Introducing aerosol inhomogeneity in remote sensing retrievals

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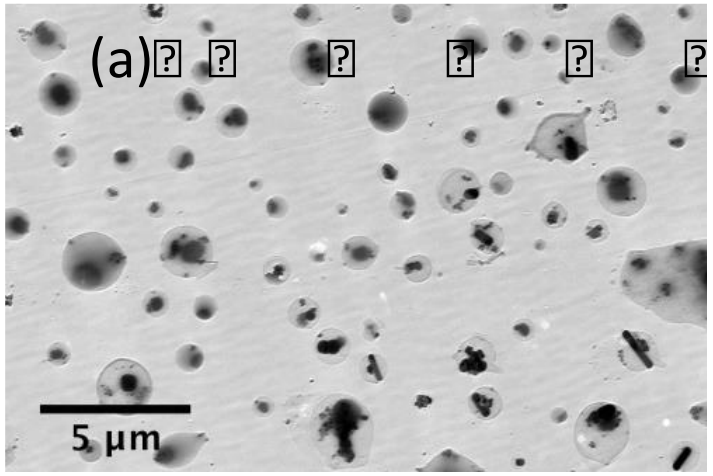
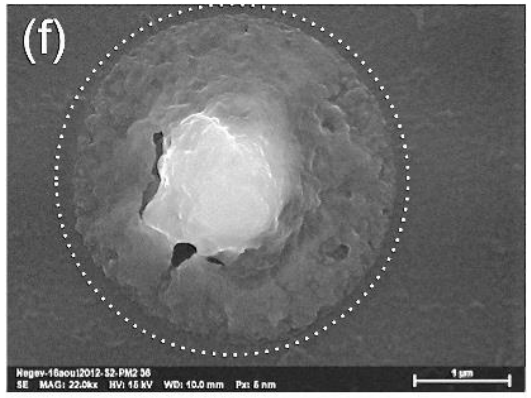
Motivation

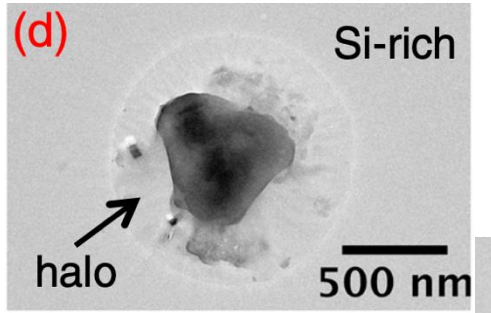
Examples of aerosol observations show presence of inhomogeneity

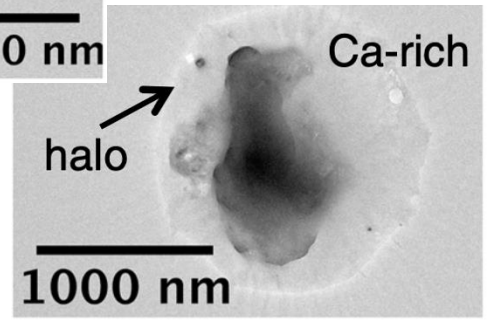
Urban aerosol (Lille, France)



Desert dust (Israel & Senegal)







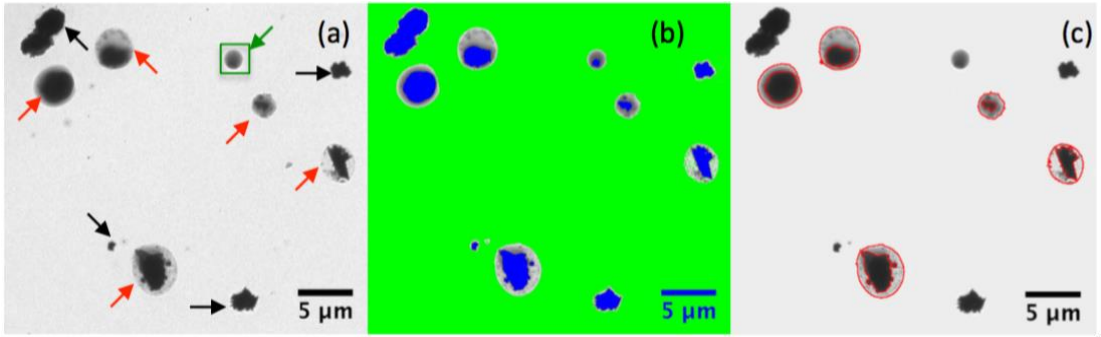
halos are residual of liquid coating

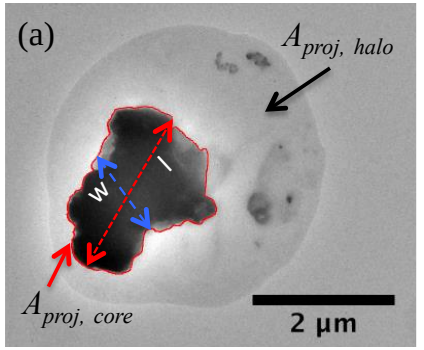
60% of 2500 particles in urban area

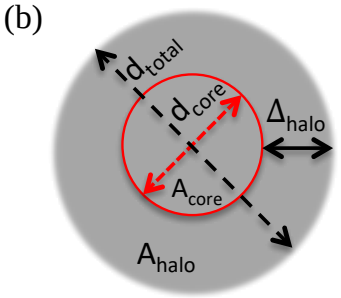
20% of 6000 particles in desert regions

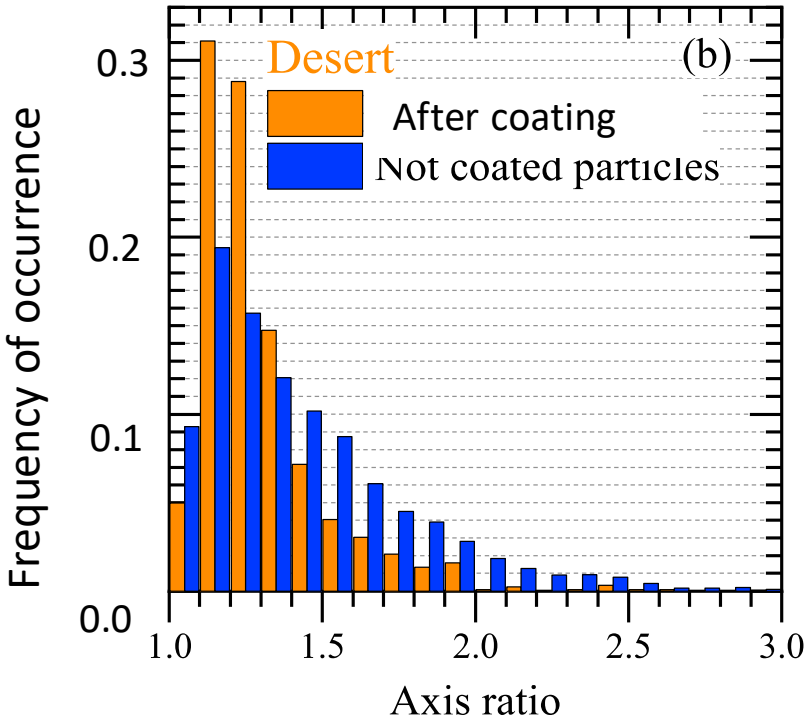
[Derimian et al., 2017; Unga, PhD thesis, 2017; Unga et al. 2018]

