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Multiple scattering by the surfaces of small Solar System objects

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Abstract

Scattering of electromagnetic waves in a macroscopic particulate medium composed of microscopic particles constitutes an open computational problem in planetary astrophysics. This problem manifests itself in the absence of inverse methods to address fundamental astronomical observations of small Solar System objects.

1. Introduction

There are two ubiquitous phenomena observed at small solar phase angles (the Sun-Object-Observer angle) from, for example, asteroids and transneptunian objects. First, a nonlinear increase of brightness is observed toward the zero phase angle in the magnitude scale that is commonly called the opposition effect. Second, the scattered light is observed to be partially linearly polarized parallel to the Sun-Object-Observer plane that is commonly called the negative polarization surge.

2. Results and discussion

The aforedescribed polarimetric and photometric observations of small Solar System objects are interpreted using a radiative-transfer coherent-backscattering model (RT-CB, [1]) that makes use of a so-called phenomenological fundamental single scatterer [2]. For the validity of RT-CB, see [3, 4]. The modeling allows us to constrain the single-scattering albedo, phase function, and polarization characteristics as well as the mean free path length between successive scatterings. With the help of laboratory experiments (Muñoz et al. and Peltoniemi et al., present meeting) and exact theoretical methods (e.g., Markkanen et al., present meeting), it further allows us to put constraints on the size, shape, and refractive index of the fundamental scatterers. We illustrate the application of RT-CB by interpreting the polarimetric and photometric observations of the C, M, S, and E-class asteroids.

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