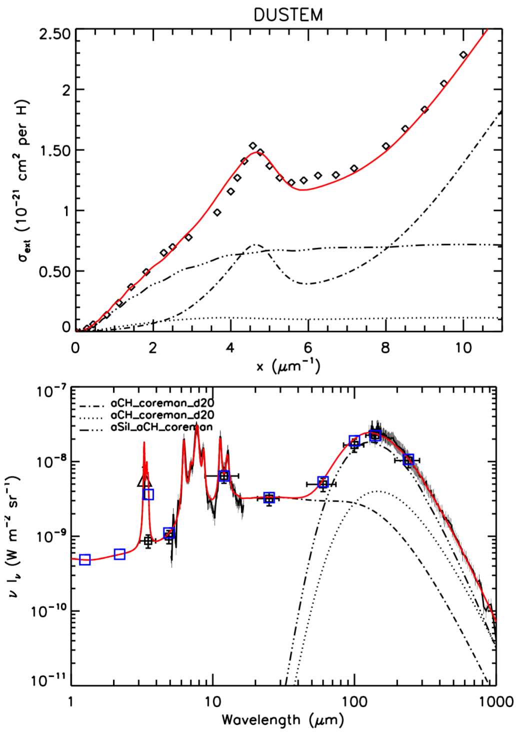


Dust Modelling

a THEMIS update

Ant Jones, Nathalie Ysard, Melanie Köhler,
Marco Bocchio, Laurent Verstraete, …

Réunion P2IO JWST - IAS, Friday 9 June 2017

THEMIS / DustEM

What does DustEM do?

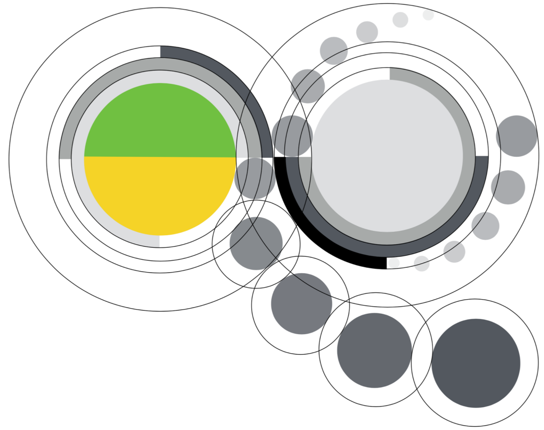
- extinction (FUV-FIR)
- emission (IR-cm) - photon and electron heating
- polarisation (FUV-cm)
- charge distribution - Z(a)
- photo-electron heating
- anomalous microwave emission (“spinning dust”)

Compiègne et al. (2011)

THEMIS

(The Heterogeneous dust Evolution Model for Interstellar Solids)

What is it?



- a new core/mantle (CM) dust model
- mixed solid phases - a-C:H/a-C & a-Sil$_{Fe,FeS}$/a-C
- dust evolution - from diffuse to dense ISM
  - a-C:H ⟷ a-C, mantle accretion & dust coagulation

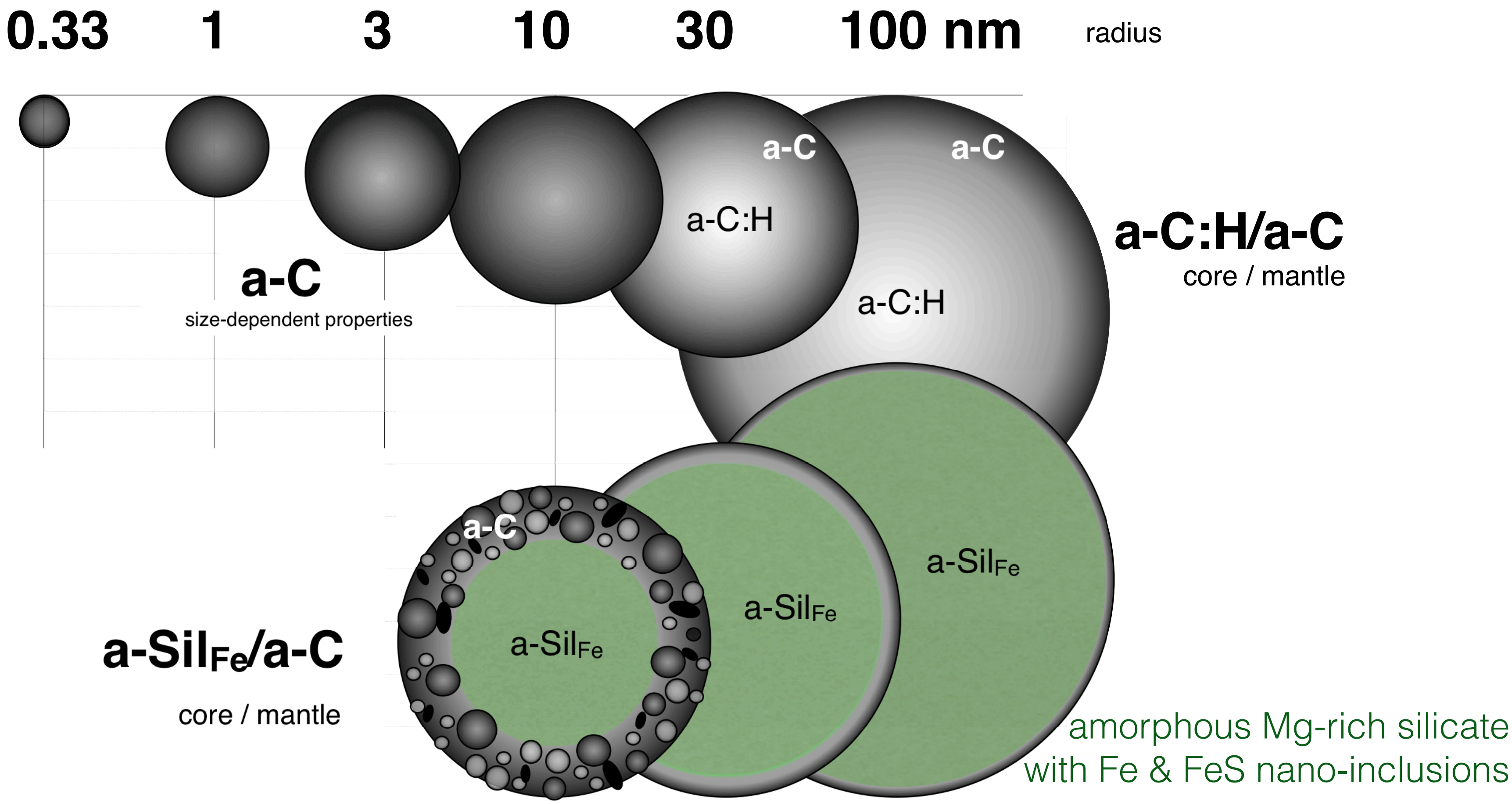
a-C = amorphous carbon   a-C:H = hydrogenated amorphous carbons