Statistics on morphology based on SEM/EDX images

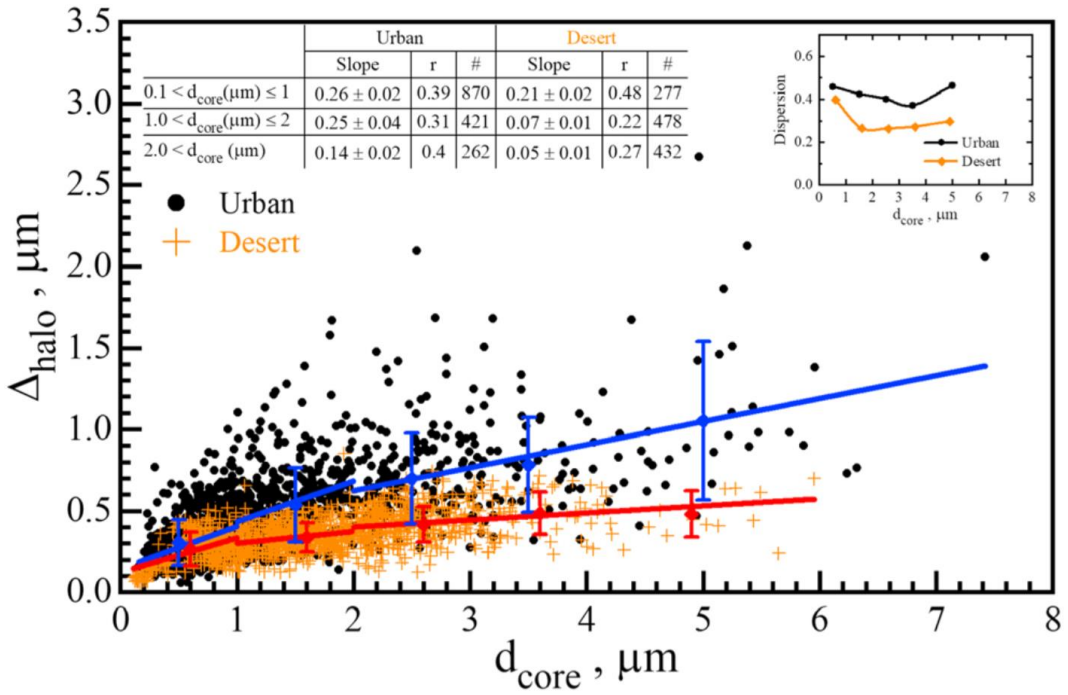








Coated dust is more spherical



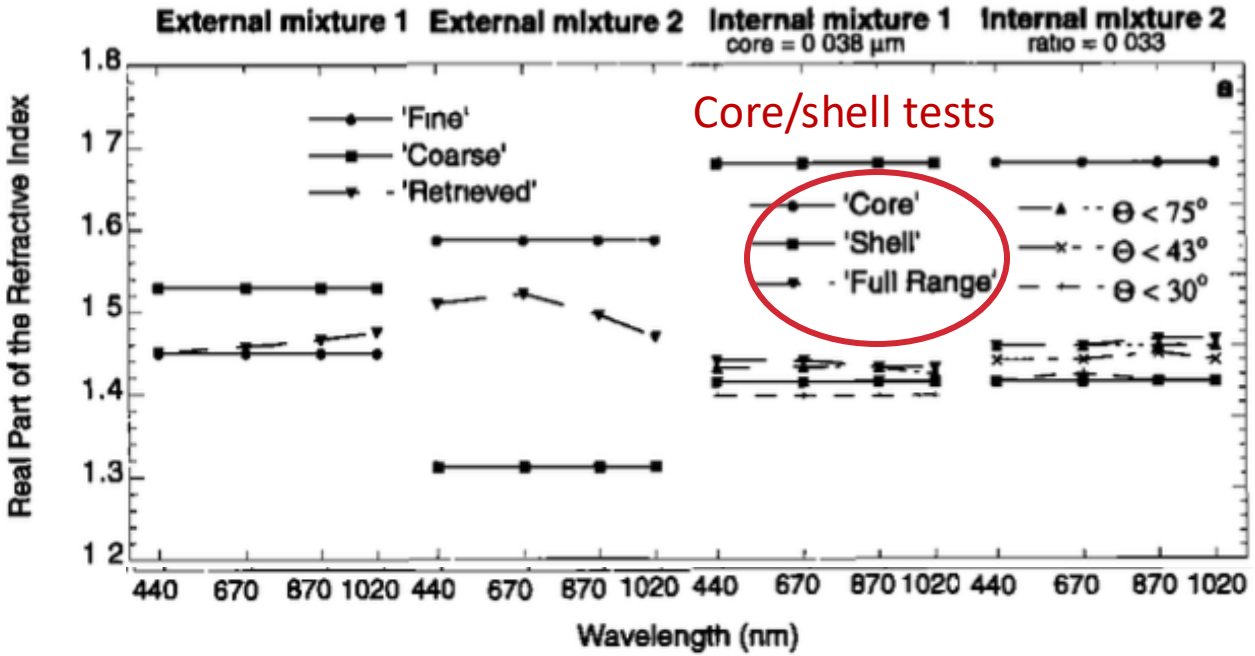
ΔShell is up to ~30% of total radius

[F. Unga, PhD thesis, 2017; Derimian et al., 2017; Unga et al. 2018]

