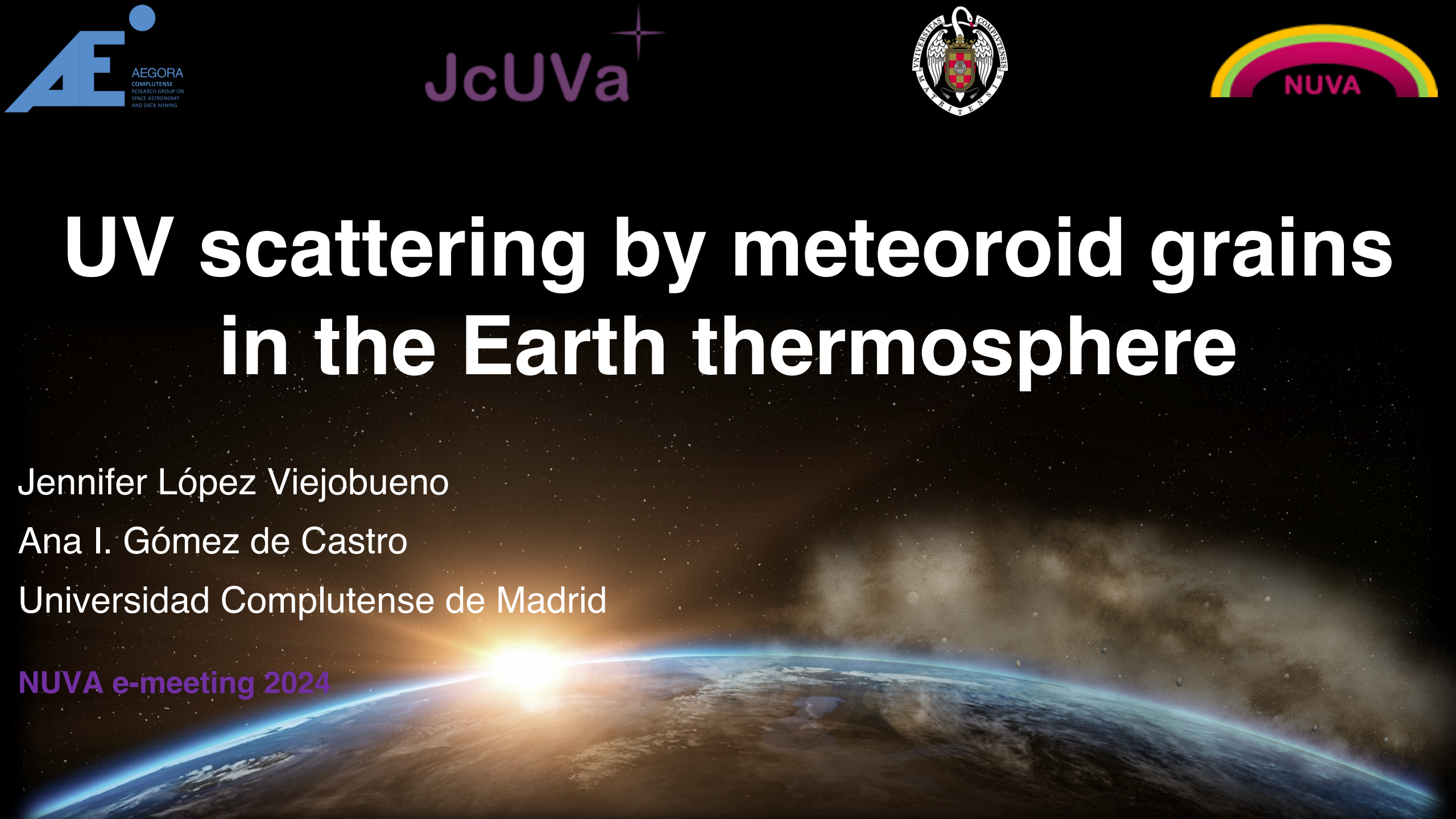
UV scattering by meteoroid grains in the Earth thermosphere