Jones et al. (2013, 2017), Köhler et al. (2014)

THEMIS

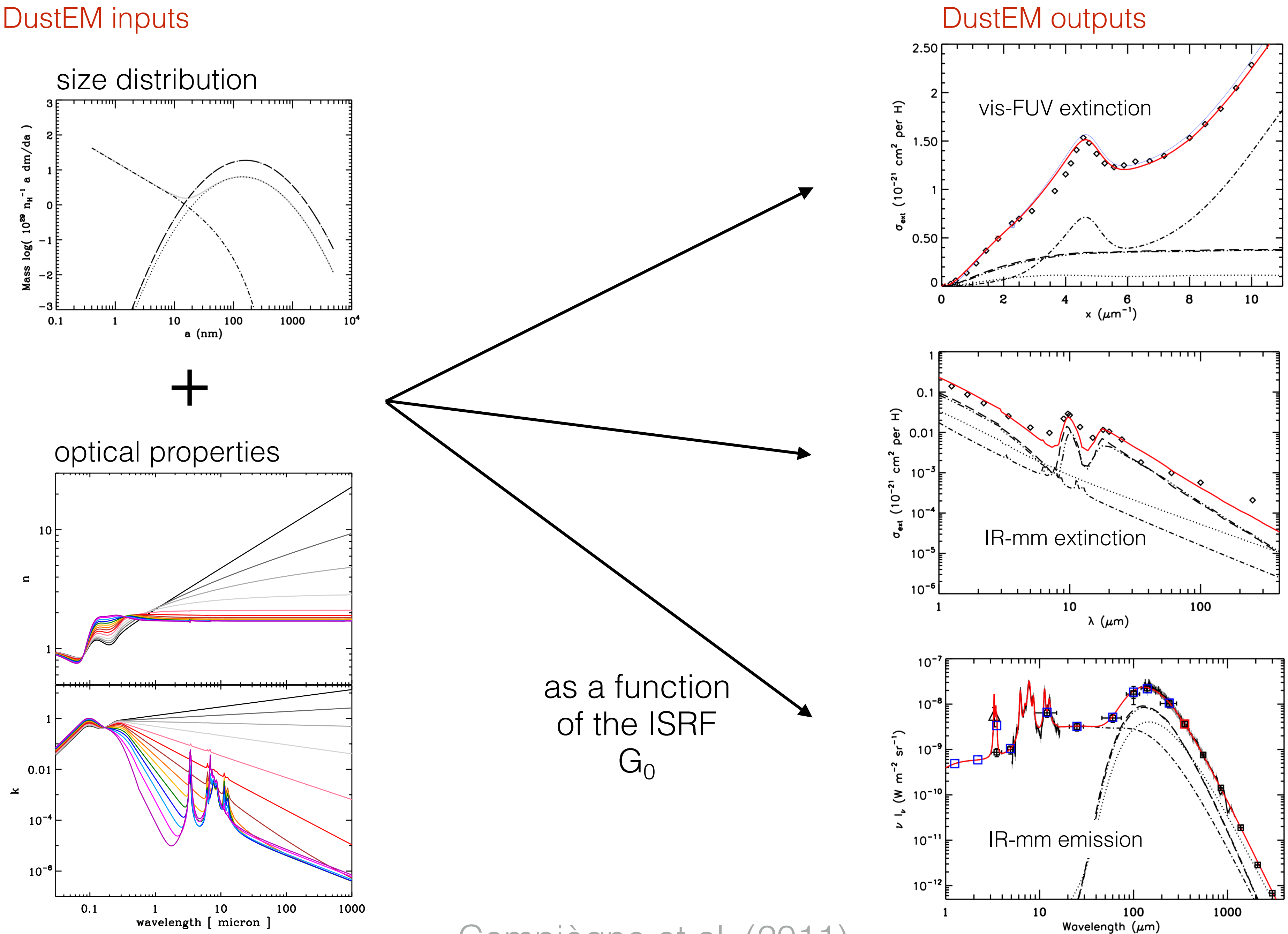
(The Heterogeneous dust Evolution Model for Interstellar Solids)

What does it look like?