Accounting for aerosol morphology in AERONET

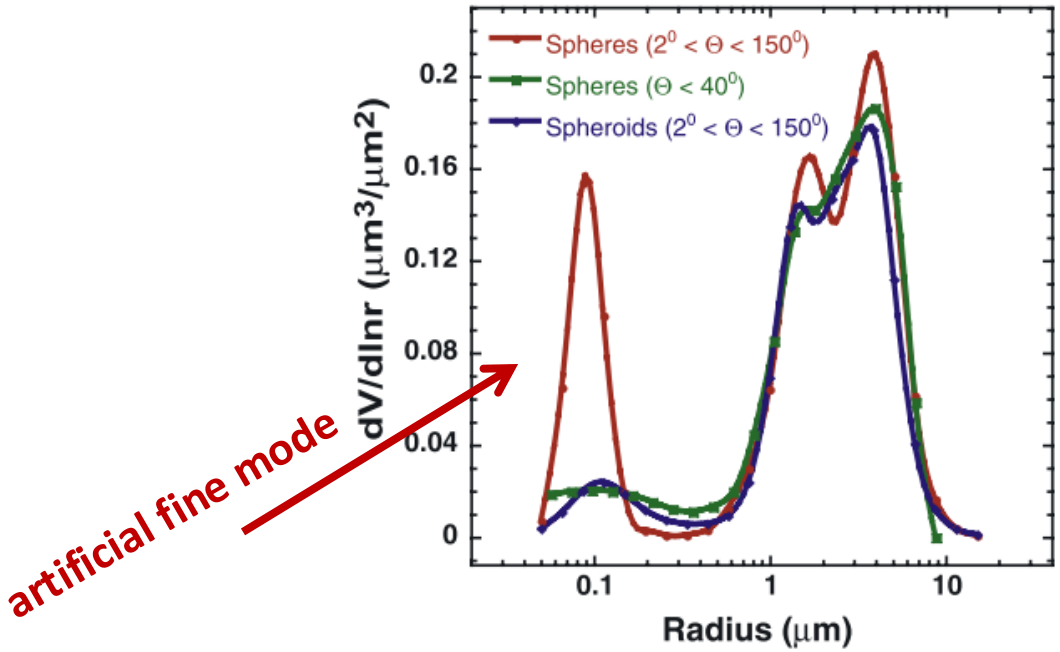
Dubovik et al., 2000

- Core/Shell in fine mode tests for AERONET showed a homogeneous equivalent



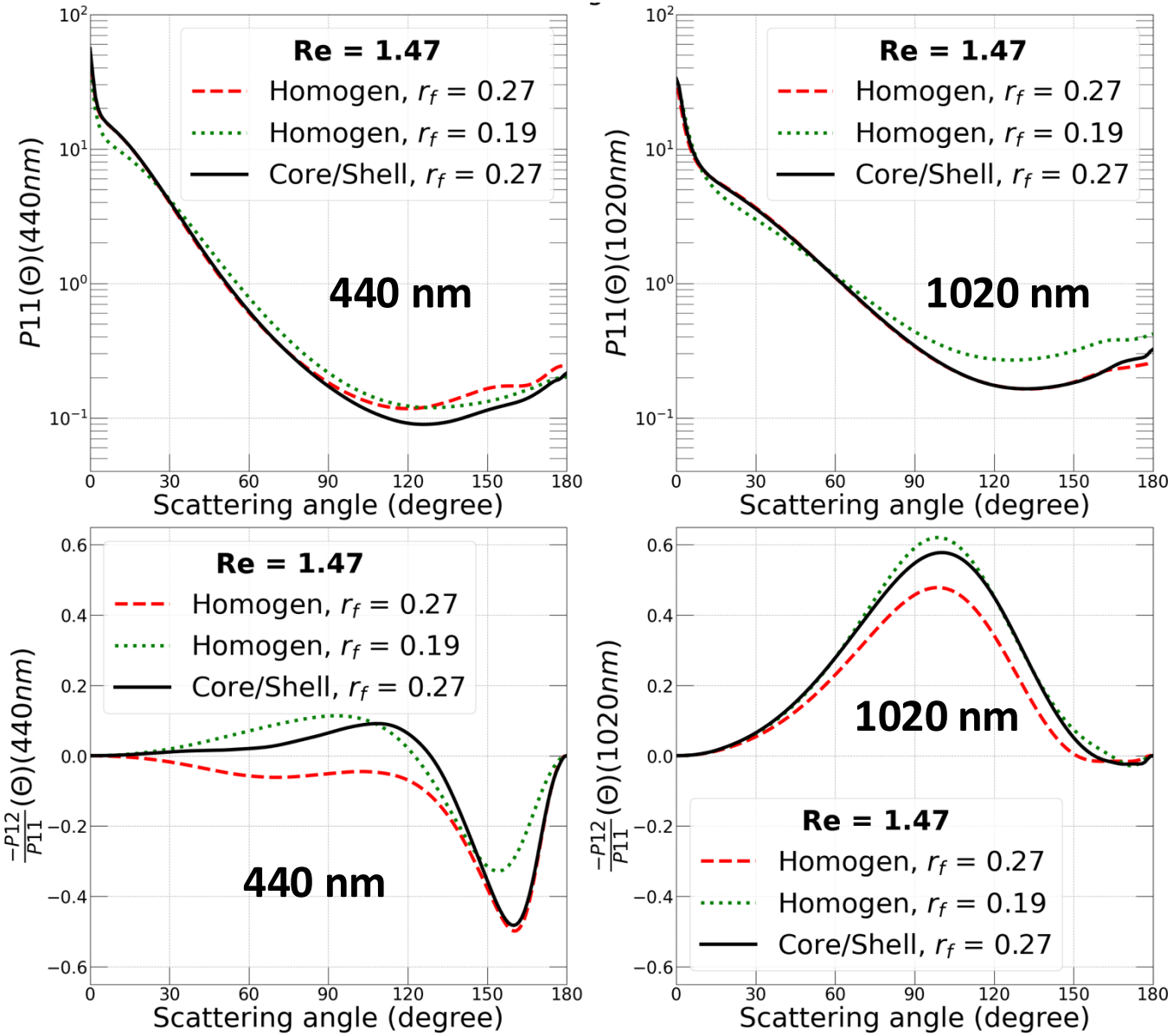
Dubovik et al., 2002

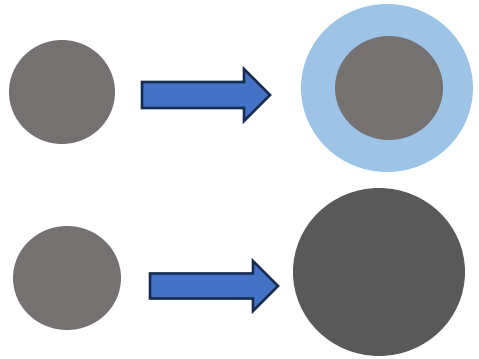
non accounting for non-sphericity caused an artificial fine mode in retrievals



Core/shell vs. Homogen. in single scattering approximation

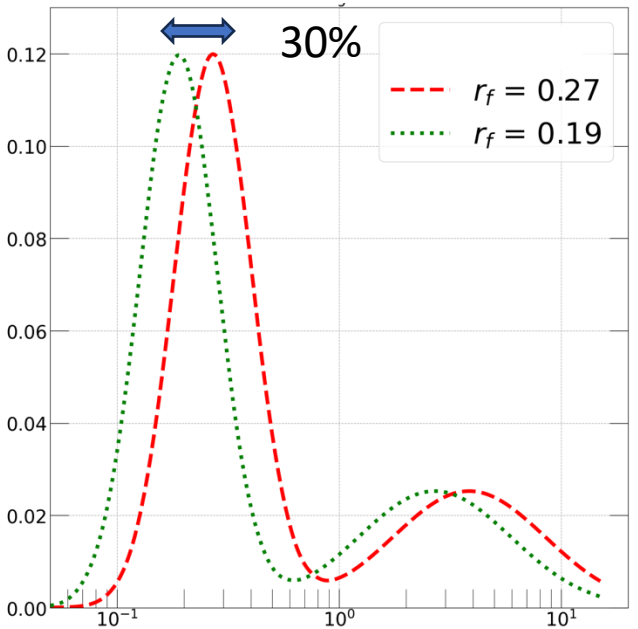
Fine mode dominated





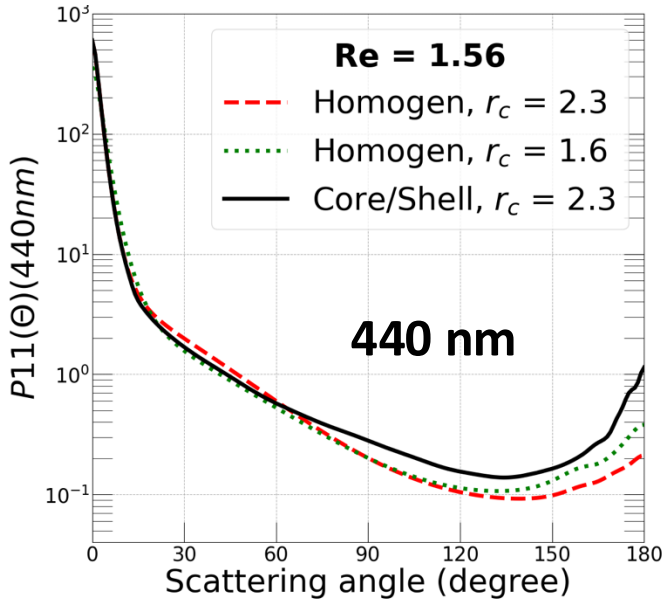
Shell = 30%
Ref. Index Shell
n = 1.37
k = 1e-8

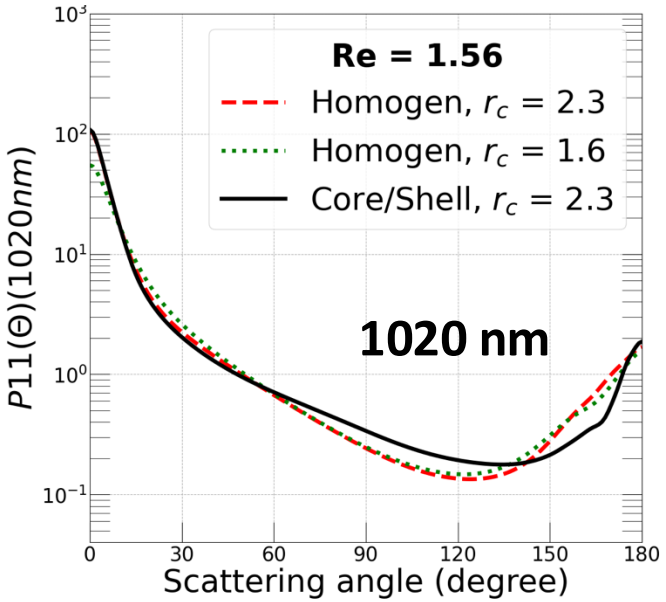
Fine mode dominaited

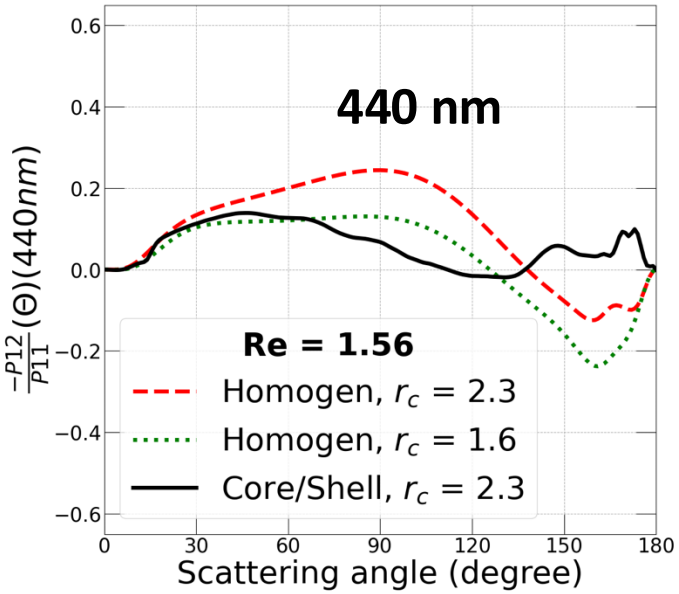


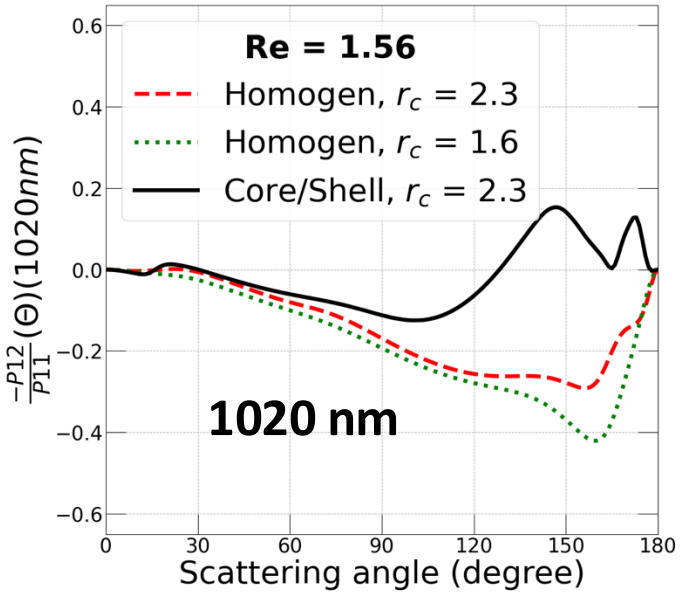
Core/shell vs. Homogen. in single scattering approximation