Jennifer López Viejobueno

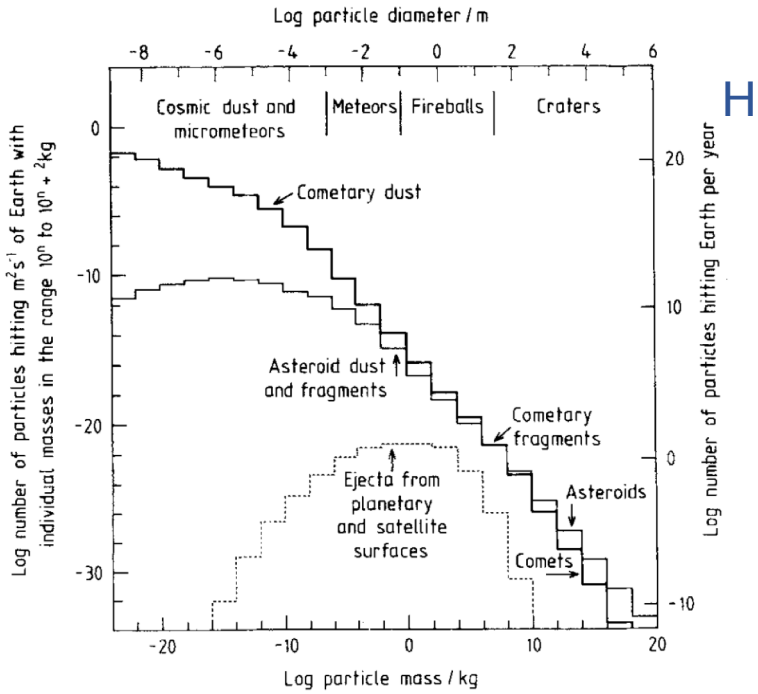
Ana I. Gómez de Castro

Universidad Complutense de Madrid

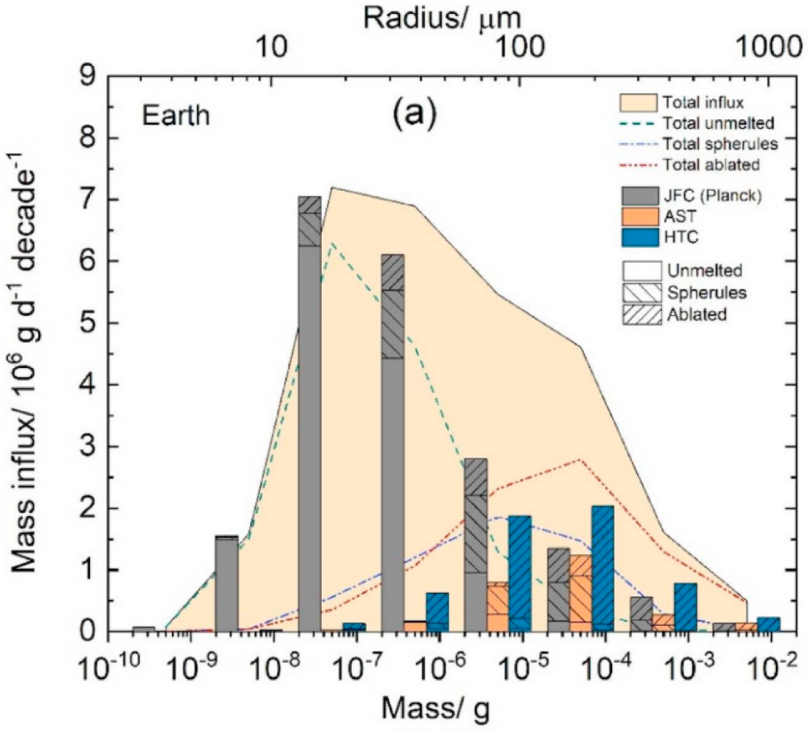
NUVA e-meeting 2024



Context



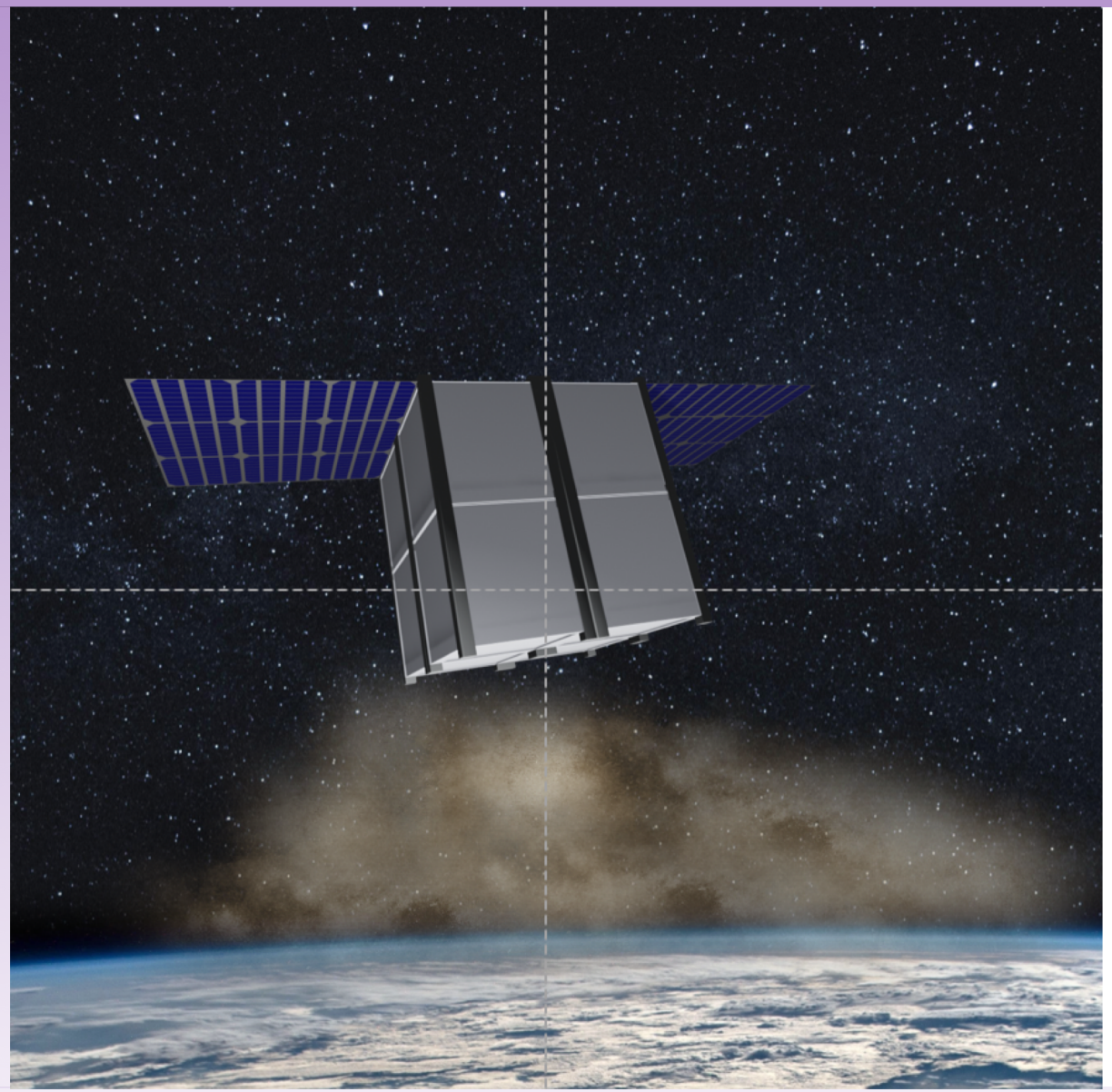
Hughes (1994)



Carrillo-Sánchez et al. (2020)

- Influx space particles into Earth atmosphere
- Current measurements:
  - Ground-based meteorite search
  - Meteor and fireball observations

Context



- Cosmic dust and small meteoroids
- Space observation from LEO
- Material falling on Earth (Kármán line to 500 km LEO orbit)

Numerical simulations

Expected radiation and polarization in UV

Infalling dust model

INPUTS

- Absorption and scattering opacities
- Mueller matrix
- Spatial density distribution
- Grid
- Solar spectrum

Dullemond et al. (2012)