Jones et al. (2013, 2017), Köhler et al. (2014)

DustEM & THEMIS



Compiègne et al. (2011)

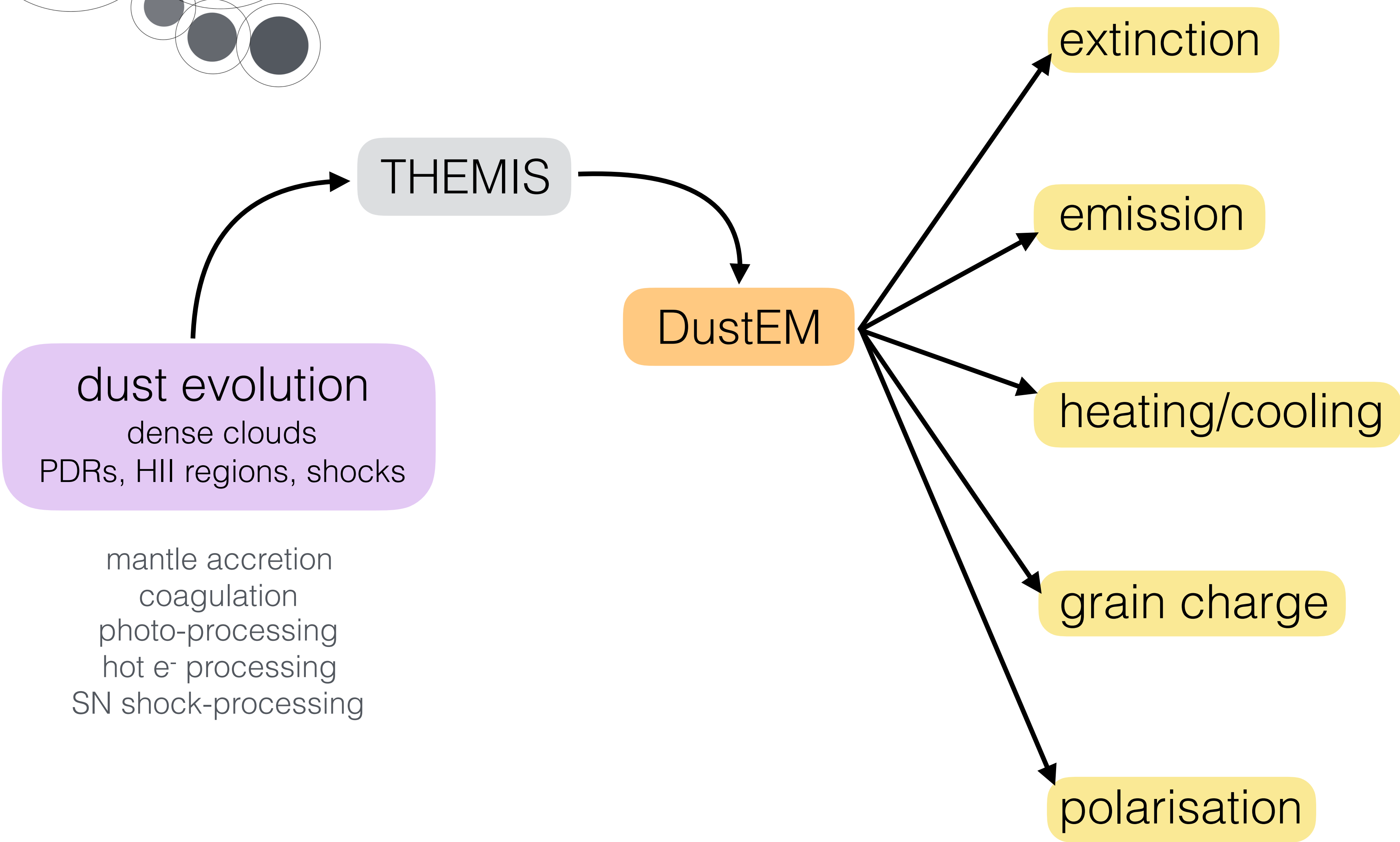
THEMIS / DustEM

What can it do with THEMIS?

- extinction (FUV-FIR)
- emission (IR-cm) - photon and electron heating
- polarisation (FUV-cm)
- charge distribution - Z(a)
- photo-electron heating
- anomalous microwave emission (“spinning dust”)

Compiègne et al. (2011)

DustEM & THEMIS
Summary



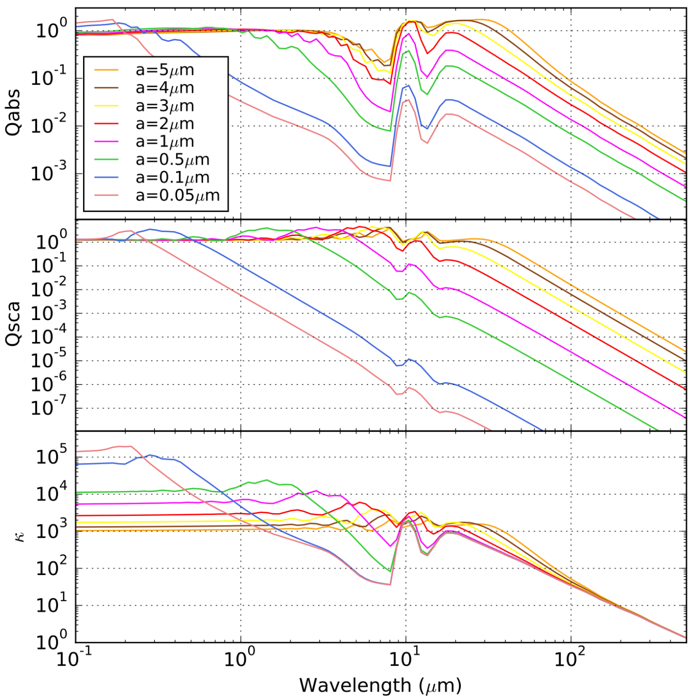
What's new with THEMIS?