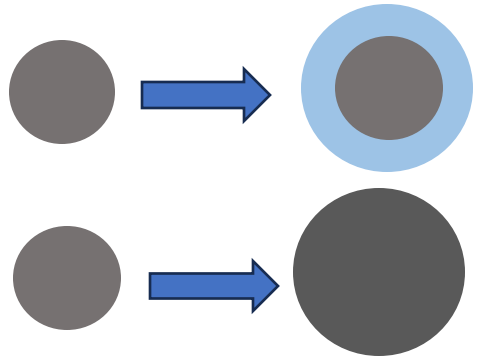
Coarse mode dominated











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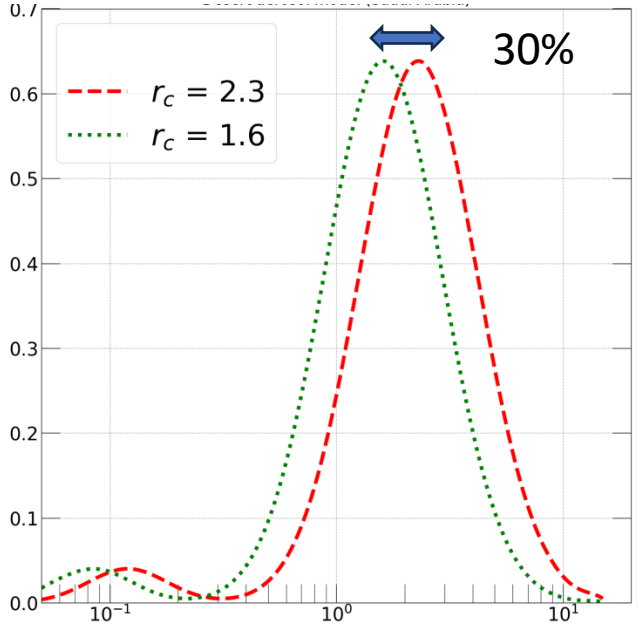
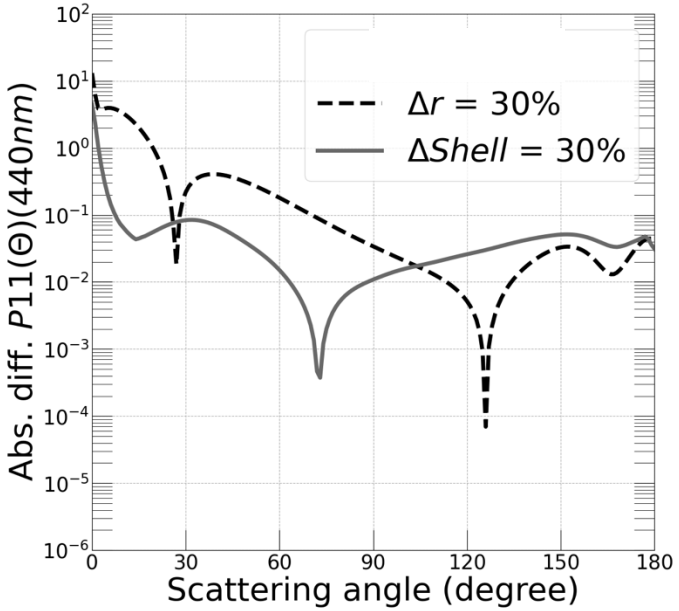


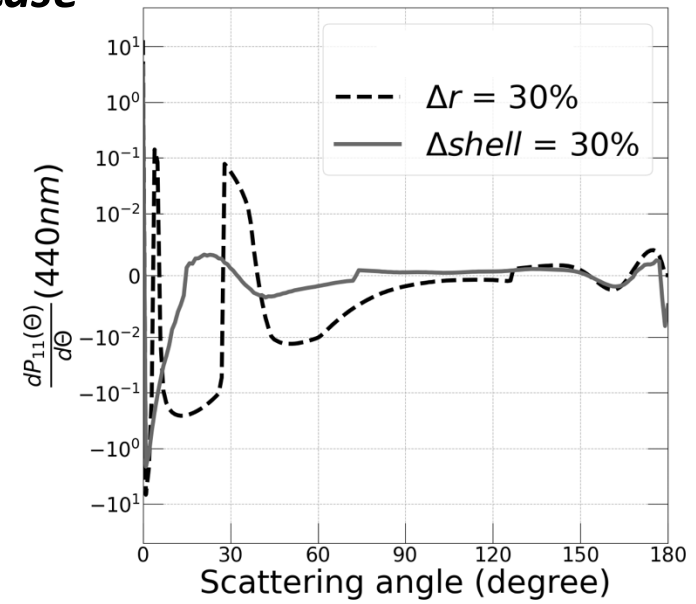
Core/Shell vs. Homogeneous

Difference in absolute values and in angular dependance

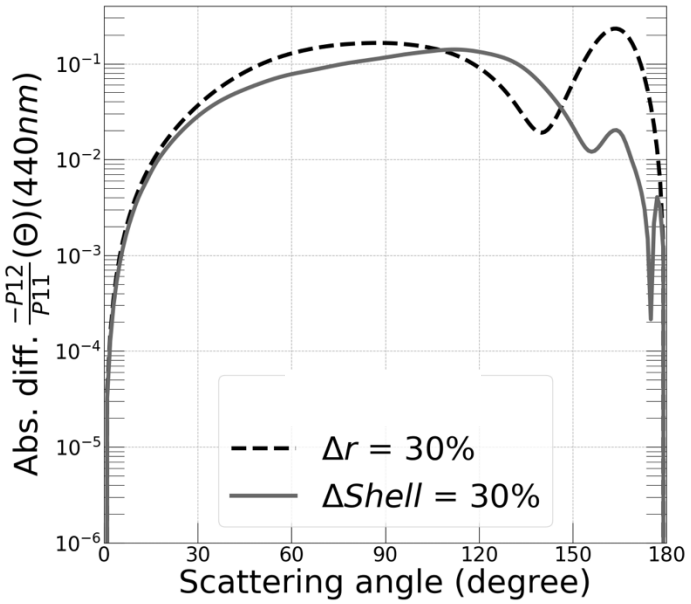
Fine mode case

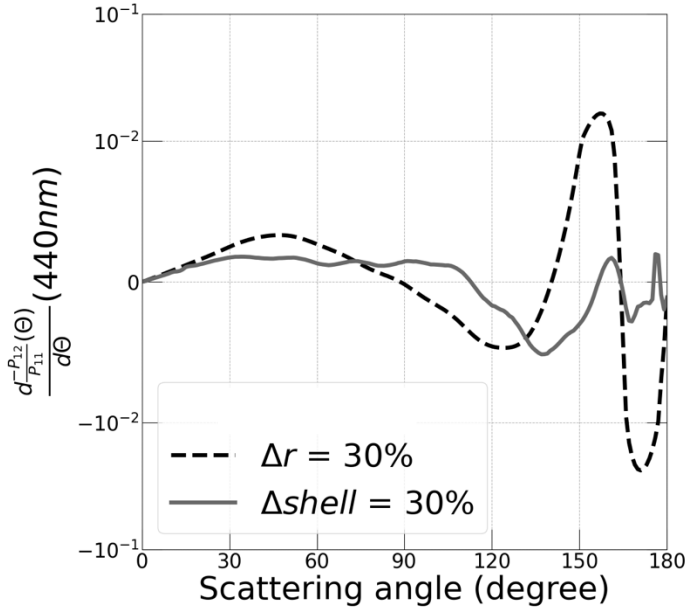
P11





-P12/P11





New kernels in GRASP for spherical core/shell particles

[We used Mie code for inhomog. particles of Victor P. Tishkovets, Inst. of Radio Astronomy, NAS of Ukraine]