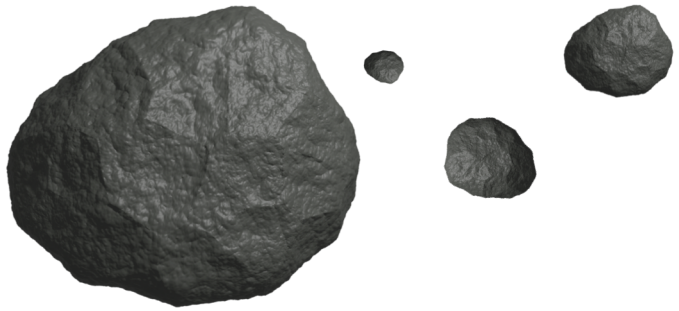
OUTPUTS

Synthetic images
Stokes vector (I, Q, U, V)

Infalling dust model

Characterizing the particles…

López-Viejobueno et al. (2023)



Material
Silicate
Carbonate
Iron

Grain size
0.01 μm
to
1 cm

Spatial density
$N(h \geq 130\ \mathrm{km}) = 0.22\ \mathrm{part\ cm^{-3}}$

$$\frac{dn(a)}{da} = n_0 a^{\alpha}$$

Power of size distribution
-3.5
-3.0
-2.5
-2.0

Infalling dust model – scattering

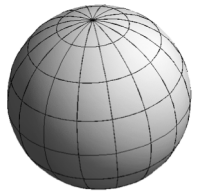
Randomly oriented particles/spheres

Bohren & Huffman (1998)
Mishchenko et al. (2000)

$$\begin{pmatrix} I_s \\ Q_s \\ U_s \\ V_s \end{pmatrix} = \frac{m}{r^2} \begin{pmatrix} Z_{11} & Z_{12} & 0 & 0 \\ Z_{12} & Z_{11} & 0 & 0 \\ 0 & 0 & Z_{33} & Z_{34} \\ 0 & 0 & -Z_{34} & Z_{33} \end{pmatrix} \begin{pmatrix} I_i \\ Q_i \\ U_i \\ V_i \end{pmatrix}$$

