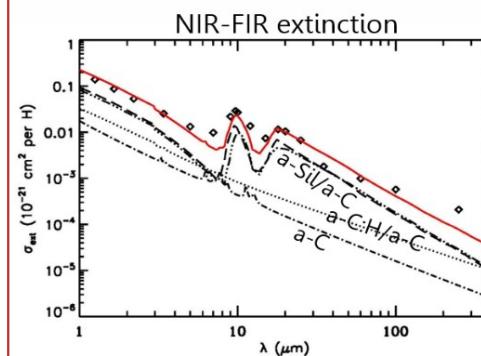
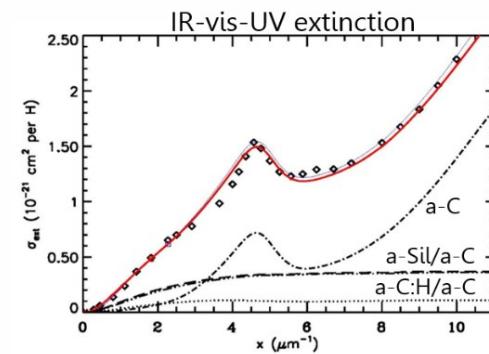
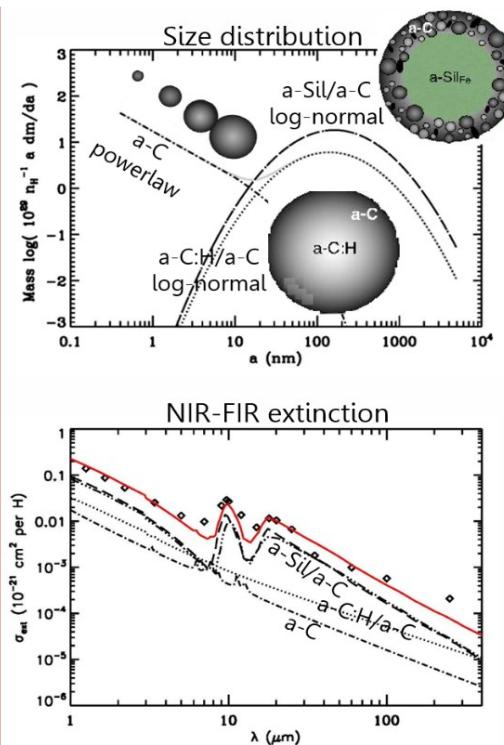


credit : www.ias.u-psud.fr/themis



THEMIS : The Heterogeneous dust Evolution Model for Interstellar Solids

- ISD size **distribution**, chemical **composition** and **structure** react to and adjust to :
 - local radiation field**
intensity and hardness ;
 - gas density and dynamics**
(diffuse ISM, molecular clouds).



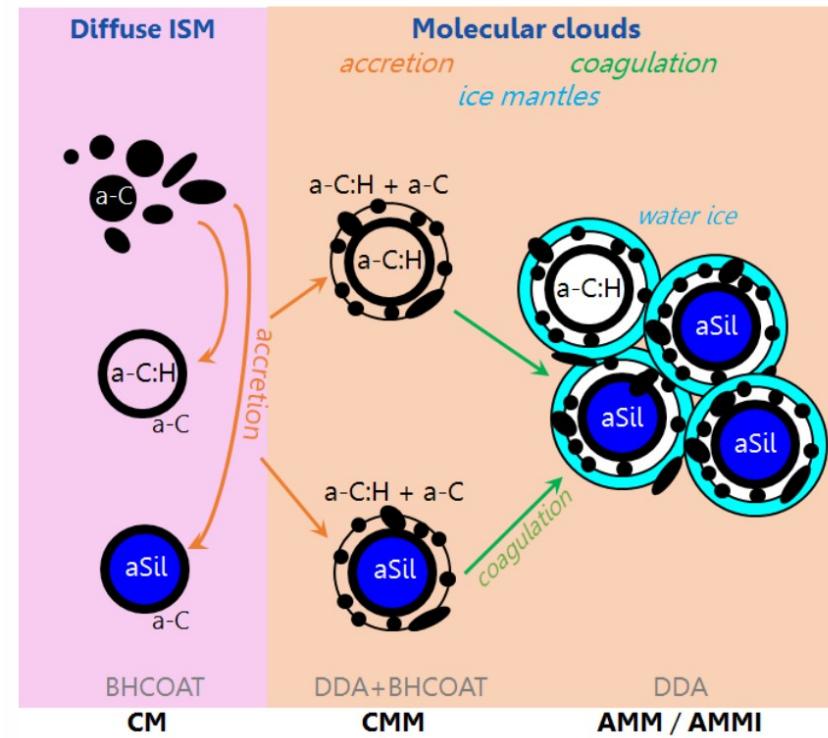
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- Modelling ISD evolution.