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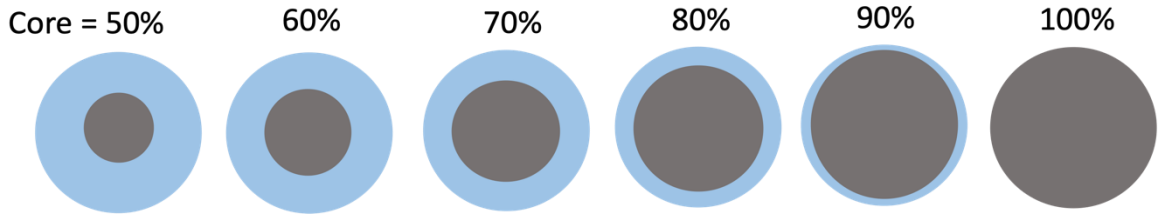
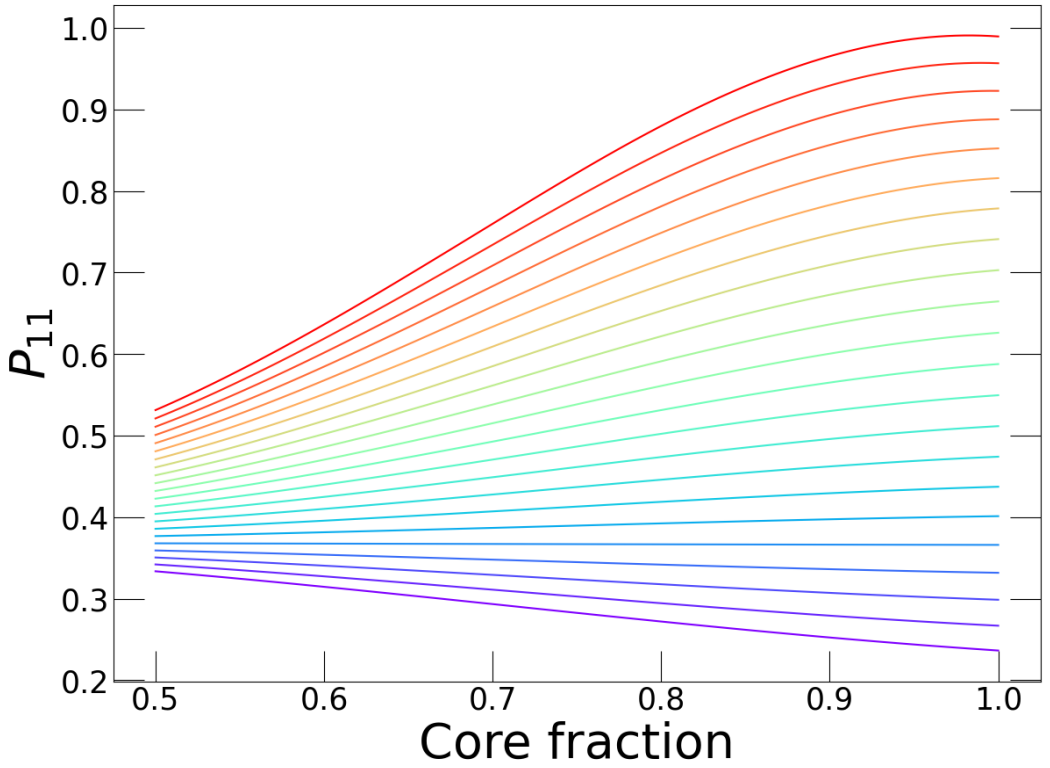


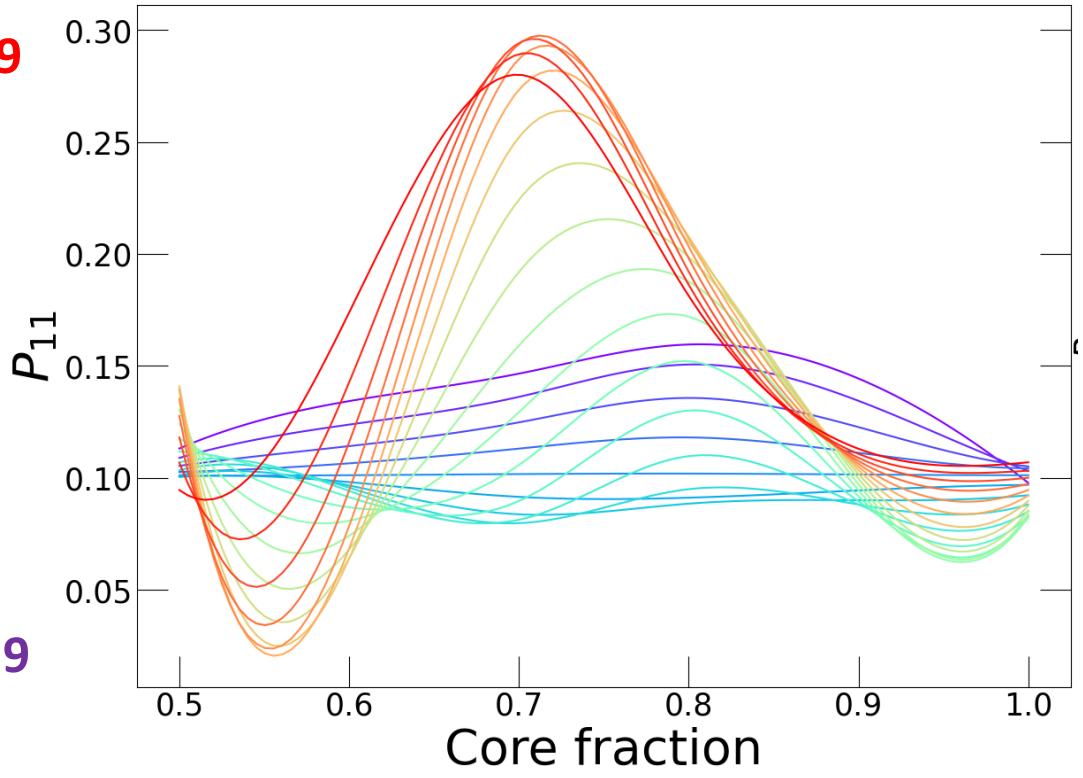
An example for Scattering angle = 120 deg.

Ref. Index Core
k = 1e-8
n = 1.69
n = 1.29

Size Parameter = ~1



Size Parameter = ~10



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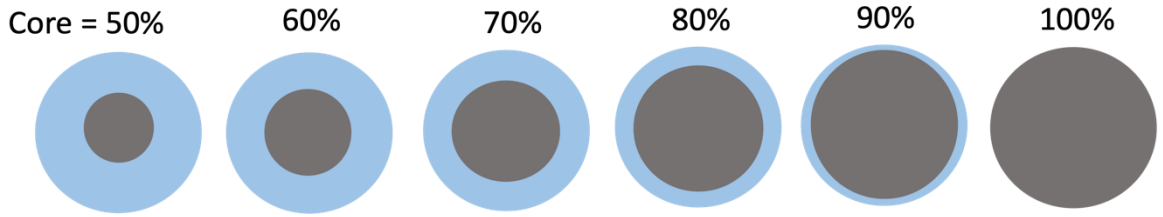

