Single-Scattering, Porosity, and Surface-Roughness Properties of Planetary Regoliths from Space-Based Imaging Data

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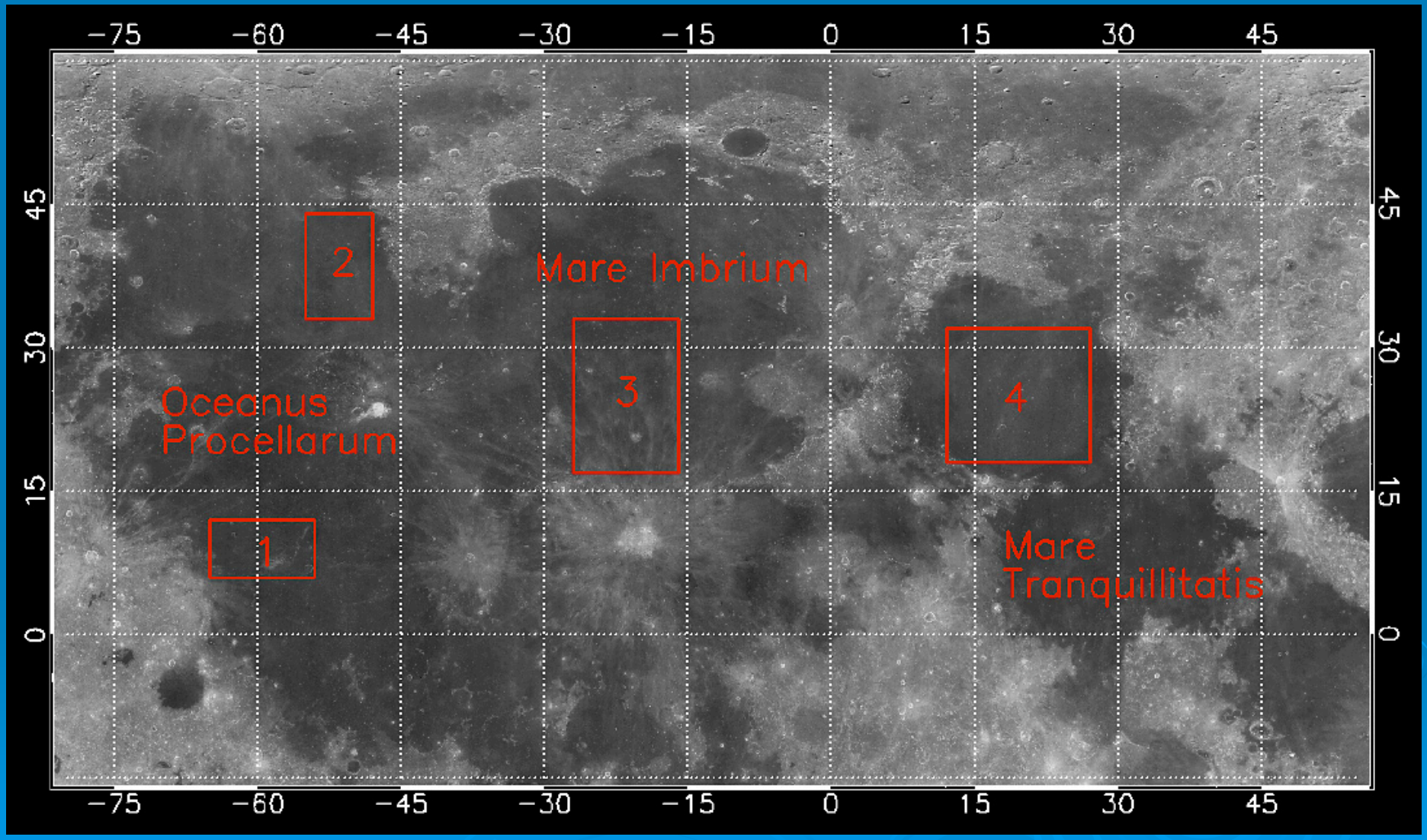
Introduction