Polarization

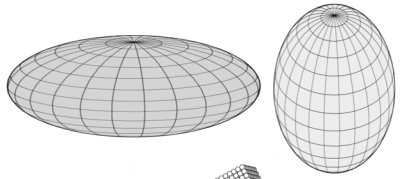
$$P = -\frac{Z_{21}}{Z_{11}}$$



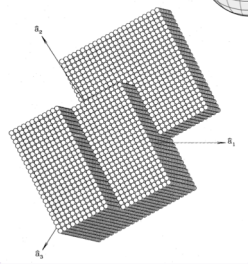
Size parameter $x=2\pi a/\lambda$

Mie theory

No restrictions x



T-matrix $x \lesssim 30$ Mishchenko et al. (1996)



DDSCAT $x \lesssim 12$ Draine & Flatau (1994)

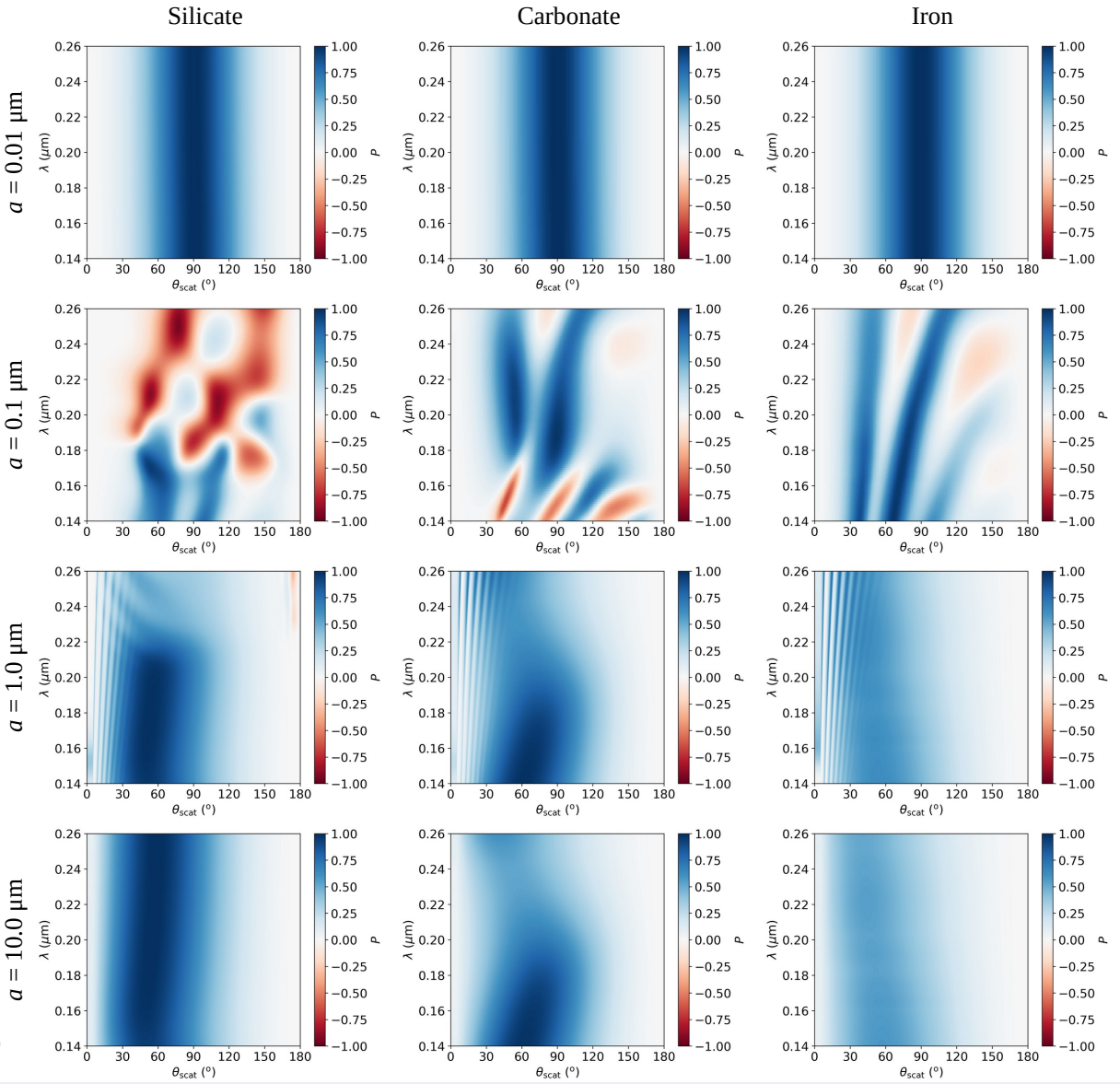
Infalling dust model – scattering

Sphere
Mie theory

Rayleigh regime
$a << \lambda$

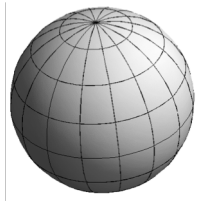
Resonance regime
$a \sim \lambda$

Geometrical optics regime
$a >> \lambda$



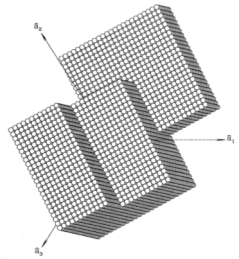
López-Viejobueno & Gómez de Castro in prep.