- Larger grain optical properties
- Larger aggregate optical properties
- New silicate n & k coming soon (may be ?)
- A global view of dust (Jones 2016a,b,c RSOS)

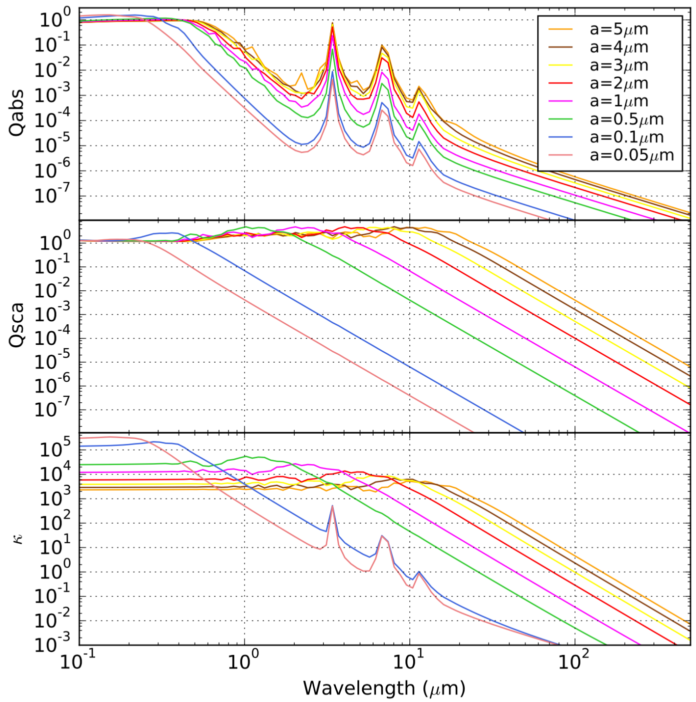
Larger grains

absorption, scattering & kappa

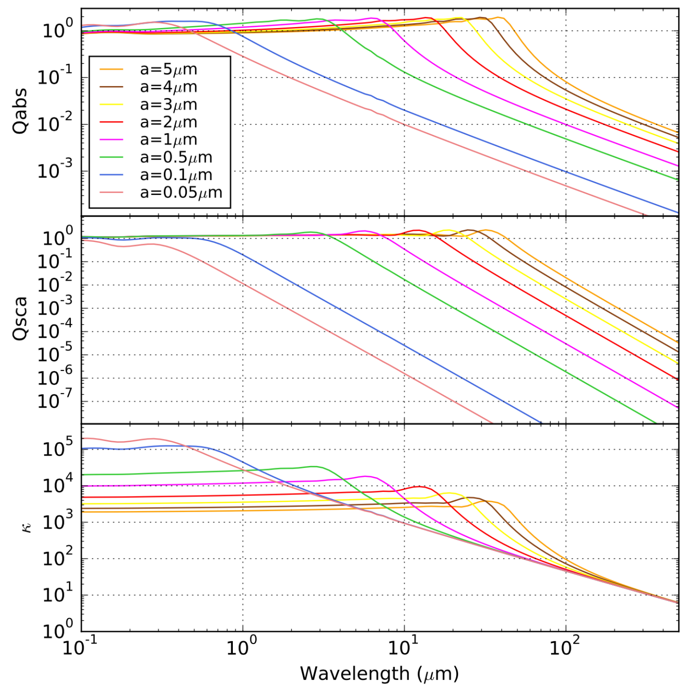
a-Sil



a-C:H



a-C

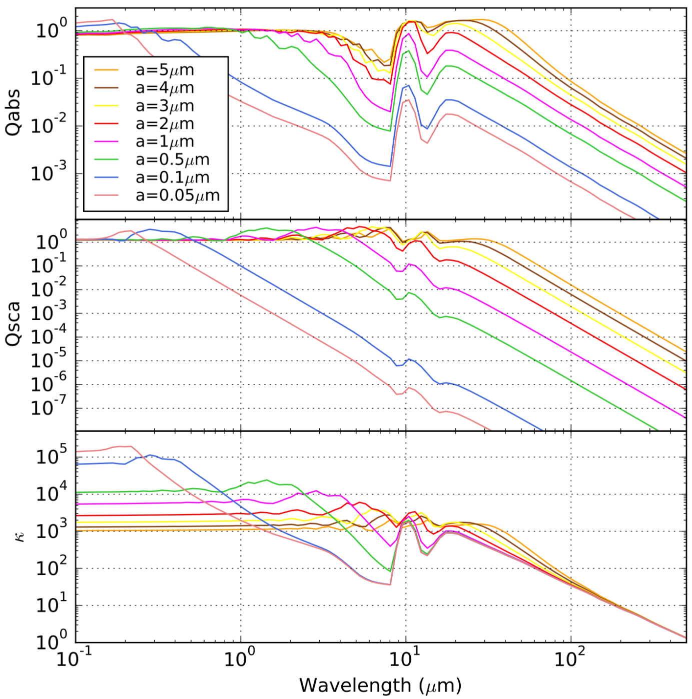