The Moon

SMART-1 / AMIE



Muinonen et al., 2009, submitted

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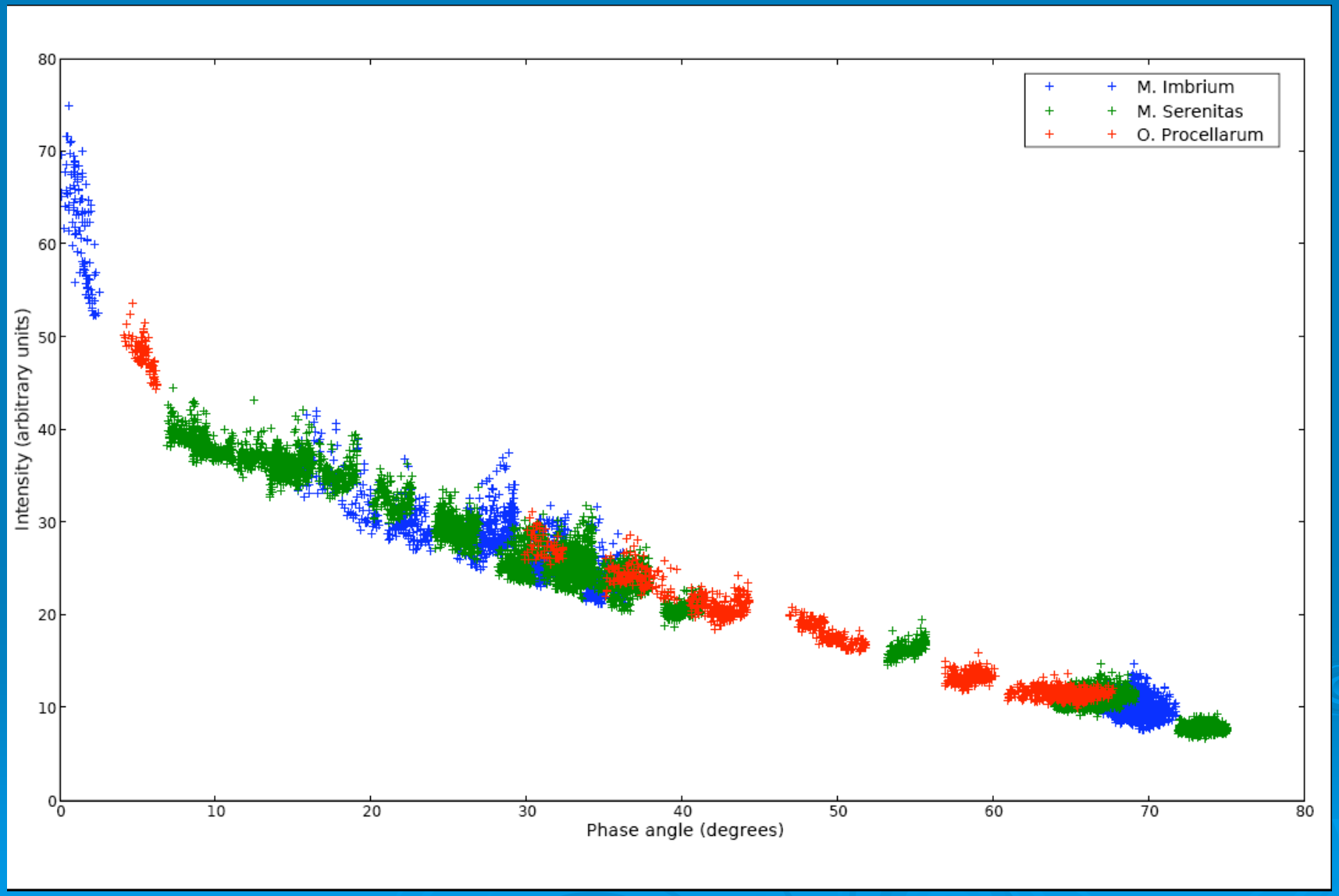
The Moon