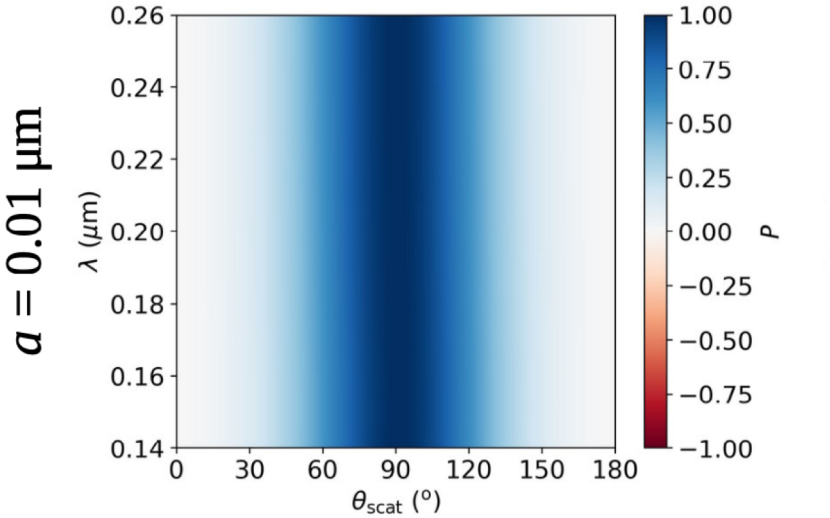
Infalling dust model – scattering

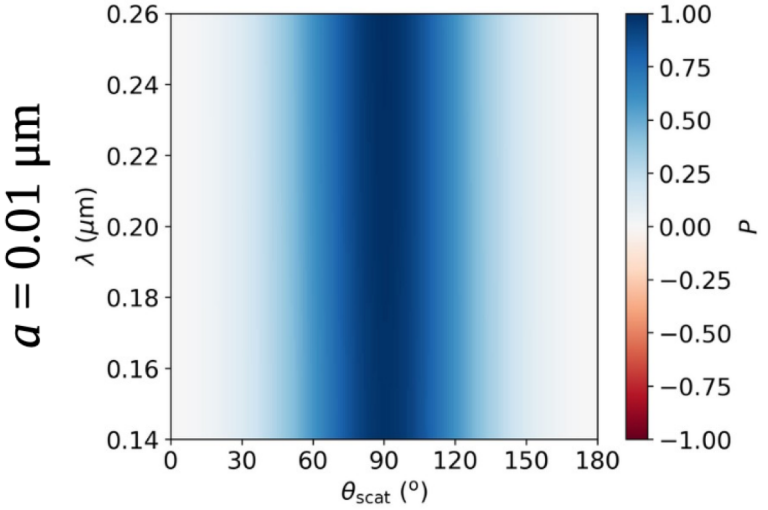


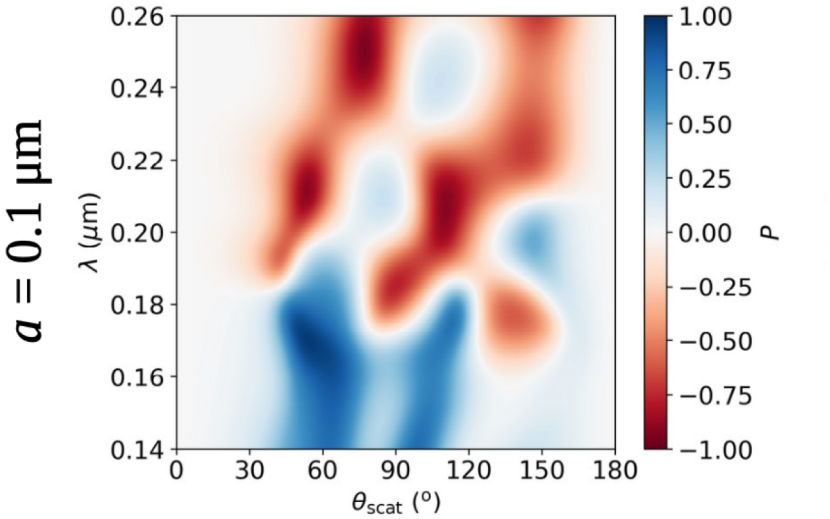
Mie

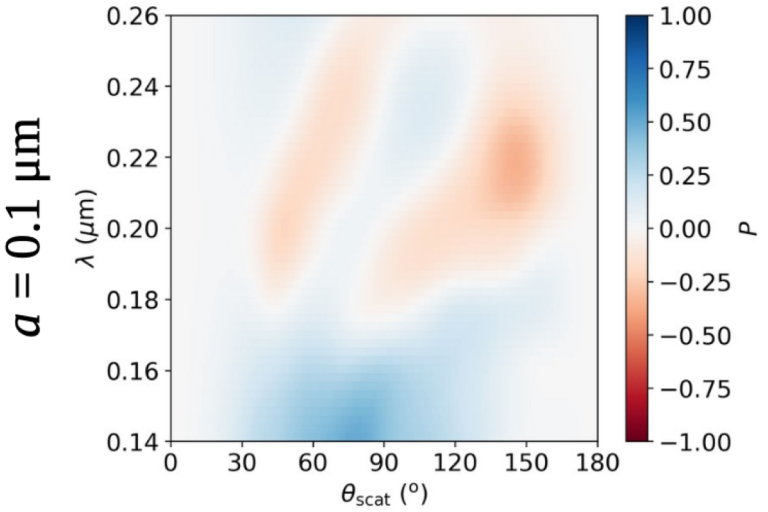
DDSCAT



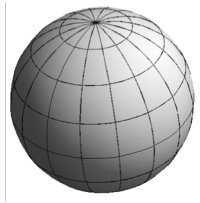


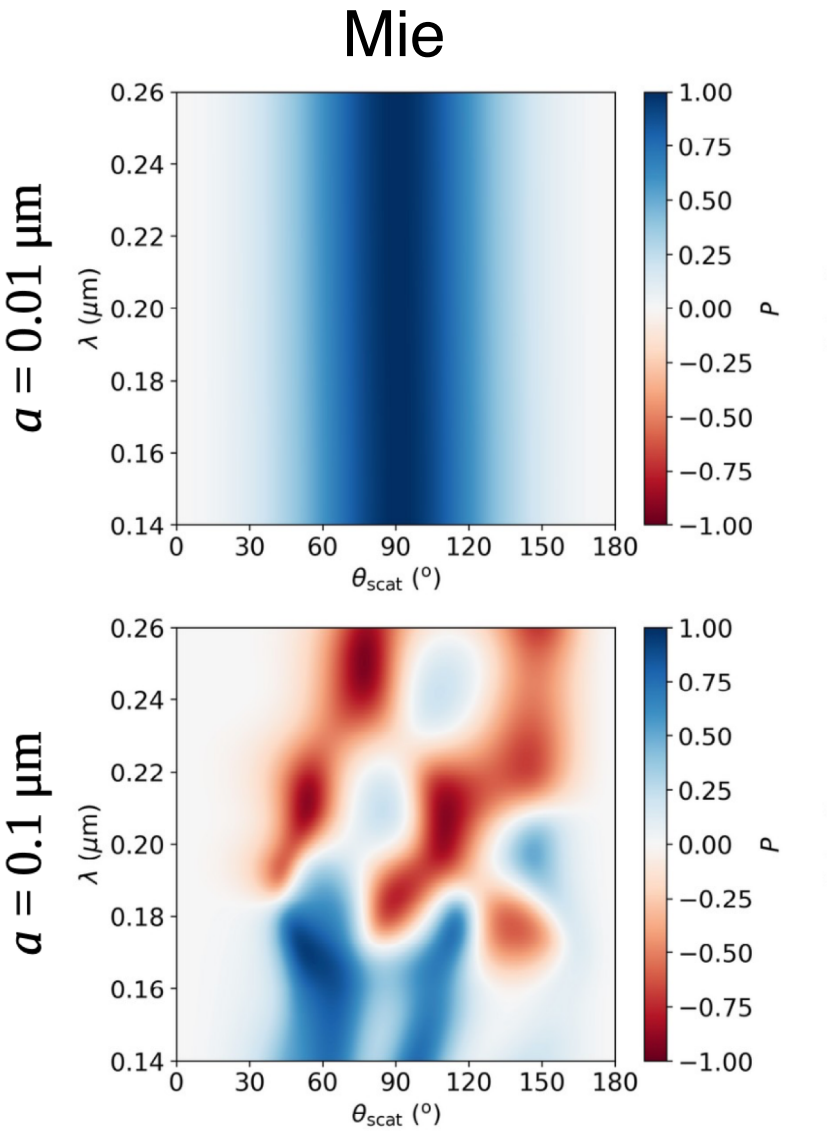