grain radii = 0.05 to 5 micron

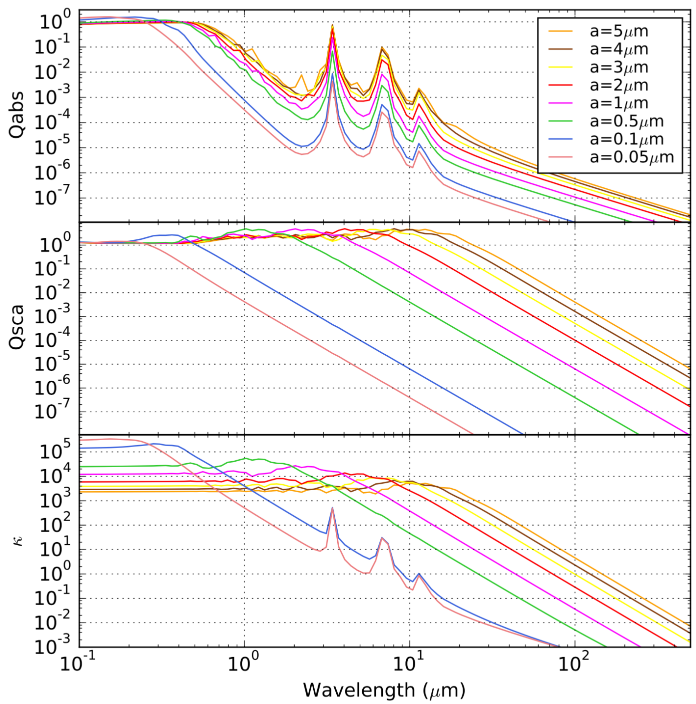
Larger grains

absorption, scattering & kappa

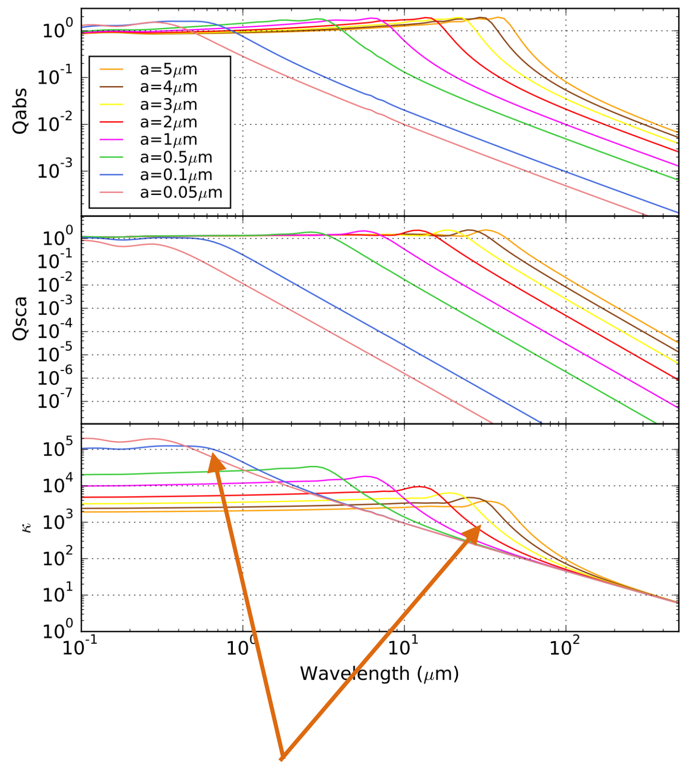
a-Sil



a-C:H



a-C



grain radii = 0.05 to 5 micron

slope break is a depends on size

Large grains

albedos

a-Sil a-C:H a-C

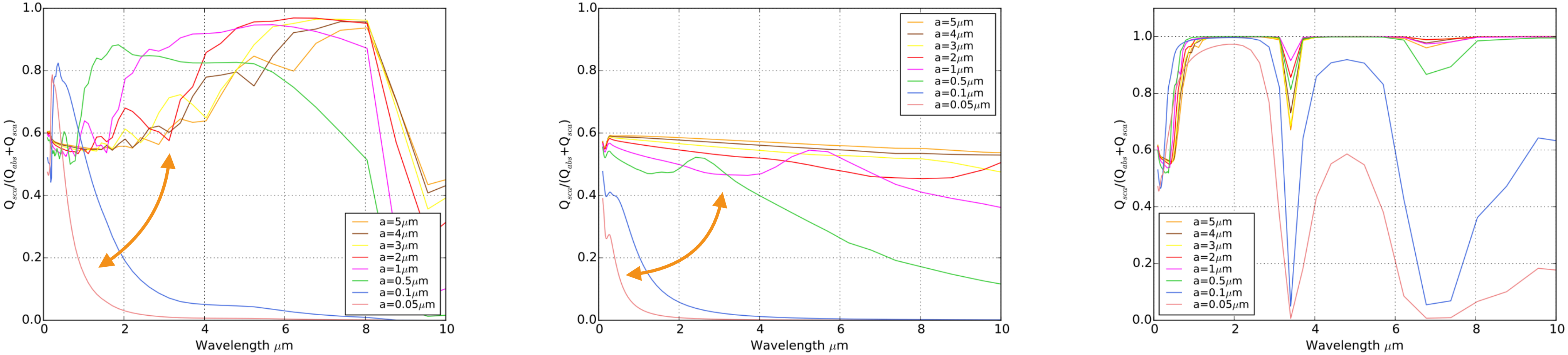
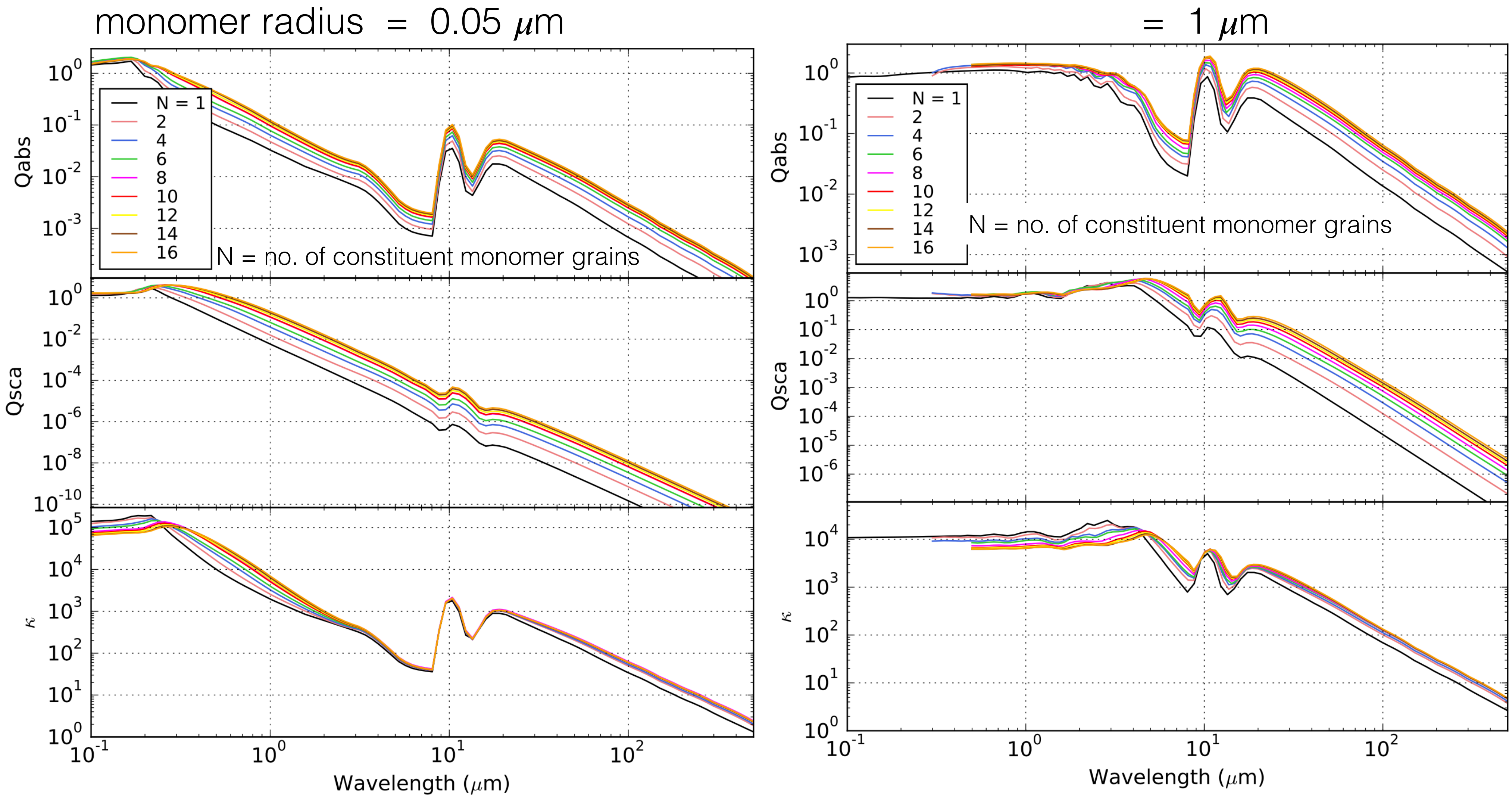


Fig. 4. Albedo, $Q_{sca}/(Q_{abs}+Q_{sca})$, for compact spherical grains. Left: amorphous silicates. Middle: amorphous carbonaceous grains with E_g = 0.1 eV. Right: with E_g = 2.5 eV.

albedo "jump" a = 0.1 - 0.5 μm for $\lambda > 1$ μm (i.e., a ~ λ)

grain radii = 0.05 to 5 micron

Aggregates



aggregates with 1 to 16 monomers (radii 0.05 & 1 micron)

