Modeling of asteroid surfaces and interiors using ray optics with diffuse scattering

A. Virkki[1], K. Muinonen[1,2], and A. Penttilä[1]

[1]Department of Physics, P.O. Box 64, FI-00014 University of Helsinki, Finland
[2]Finnish Geodetic Institute, P.O. Box 15, FI-02431 Masala, Finland

We simulate electromagnetic scattering from a realistic model of an asteroid using an algorithm of ray optics with Fresnel reflection and refraction as well as diffuse scattering [1]. The application of the study is to simulate radar scattering, that is, scattering from centimeter-sized structures, and as a result, study the radar properties of realistic media in terms of structure and material. The results show the circular-polarization ratios and radar albedos of the asteroid models for scatterers from a sub-wavelength scale to a scale of few times the wavelength.

We use two kinds of structures: the first is a uniform, internal diffuse medium inside a host body, and the second is an external layer on the surface of a host body. The host body is spherical and it has a diameter of 30 times the wavelength, and the external layer has thickness from a few wavelengths up to about 10 wavelengths. We study both spheres and aggregates of spheres of different sizes as constituents of the diffuse medium, and thus, connect our previous results (e.g., [2]) to a more realistic model for asteroids. As for materials, we mimic rocks and vacuum inclusions in powdered silicate or basaltic materials and a layer of rocks on a rocky host body.

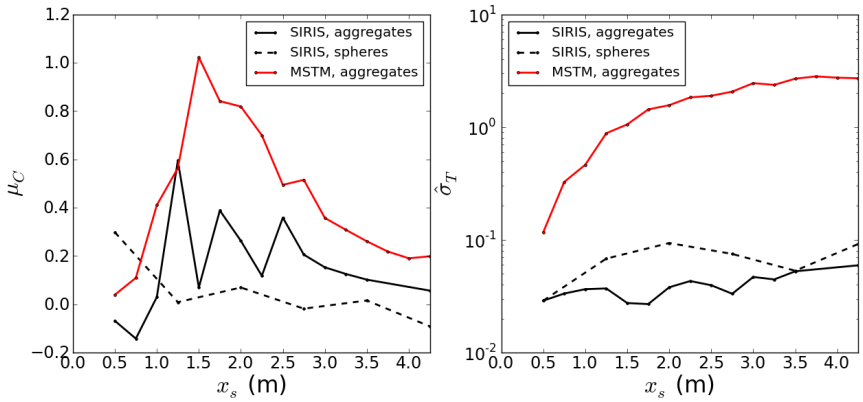

Figure: The circular-polarization ratio (μ_C) and the radar albedo ($\hat{\sigma}_T$) for an internal diffuse medium of spheres and aggregates of spheres, when the refractive index of the host body is $1.4 + 0.001i$ and the refractive index of the scatterers is a mixture of $1.86 + 0.0074i$ and $1.78 + 0.0089i$ for the aggregates and, the average of these, $1.82 + 0.00815i$ for the spheres.

References: [1] K. Muinonen, T. Nousiainen, H. Lindqvist, O. Muñoz, G. Videen (2009). Light scattering by Gaussian particles with internal inclusions and roughened surfaces using ray optics. *Journal of Quantitative Spectroscopy & Radiative Transfer* **110**, 1628–1639. [2] A. Virkki, K. Muinonen, A. Penttilä (2013). Circular polarization of spherical-particle aggregates at backscattering. *Journal of Quantitative Spectroscopy & Radiative Transfer* **126**, 150–159.