Muinonen et al. 2009, submitted

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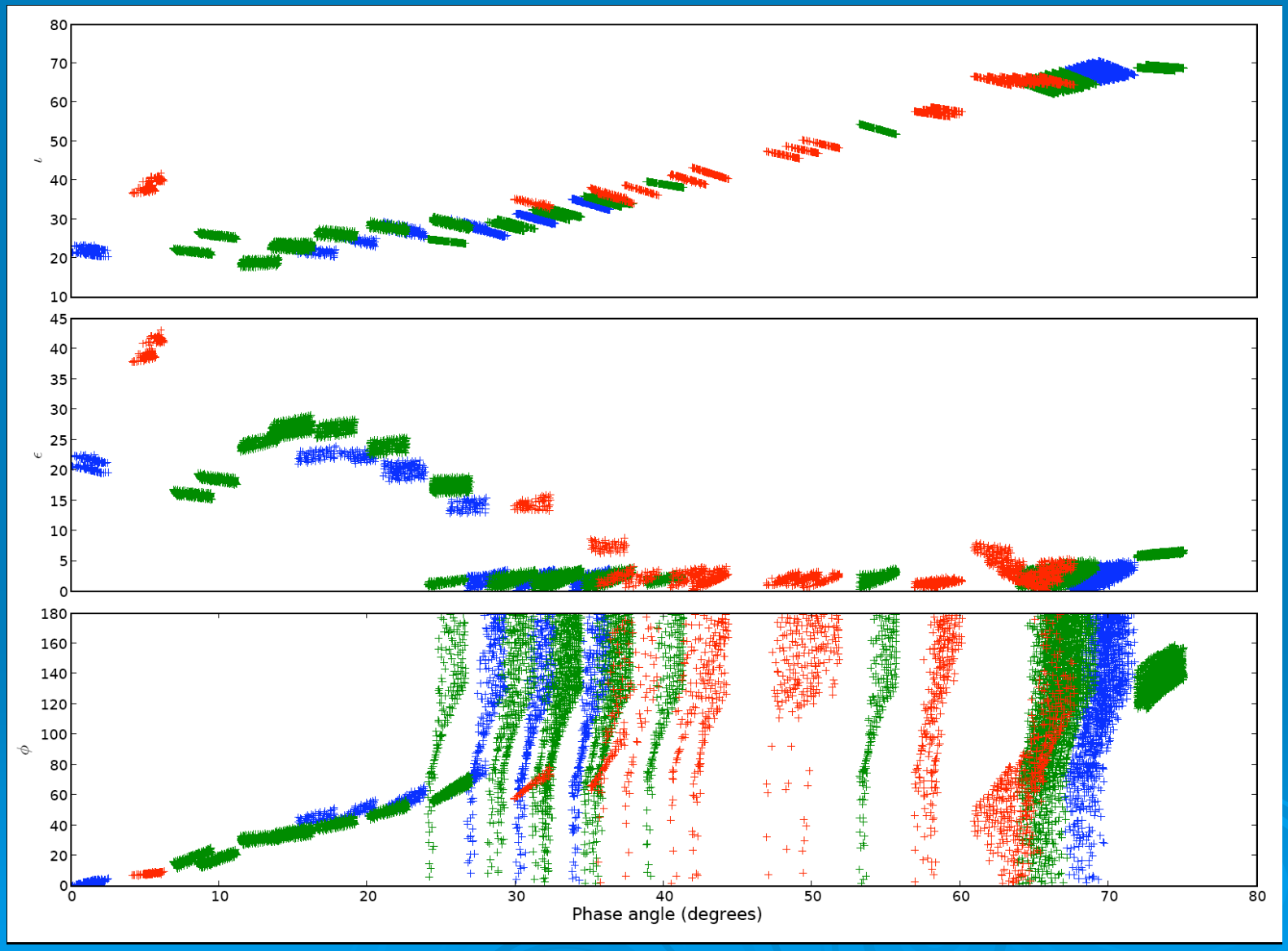
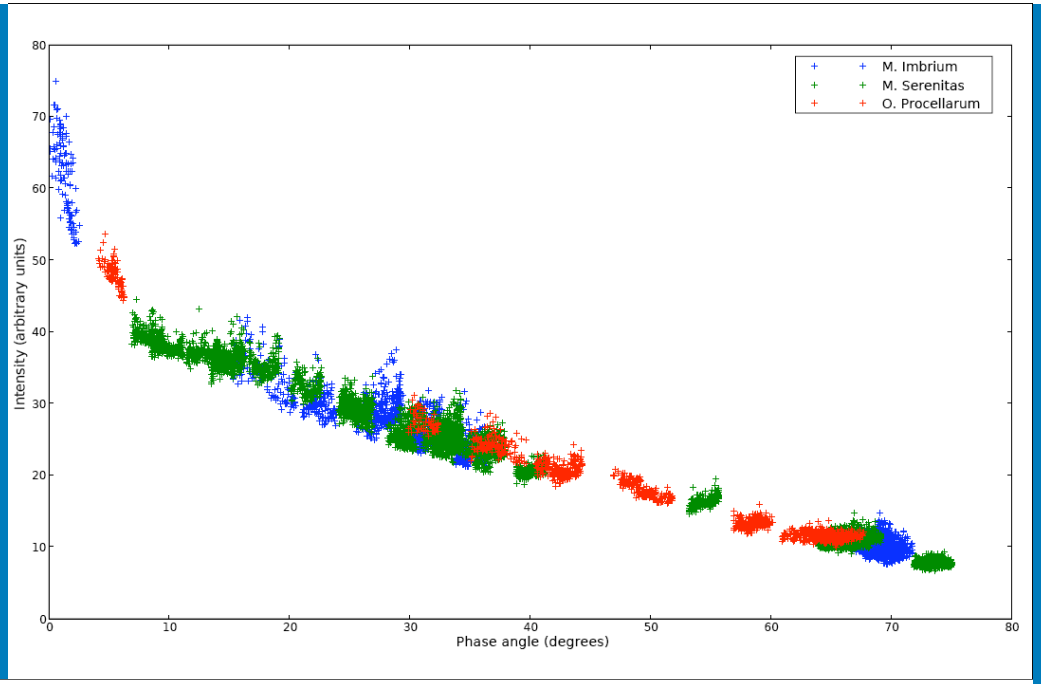
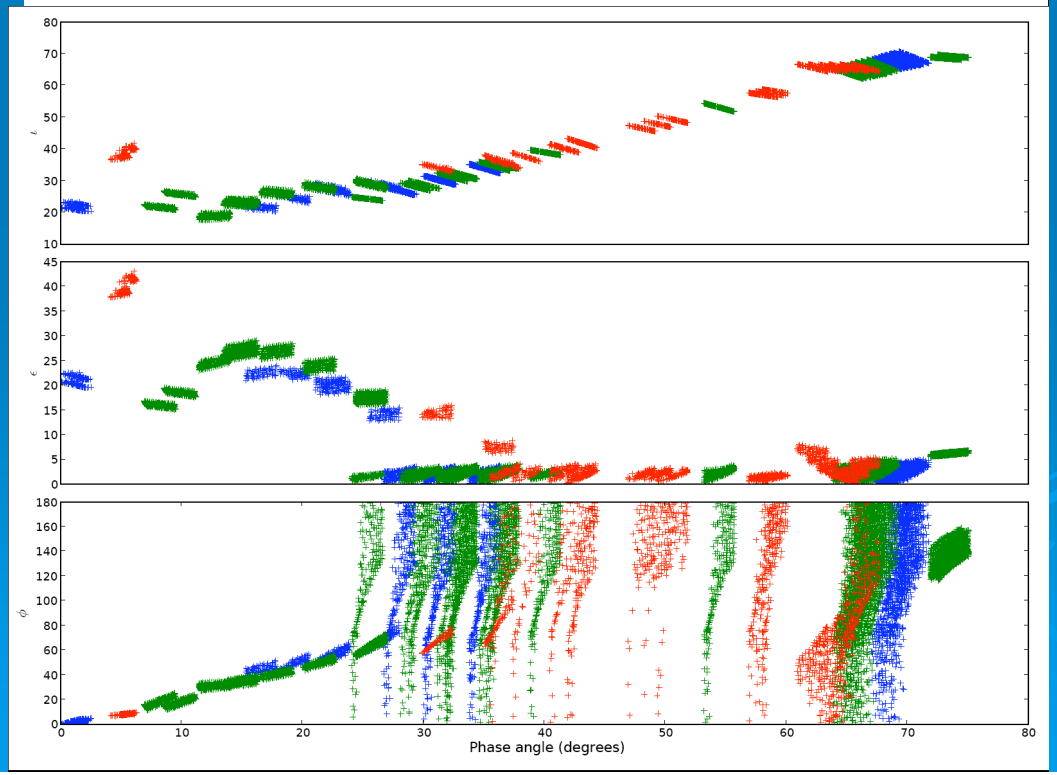


