

## UNDERSTANDING PHYSICAL PROPERTIES OF REGOLITH: THEORY AND EXPERIMENT

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**Introduction:** For more than a century, controlled experiments in the laboratory have attempted to replicate the astronomically observed angular scattering (polarization and reflectance) properties of Atmosphereless Solar System Bodies (ASSBs) in efforts to understand the regolith texture. Concurrently, theorists attempted to model regolith properties assuming various (often spherical) particle morphologies. The goal of both approaches is to use astronomical measurements to constrain the regolith texture.

**The Problem:** Until recently, attempts to reconcile astronomical observations, laboratory measurements, and theory have been marginally successful. Expert theorists note the absence of laboratory measurements of regolith analogs that match the theoretical assumptions. Laboratory experimentalists rarely have access to materials approximating the idealized assumptions used in theoretical models, particularly those of well-constrained particle size and morphology.

**The Progress:** Recently, experimentalists have measured the reflectance properties of well-sorted particulate abrasives serving as regolith analogs and have found success in explaining the astronomically observed reflectance and polarization properties of highly reflective ASSBs such as Europa (Nelson et al., 2018). This progress has now been extended to two more highly reflective ASSBs, Enceladus and Rhea.

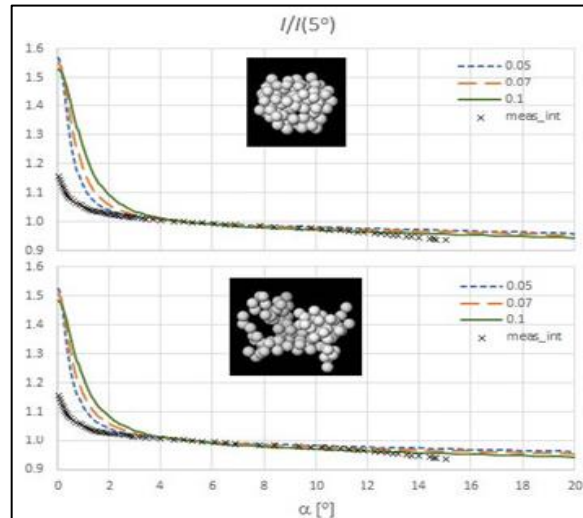
Typical theoretical predictions and laboratory measurements of reflectance (Fig. 1) and polarization (Fig. 2) phase curves for highly reflective ASSBs, Enceladus and Rhea, are compared with angular scattering measurements of  $\text{Al}_2\text{O}_3$  particles measured in our lab (Figures 1 and 2) (after Petrova et al., 2019).

**Conclusion:** The polarization characteristics of highly reflective ASSBs can be explained by high albedo, sub-micron sized particulate regoliths of extremely high porosity.

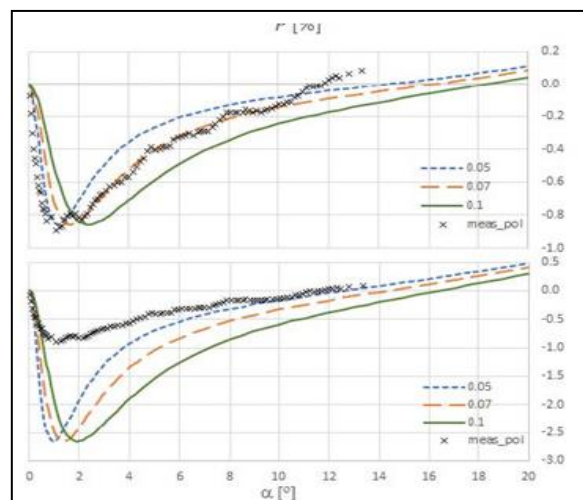
### References:

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**Figure 1.** Phase curves of reflectance, normalized at phase angle  $\alpha = 5^\circ$  ( $\lambda = 0.635 \mu\text{m}$ ) reflected by  $\text{Al}_2\text{O}_3$  samples containing particles with diameter  $= 0.1 \mu\text{m}$  (porosity 97%) at different theoretical concentrations of scatterers. The measurements of Nelson et al. (2018) (crosses) are compared to models for two particulate media composed of clusters of different porosities (90% (solid line), 93% (long dashes), and 95% (short dashes). In these models, the refractive index of particles is 1.7659, and there is no absorption.



**Fig 2.** Polarization phase curves of the materials shown in Fig 1. The polarization phase curves theoretically predicted for equant particles agree remarkably well with laboratory measurements.