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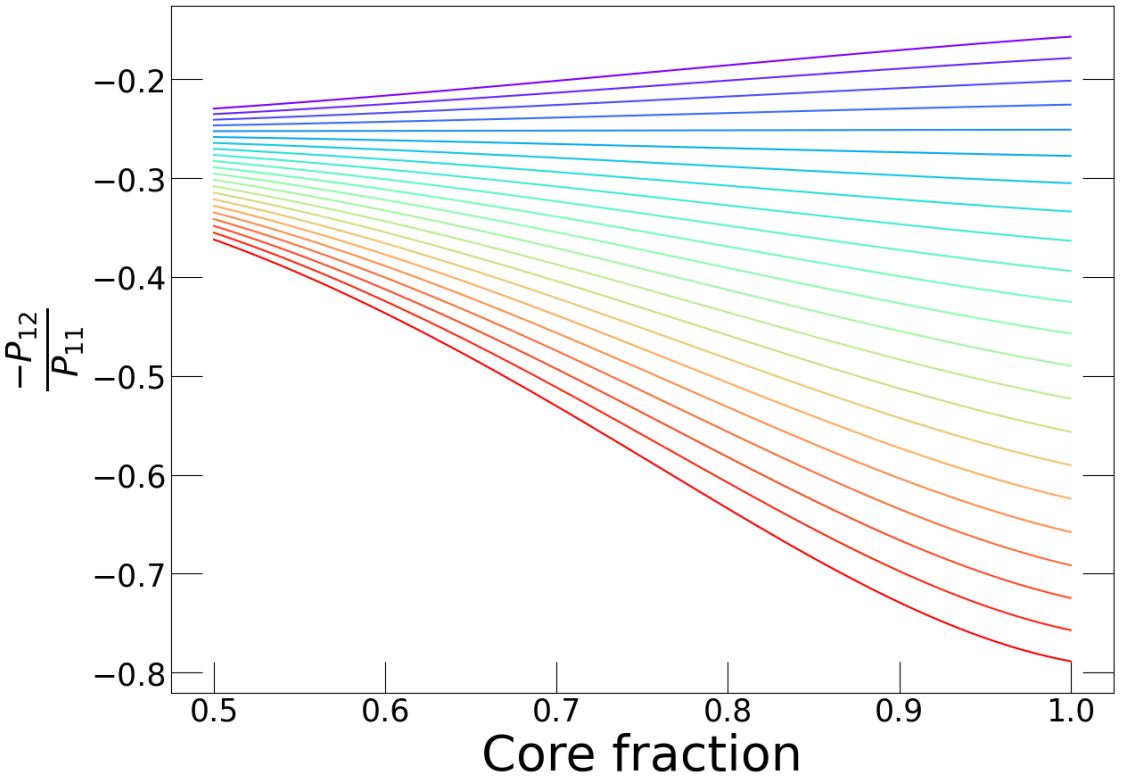
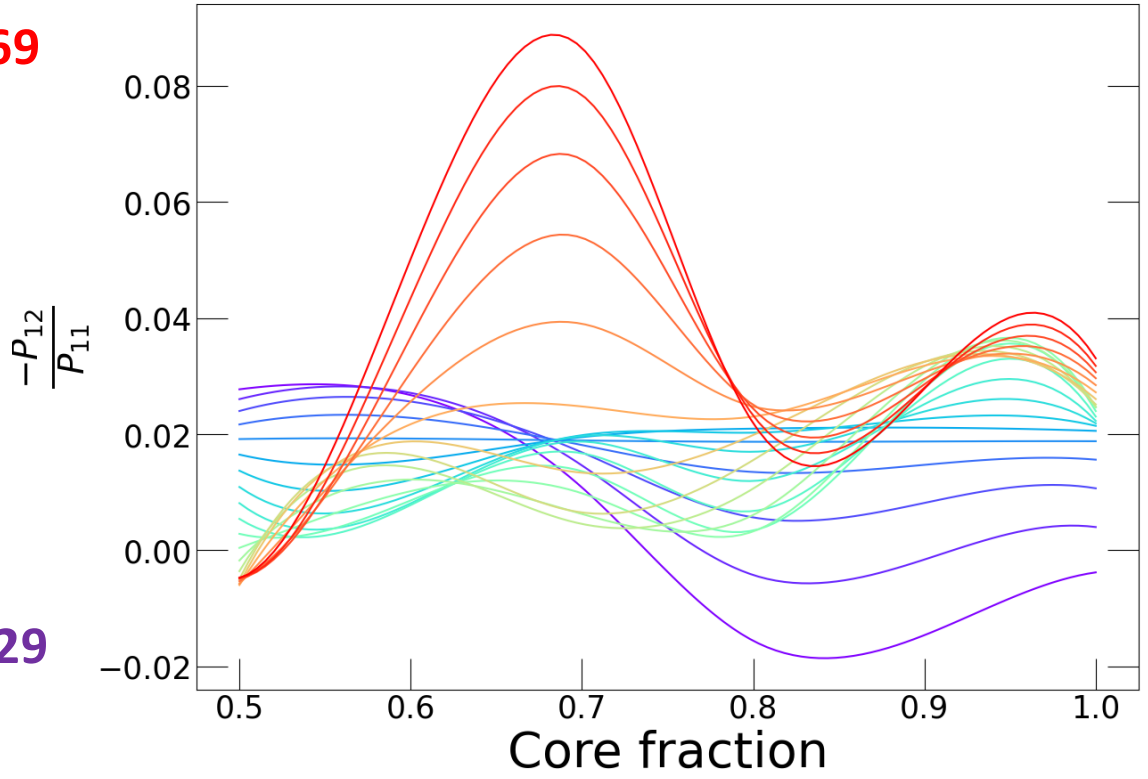


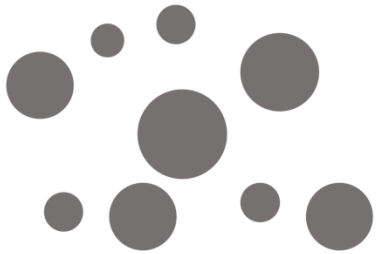
Size Parameter = ~10



Retrieval of core/shell parameter in GRASP

Kernels :

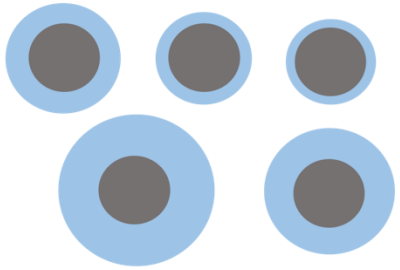
Homogeneus Spheres



Homogeneus Spheroids

+

Core/Shell Spheres



Ref. Index of Shell is fixed; n = 1.37; k = 1e-8

Ref. Index of Core is varying

Retrieved parameters :

Spheres

or

New

Homogen., as standard retrieval

Fraction of core in total radius ; complex ref. index of core (ref. index of shell is fixed)

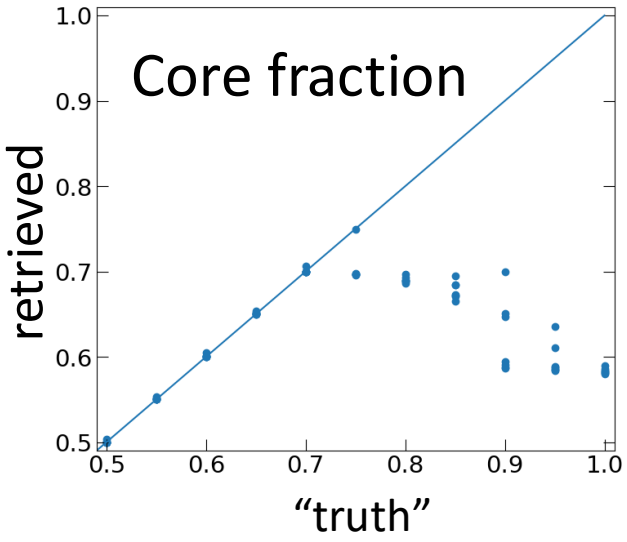
Spheroids

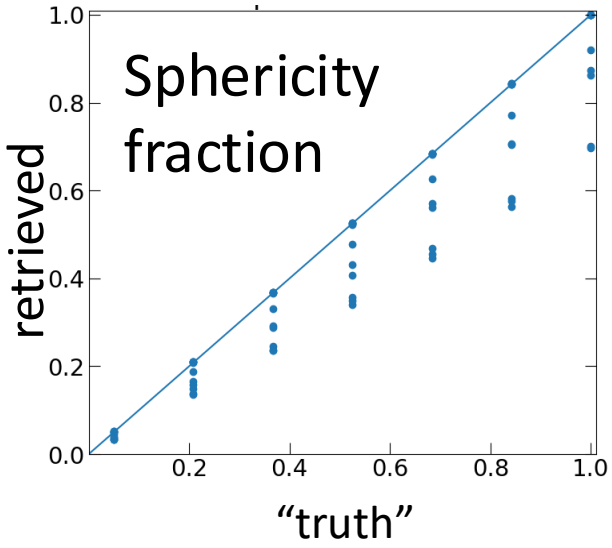
Homogenous, as standard retrieval, including fraction of spherical/non-spherical