The incidence, emergence, azimuthal, and phase angles covered (4/16)


M. Imbrium
M. Serenitas
O. Procellarum
Intensity (arbitrary units)
Phase angle (degrees)

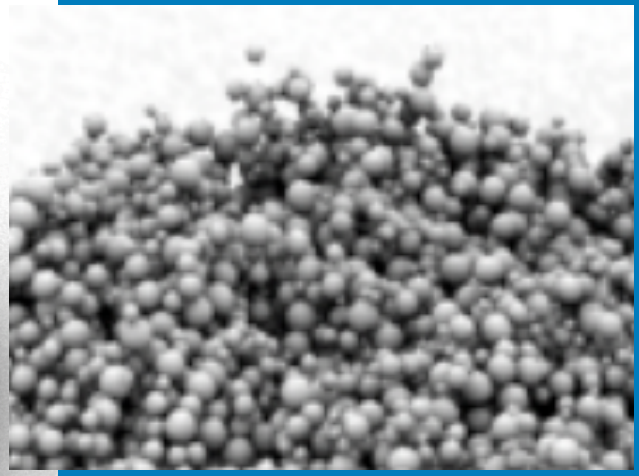

Phase angle (degrees)

Multiple Scattering

Multiple scattering from a particulate medium is a function of

- surface roughness
- volume density of the particulate medium
- size of small particles
- shape (structure) of small particles
- refractive index of small particles