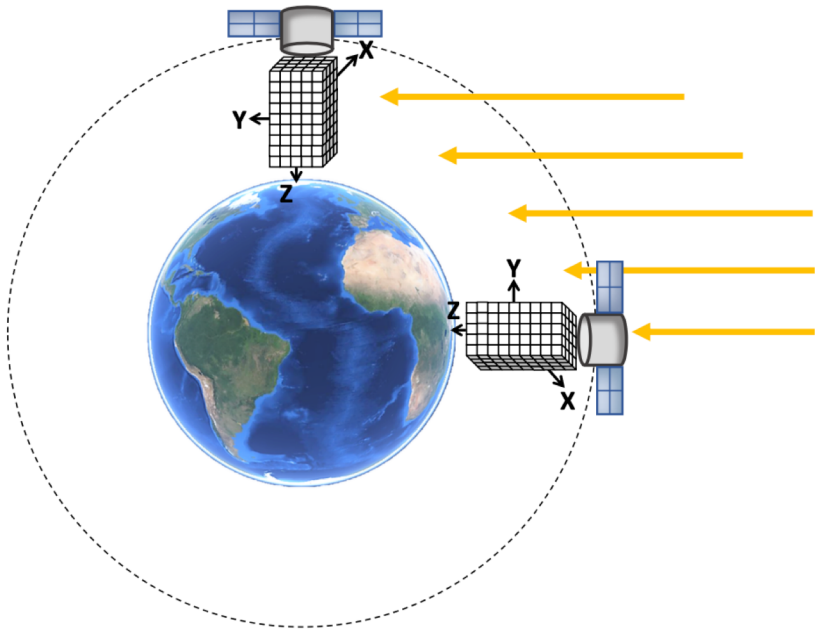
Infalling dust model – scattering

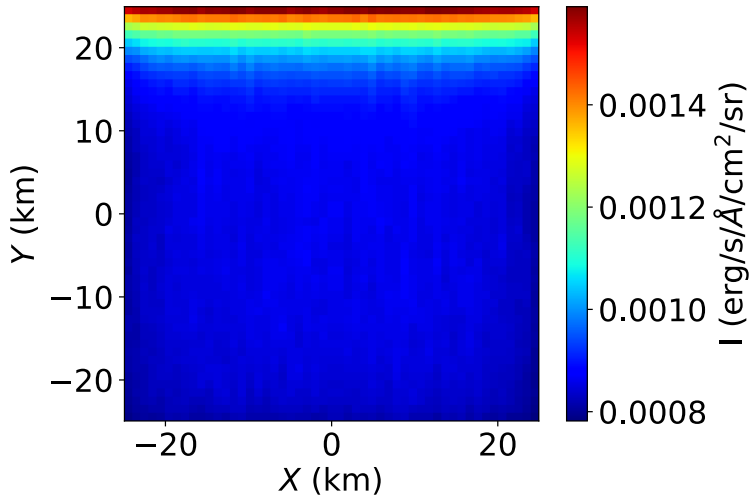


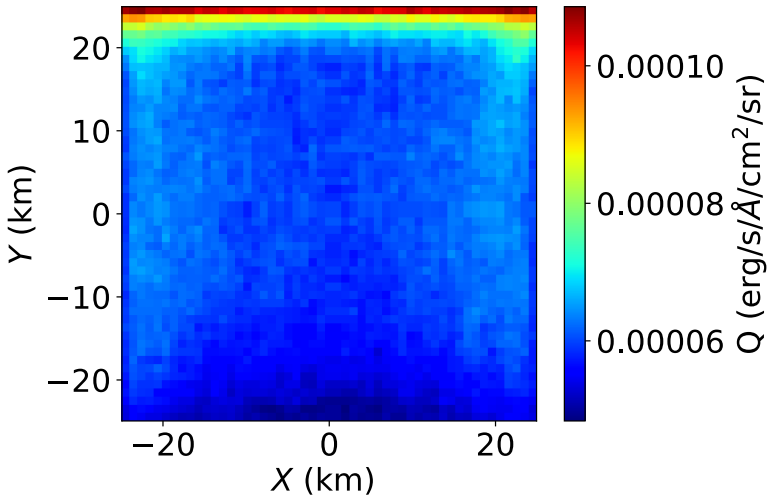


Spherical grains
First approach

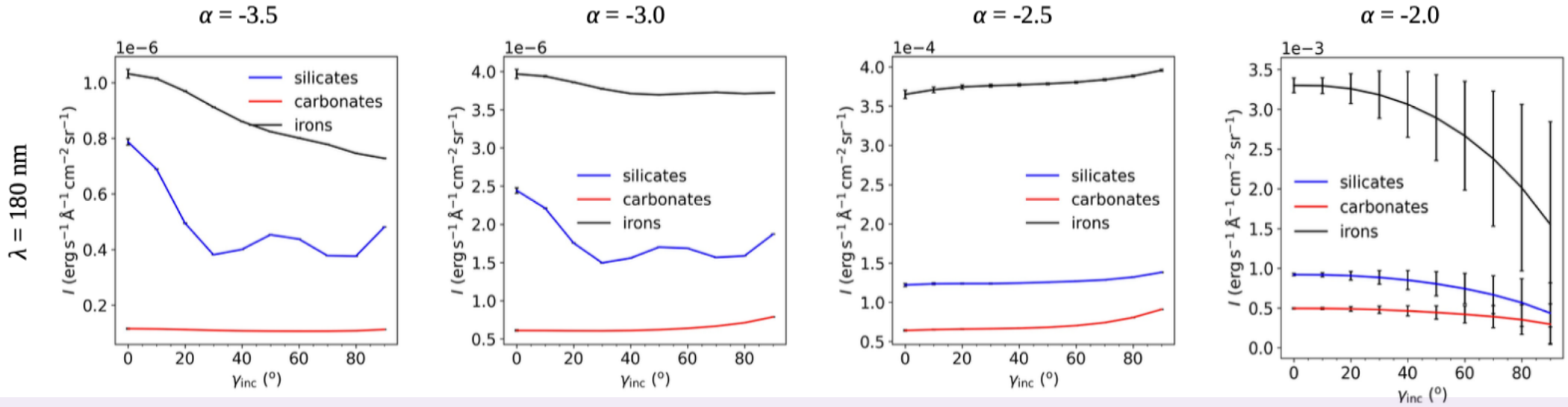
Results – scattered radiation