Aggregates

kappa normalised by monomer kappa and by equivalent volume/mass

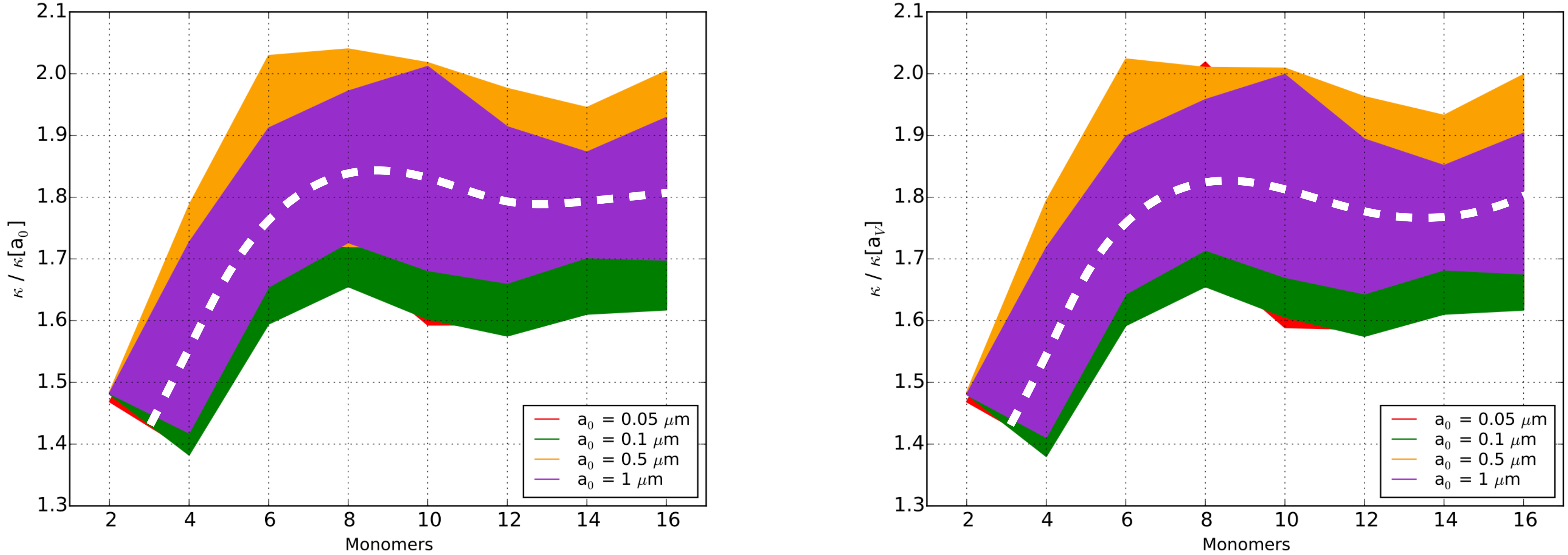


Fig. 13. Left: aggregate to monomer κ ratio at 250 μm for a_0 = 0.05 (red), 0.1 (green), 0.5 (orange), and 1 μm (purple) as a function of the number of monomers composing the aggregate. The filled area correspond to the scatter of the optical properties for 10 randomly chosen aggregate shapes. Right: aggregate to sphere of equivalent volume/mass κ ratio at 250 μm (same colour code as the figure on the left).