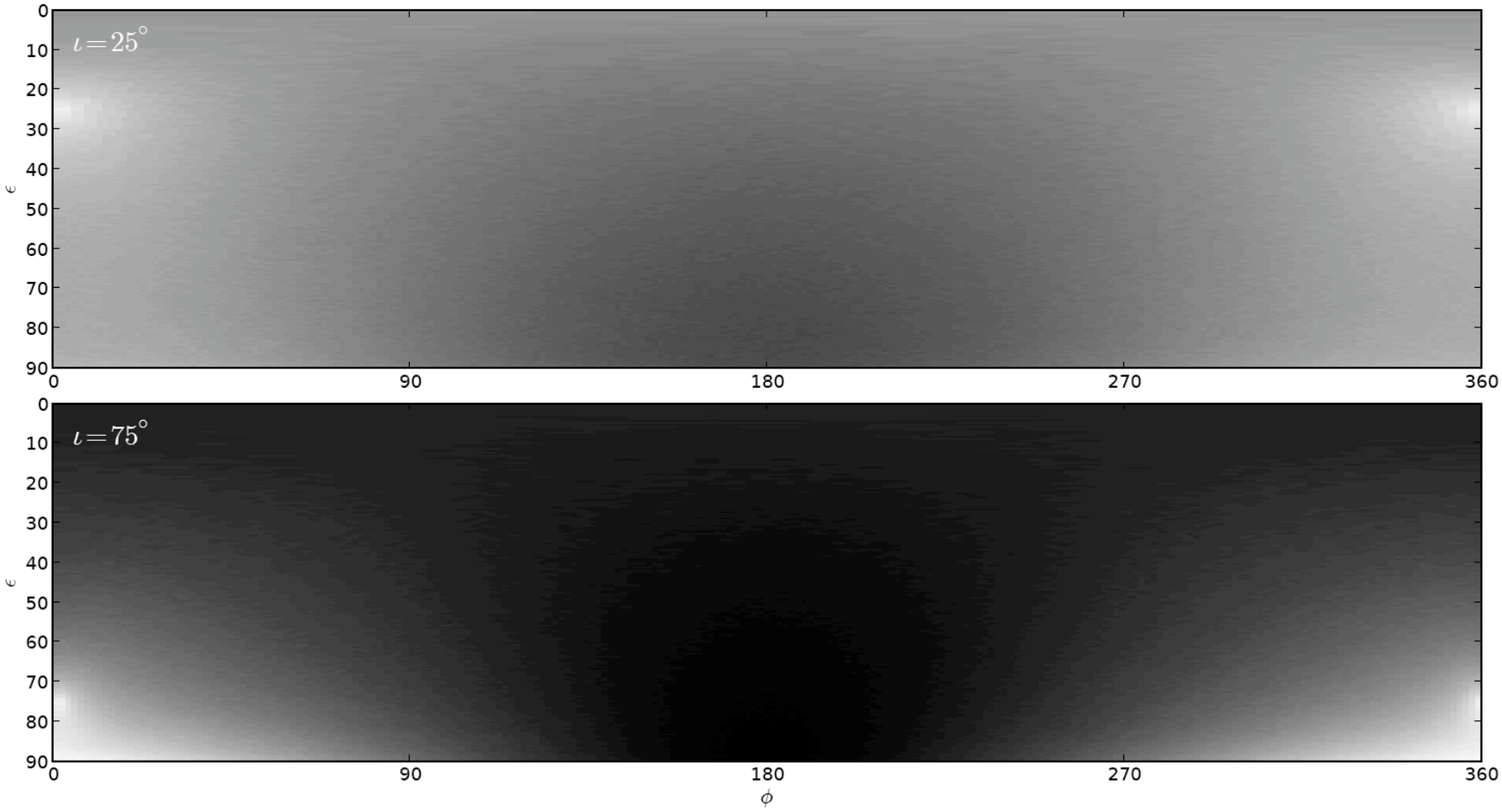
Stochastic Surface Geometry



Densely-packed random media of spheres, fractional-Brownian-motion boundary surface

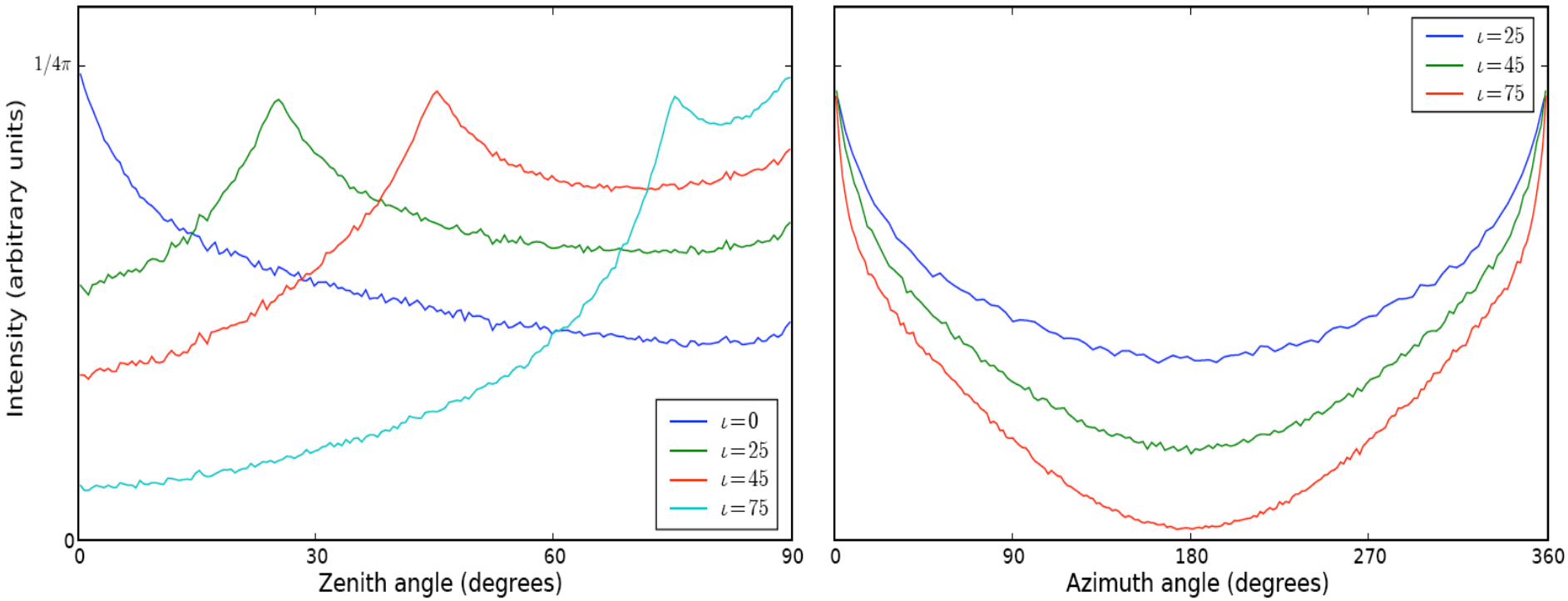
Parviainen & Muinonen, JQSRT 2007 & 2009

Shadowing



Dependence of shadowing on angles of incidence and emergence, as well as on the azimuthal angle