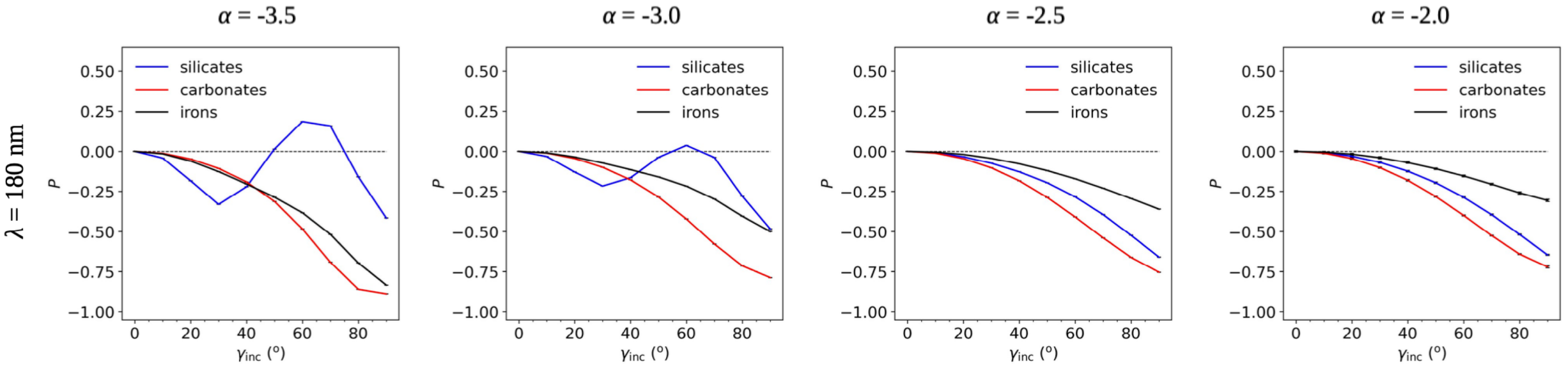




López-Viejobueno & Gómez de Castro in prep.



Results – scattering polarization



López-Viejobueno & Gómez de Castro in prep.

Summary

Model of infalling space particles in the Earth atmosphere.

First estimates of the expected signal and its polarization in UV. Baseline future space missions.

UV scattering polarization to characterize small grains.

Need for better modelling of space irregular particles in UV.


AEGORA
COMPLUTENSE
RESEARCH GROUP ON
SPACE ASTRONOMY
AND DATA MINING
JcUVa
jennilop@ucm.es
THANK YOU!
NUVA
The Network for Ultraviolet Astronomy