curent aggregates consist of 4 monomer grains - need to go to 8

Aggregates

a-Sil 10 μm band FWHM

vs. no. of monomers | vs. equivalent volume | aggregate/equivalent volume

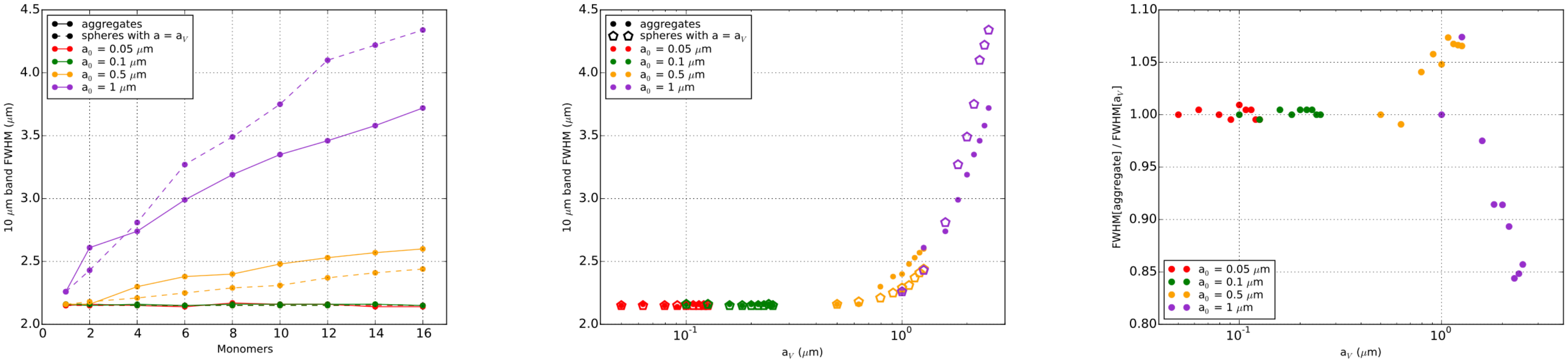


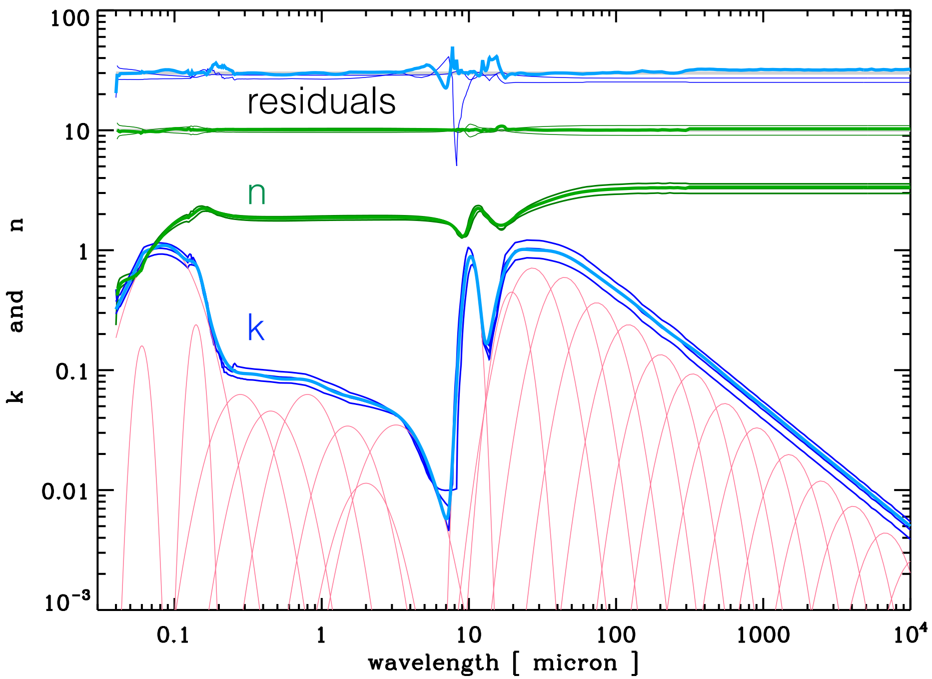
Fig. 14. Left: Solid lines show the FWHM of the 10μm silicate feature for aggregates with a_0 = 0.05 (red), 0.1 (green), 0.5 (orange), and 1 (purple) μm as a function of the number of monomers composing the aggregate. The dashed lines show the FWHM for compact spherical grains with $a = a_0$. Middle: solid lines show the FWHM of the 10μm silicate feature for aggregates with a_0 = 0.05 (red), 0.1 (green), 0.5 (orange), and 1 (purple) μm as a function of their mass/volume equivalent radius. The dashed lines show the FWHM for compact spherical grains mass/volume equivalent radiae a_V. Right: ggregate to sphere of equivalent volume/mass 10 μm FWHM ratio for aggregates (same colour code as the figure on the left).

monomer (not aggregate) size determines the a-Sil 10 μm band FWHM

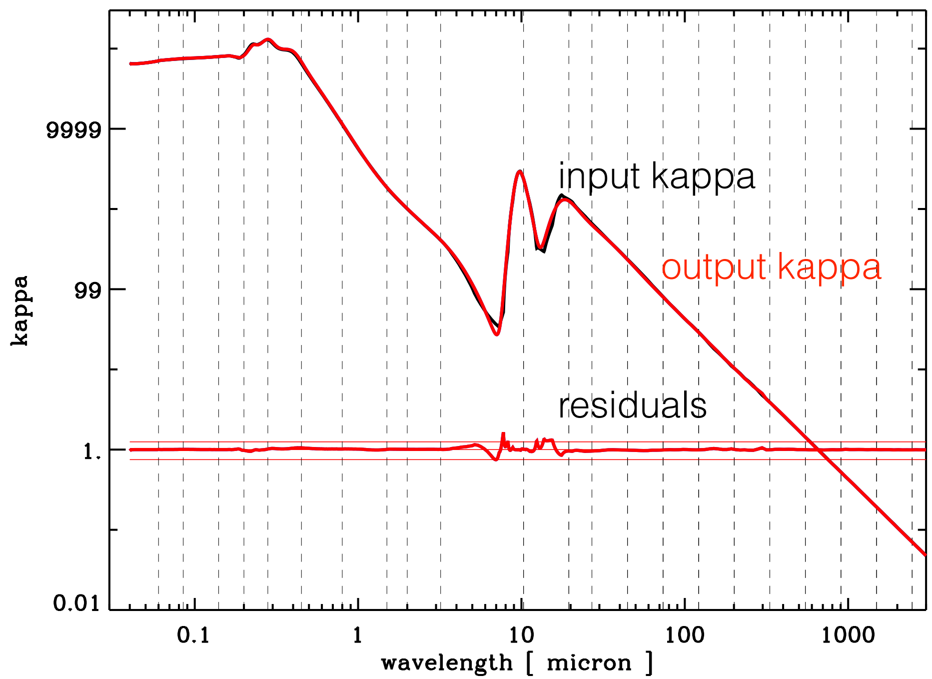
NEW SILICATE DATA?

- Currently no/few models use real dust analogue data at FIR-mm wavelengths
- Lab-measured amorphous silicate data is very different from the model data
- Need to introduce new lab measurements in the THEMIS model
- Problem: kappa is measured and not n & k directly
- Problem: non-trivial inversion in complex number (n,k) parameter space

derivation of n and k from lab data



error in the derived n & k is ±10-20 %



input lab data kappa dust fitted to within 1%

methodology

- use input lab data kappa to first-guess k (and then derive n via Kramers-Kronig relations)
- use new n and k to calculate Q_{ext} and kappa
- use new kappa to derive k (and then n …)
- iterate on n and k to get a fit to kappa with the required precision
- output acceptable values of n and k (hard to do much better than ±10-20 %)

Dust Modelling

future THEMIS updates

- ISM - bigger aggregates in dense regions
- discs - bigger grains and aggregates
- incorporate new silicate lab data at long wavelengths?
- ISM + discs - new ideas on a-C(:H) nanoparticles?