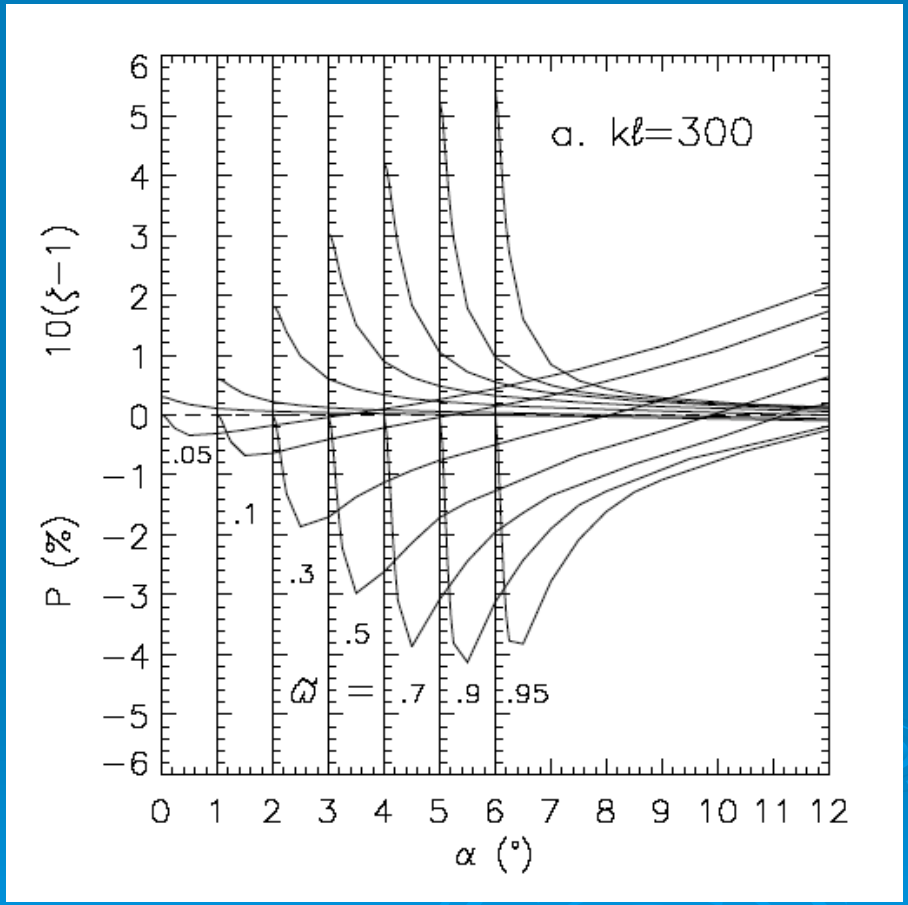
Shadowing



Slices in constant azimuthal angle and in constant emergence angle

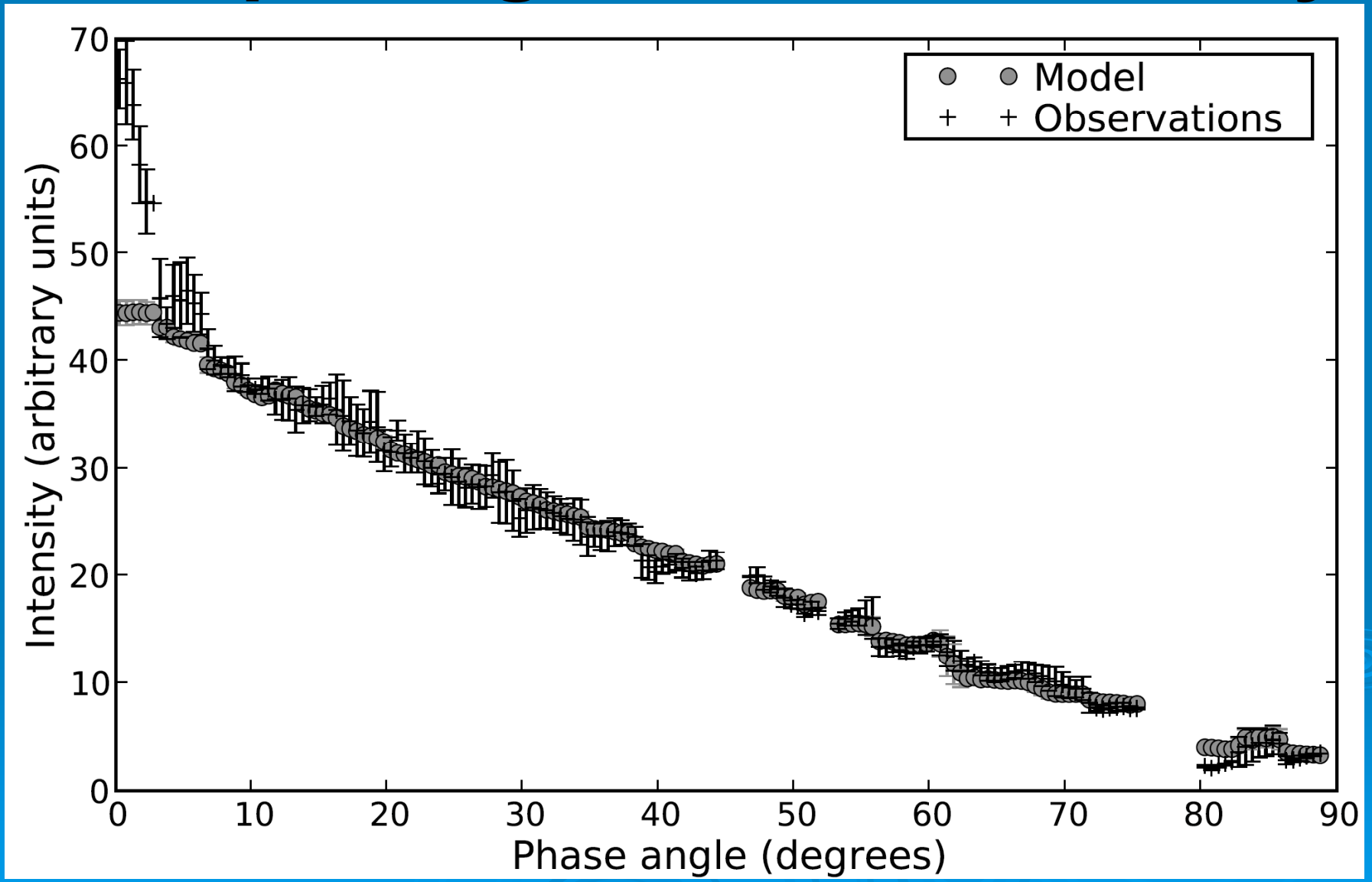
Coherent Backscattering

- Polarization and intensity surges due to interference in multiple scattering
- Monte Carlo for radiative transfer and coherent backscattering
- Full angular profiles for complete reflection coefficient matrices