Tests with synthetic AERONET data

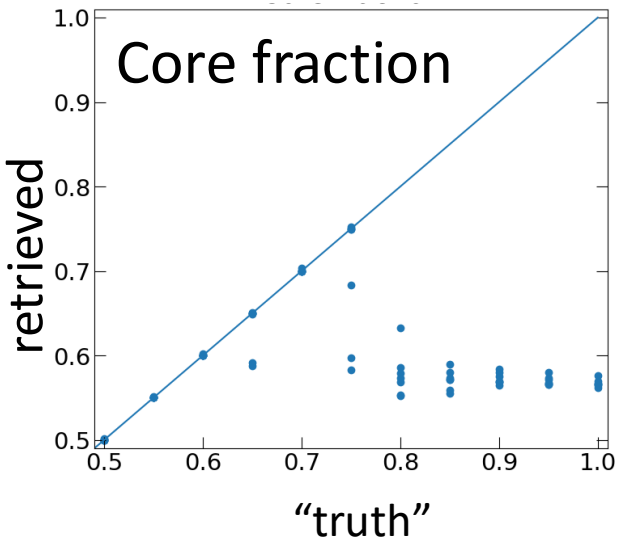
Coarse mode dominated

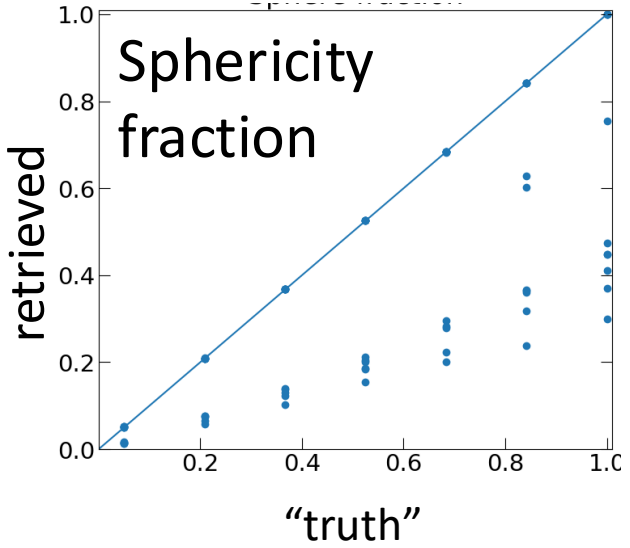
Core Real RI = 1.41

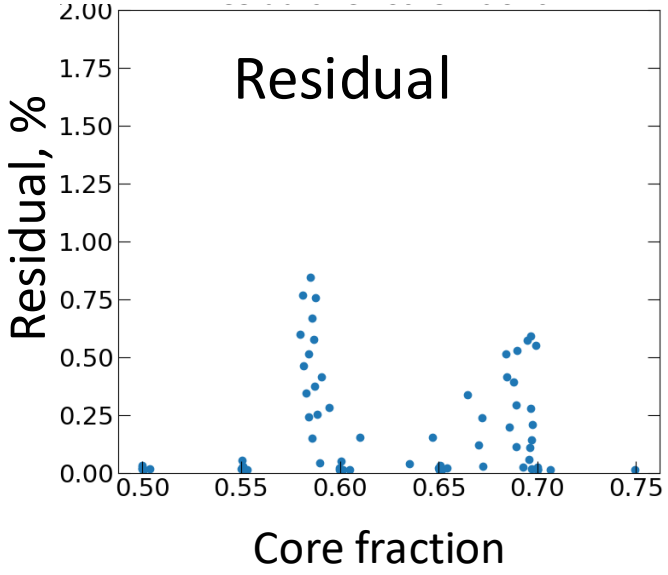


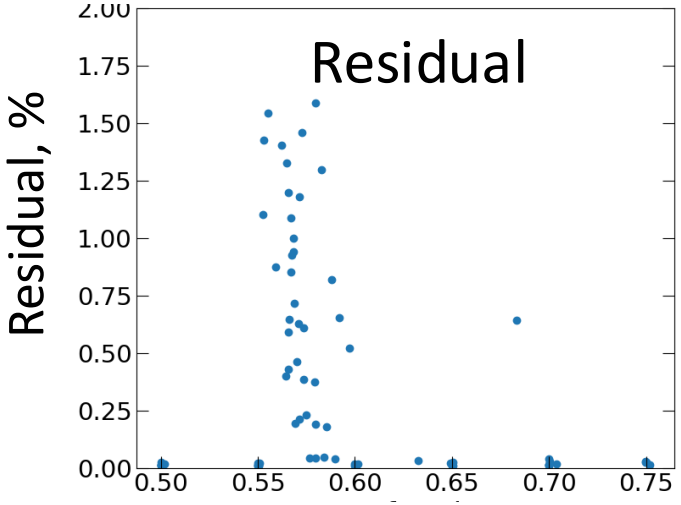


Core Real RI = 1.50







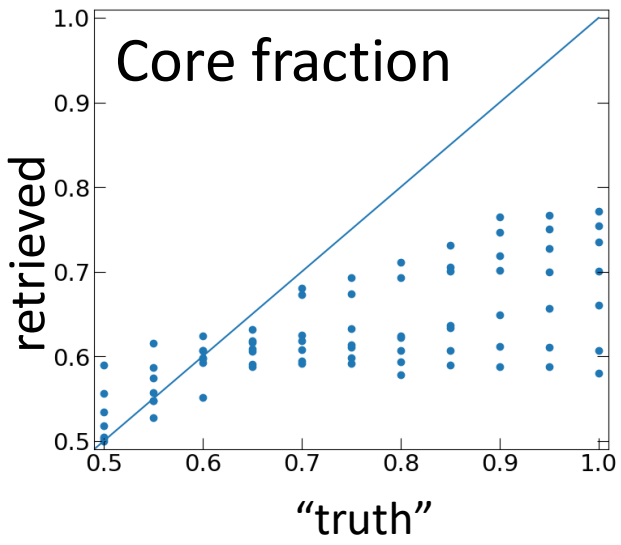


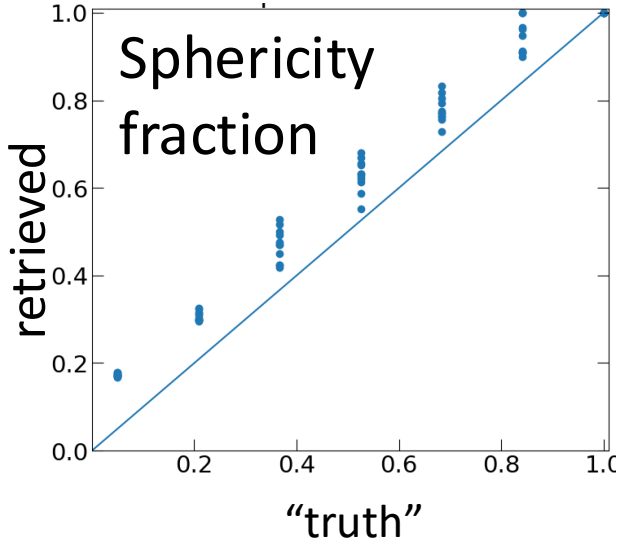
Good agreement with "truth" for all other retrieved parameters

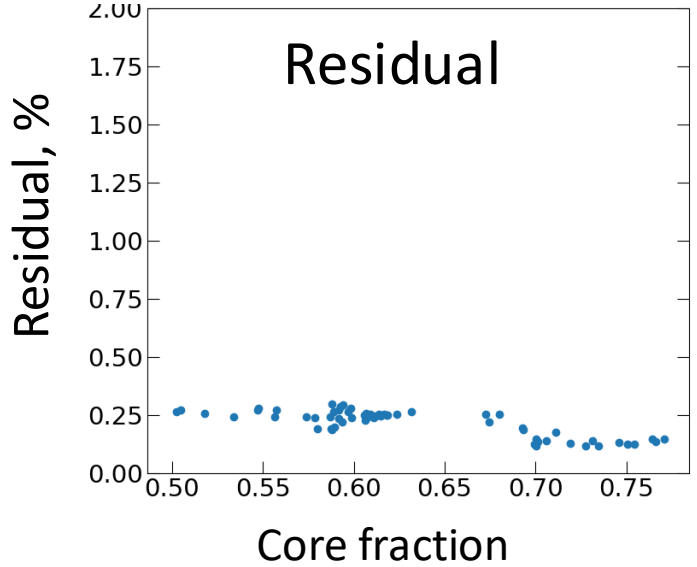
Tests with synthetic AERONET data

Fine mode dominated

Core Real RI = 1.50







Summary

- The aim is introducing particles inhomogeneity in remote sensing retrievals for improving aerosols physico-chemical characterization

- We conducted study on sensitivity of P11 and -P12/P11 to core/shell aerosol model

- shows differences in absolute value and angular dependence with respect to homogeneous

- New Core/Shell kernels are calculated and integrated into GRASP algorithm

- the new retrieved parameter is the fraction of core in total particle radius *(varying from 50 to 100% of the total size)*

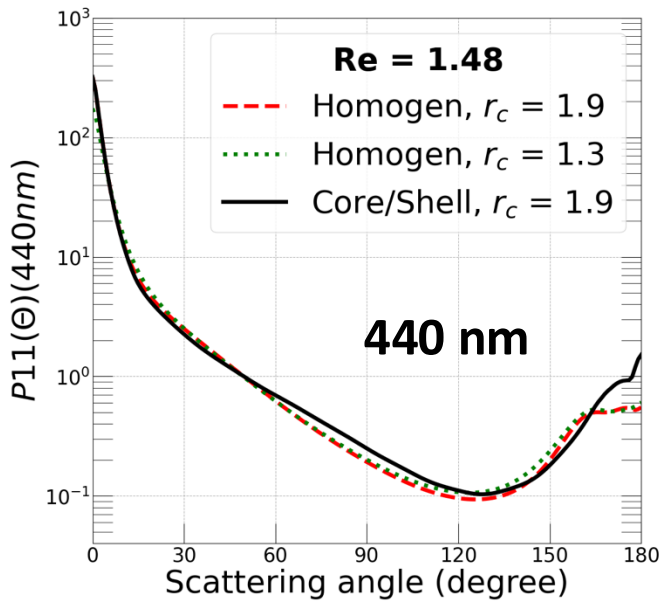
- AERONET measurements are used for investigation of sensitivity to inhomogeneity on the level of atmospheric radiances