THEMIS : The Heterogeneous dust Evolution Model for Interstellar Solids

- ISD size **distribution**, chemical **composition** and **structure** react to and adjust to :
 - **local radiation field**
intensity and hardness ;
 - **gas density and dynamics**
(diffuse ISM, molecular clouds).
- ISD is **heterogeneous**, as a result of
 - grain surface **photo-processing** ;
 - **mantle accretion** and **coagulation**.



credit : www.ias.u-psud.fr/themis

HerBIE : Hierarchical Bayesian Inference for dust Emission

Constraining ISD grain properties
through dust SED fitting



Accurate retrieval of the parameters
and their intercorrelations

🚫 Series of **noise-induced false correlations** between derived parameters, when performing least-squares fit.
(Shetty et al. 2009)

Multilevel approach :

- dust parameters of each source (mass, temperature, etc.) ;
- a set of **hyperparameters** controlling the distribution of these dust parameters.

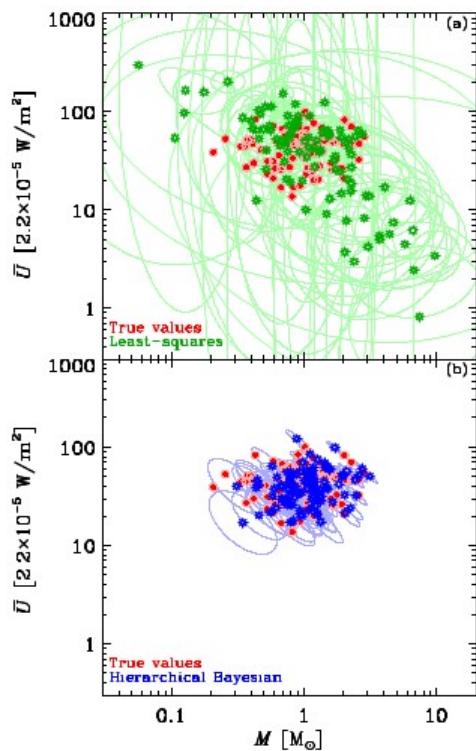


✓ Hierarchical Bayesian model **accounts for** both **noise** and correlated calibration uncertainties.
(Kelly et al. 2012)



- Modelling ISD evolution.

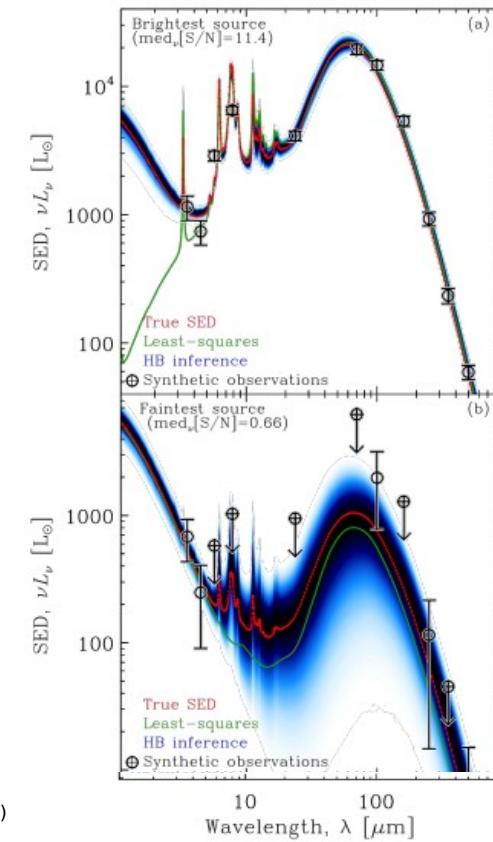
HerBIE : Hierarchical Bayesian Inference for dust Emission



HerBIE applies the HB approach to full dust models.

It includes :

- realistic optical properties by THEMIS ;
- stochastic heating ;
- mixing of physical conditions in the observed regions.
- Efficient at **recovering true correlations** between parameters and their intrinsic scatter.
- **Closer inferred values** to their true values than the least-square ones, and distributed symmetrically around them.
- Compensates for a partial lack of spectral coverage.
- **Accurate** over a wide range of sample sizes, source properties, S/N ratios and number of model parameters.



F. Galliano (2018)

Summary

1

NIKA2 millimeter maps
(IMEGIN ; PI : Madden)



DustPedia multi-wavelength data
(optical/near-IR-to-cm)

Spatially-resolved
observed SEDs ;

2

THEMIS dust
grains evolution
model
(Jones et al. 2017)

HerBIE hierarchical
Bayesian SED fitting
code (Galliano 2018)

Maps of dust
parameters ;

3

Constrain ISD properties
in \neq environments

Constrain dust evolution
processes.



merci