Muinonen, Waves in Random Media, 2004

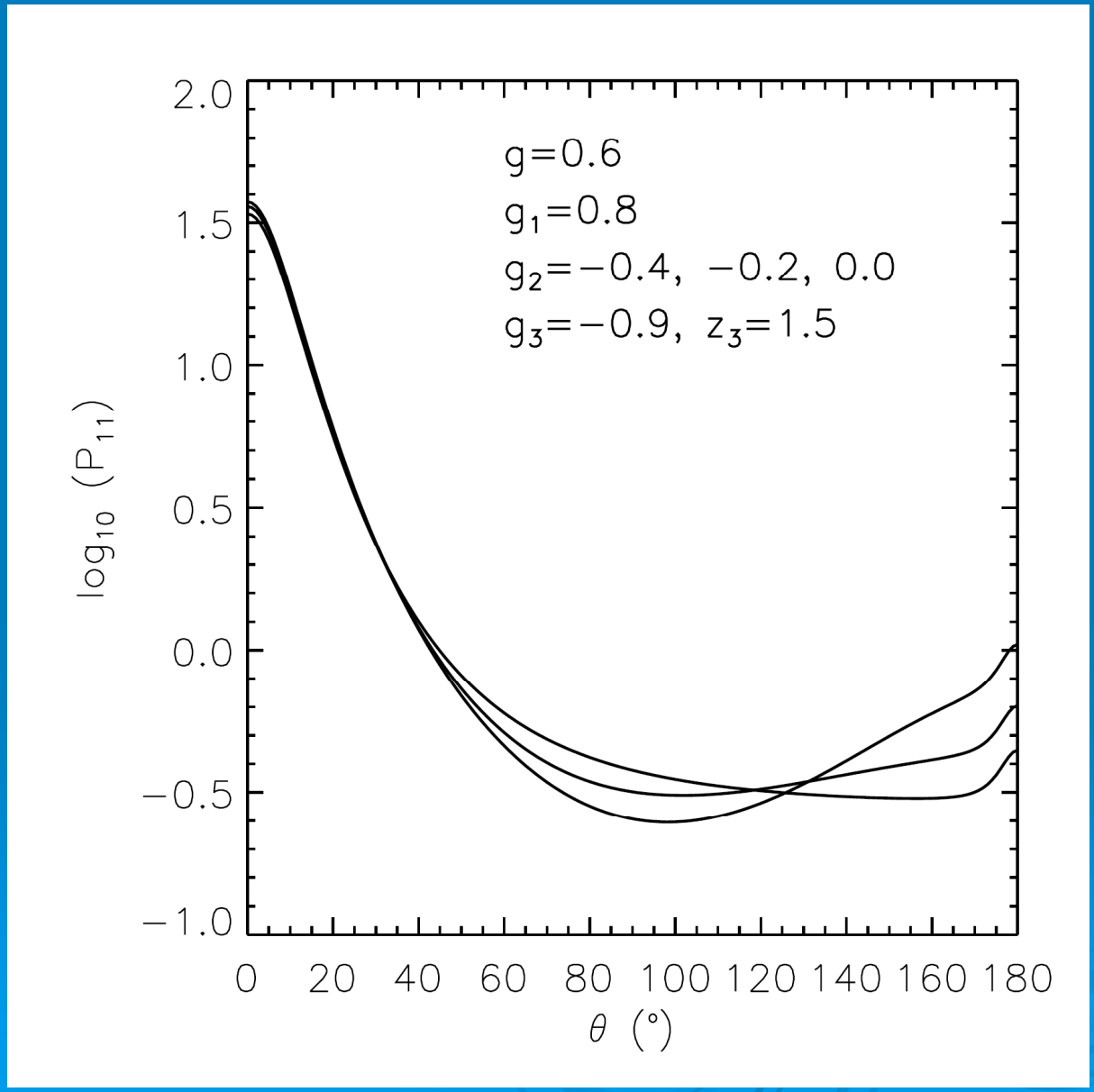
Interpreting Lunar Photometry



Interpreting Lunar Photometry

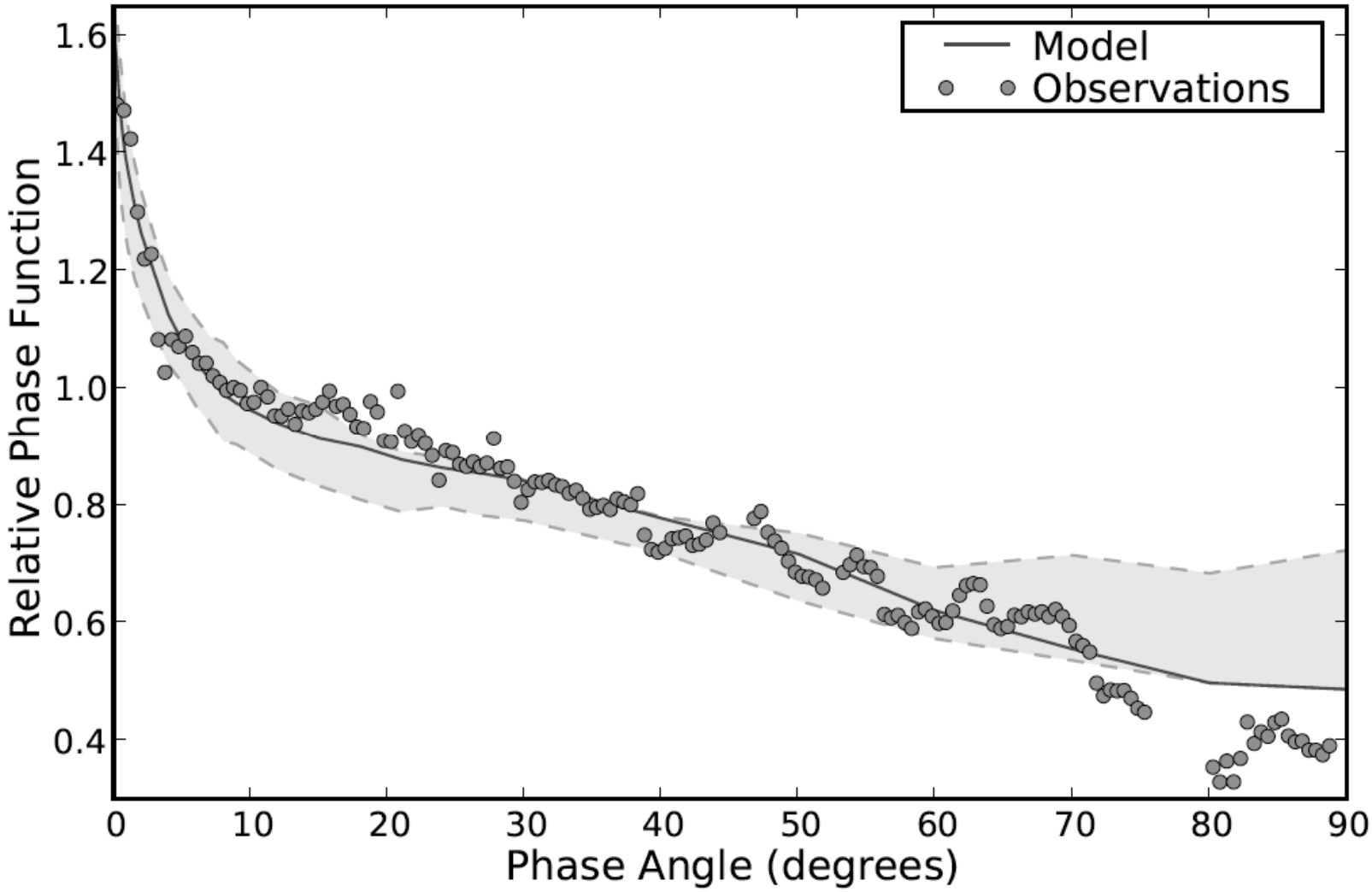
- Division of observational data by model data allows the derivation of the stochastic surface geometry
- Shadowing not the explanation for the lunar opposition effect
- Volume-element scattering phase function shows enhanced backscattering

Interpreting Lunar Photometry



Coherent backscattering: single-scattering albedo 0.7-0.8; mean free path 6-30 microns; medium radius 60 microns; triple Henyey-Greenstein single-scattering phase function, asymmetry 0.6

Interpreting Lunar Photometry



Interpreting Lunar Photometry

- Coherent backscattering and single scattering responsible for the lunar opposition effect
- Result in agreement with lunar polarimetric data and with scattering by nonspherical particles
- Novel method to derive submicron-to-micron-scale physical properties of planetary regoliths

Conclusions

- Disk-resolved photometry allows to gradually extract stochastic-surface and single-scattering characteristics
- Additional studies to be carried out for surfaces of moderate and high geometric albedos
- Applicable to the target near-Earth object of the Marco Polo mission