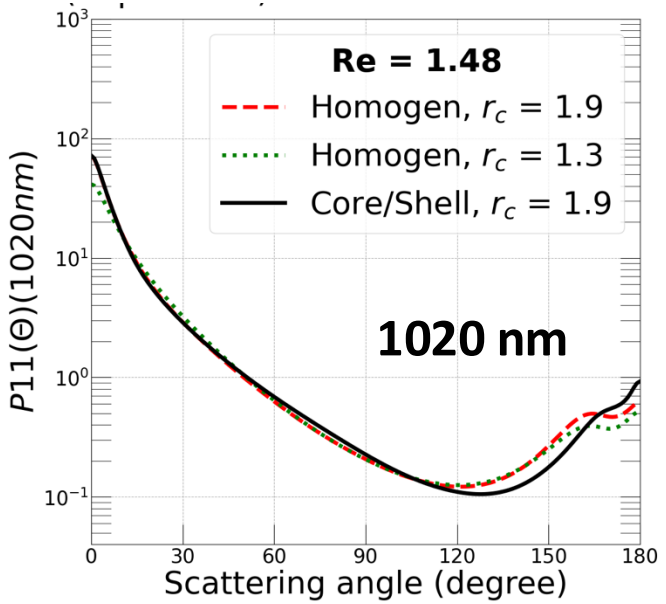
- coating in coarse mode seems to be more detectable
- involving polarization is expected to bring sensitivity to coating in fine mode

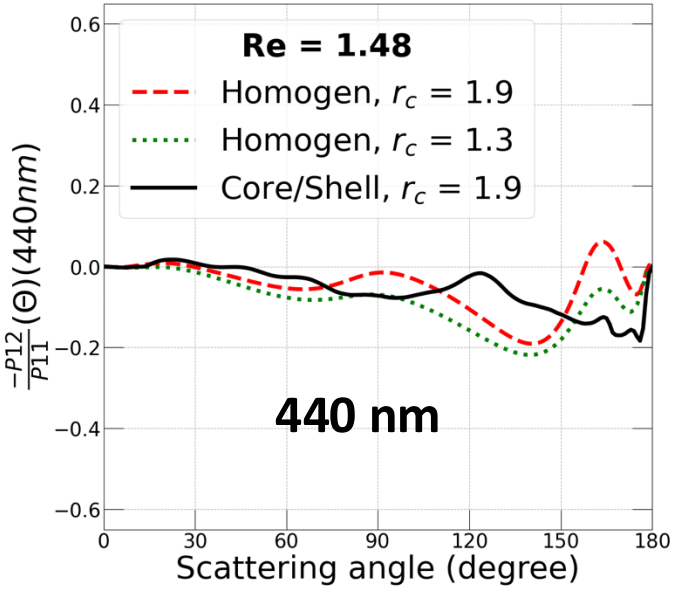
Back up slides

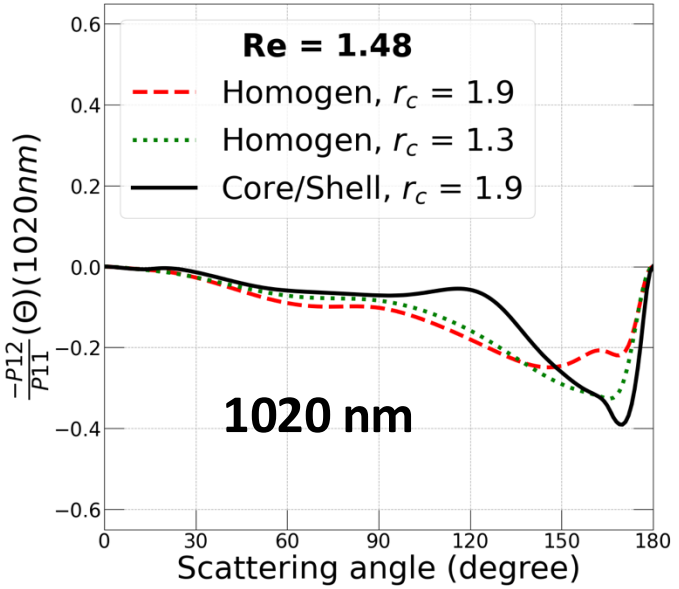
Core/shell vs. Homogen. in single scattering approximation

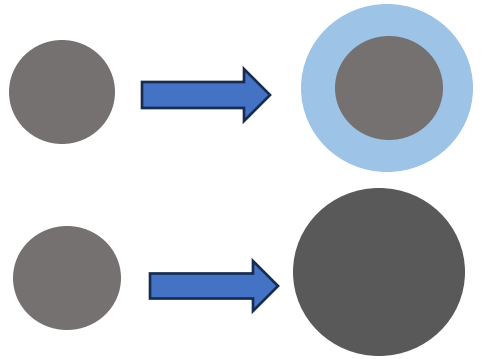
Coarse mode dominated











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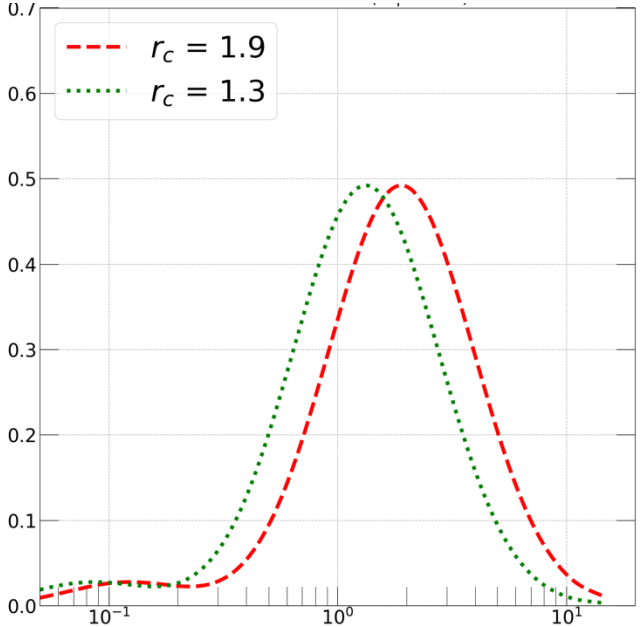
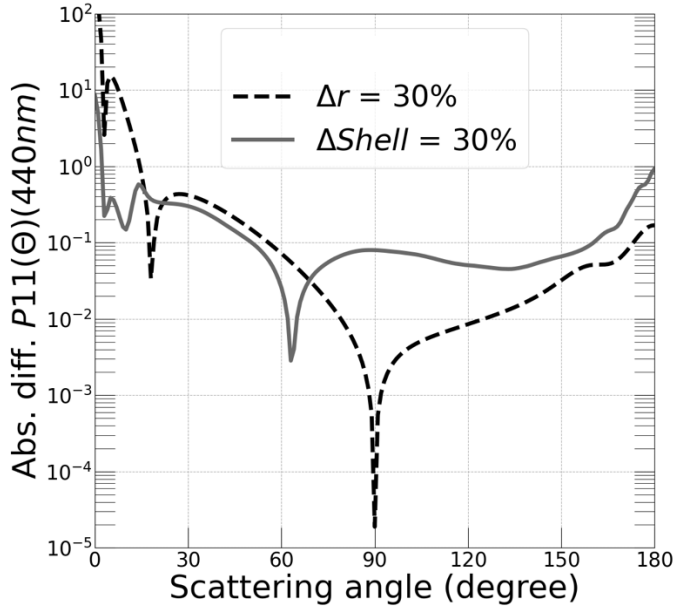


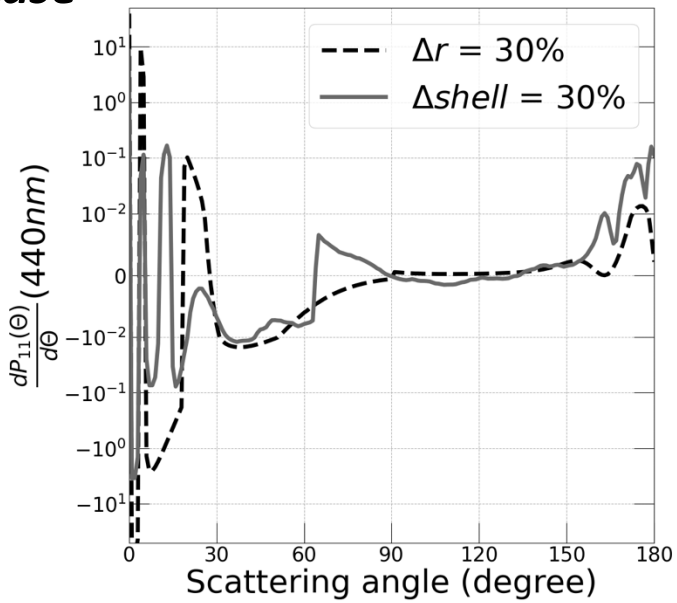
Core/Shell vs. Homogeneous

Difference in absolute values and angular dependance

Coarse mode case

P11





-P12/P11