MULTIPLE SCATTERING OF LIGHT IN THE SURFACES OF SMALL SOLAR SYSTEM BODIES USING MIE SCATTERERS.

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Introduction: We present theoretical modeling for scattering and absorption of light by the particulate surfaces of small Solar System bodies. The modeling entails the following physical characteristics of the particulate surface: the porosity of the particulate medium; the random rough interface between the surface and free space; and the size, shape, and optical properties of the scatterers. In particular, the theoretical modeling accounts for the coherent-backscattering and shadowing effects. Our primary goal is to provide a quantitative assessment of the opposition phenomena, that is, the opposition effect in brightness and the negative branch of linear polarization, observed for atmosphereless Solar System bodies.

Methods: In these initial studies, the multiple-scattering model is based on radiative transfer and coherent backscattering for wavelength-scale spherical scatterers [1] together with the computation of shadowing effects using a medium of spherical volume elements large compared to the wavelength [2]. The radiative-transfer coherent-backscattering portion of the model accounts for the so-called ladder and cyclical interaction diagrams in multiple scattering among the spherical scatterers constituting the large spherical volume elements. Extinction within the volume elements is assumed to be exponential.

The model utilizes a size distribution of spherical scatterers within a surrounding medium as well as a refractive index distribution. The scatterers can be material particles in free space or voids within host material. The size distribution is assumed to follow the inverse Gamma distribution that approaches asymptotically a power-law size distribution. The distribution of refractive indices is introduced in order to mimic the effects due to nonspherical scatterers and a heterogeneous surface.

For example, for a complex random medium composed of pure water ice, the model can assume relative refractive indices for spherical scatterers between 1/1.31 (voids in ice) and 1.31 (ice particles in free space). Thus, in the spirit of effective medium theories for electric permittivities, the refractive index is constrained within a range set by the refractive index of the material. Currently, the refractive index distribution is accounted for by discrete weights for the different refractive indices at input.

The numerical radiative-transfer coherent-backscattering code takes as input pre-computed Mie scattering characteristics for media weighted on the basis of the corresponding volume fraction. The current example includes 10 different media, each with the same size distribution of spherical scatterers (asymptotic power-law index is 3). The material refractive index assumes the values 1.2+i0.001, 1.3+i0.001, 1.4+i0.001, 1.5+i0.001, and 1.6+i0.001. One half of the spherical volume elements consists of material particles in free space; whereas, the other half consists of voids in material.

Results and discussion: We have carried out example multiple-scattering computations for weakly absorbing silicate-rich media where the real part of the relative refractive index varies between 1/1.6 and 1.6, and the asymptotic power-law index is 3. Realistic opposition effects and negative polarization branches result from the computations. The computations have been repeated for three wavelengths assuming similar optical properties. The results show a realistic, weak dependence of the intensity and polarization on the wavelength.

Conclusion: We describe a multiple-scattering model based on spherical scatterers. The model is capable of reproducing the opposition phenomena observed for small Solar System bodies, that is, the opposition effect and the negative linear polarization. The model constitutes a reference model for more approximate approaches. It is our goal to apply the model to the polarimetry and photometry observed for transneptunian objects [3,4], Centaurs, as well as main-belt and near-Earth asteroids and planetary satellites [5]. Furthermore, the present modeling can be extended to the interpretation of active remote sensing of asteroids at radar wavelengths [6].

References: [1] Muinonen K. (2004) *Waves in Random Media, 14,* 365–388. [2] Wilkman, O., et al. (2012), this meeting. [3] Boehnhardt H., et al. (2004) *Astron. Astrophys. Letters, 415,* L21-L25. [4] Belskaya, I. N., et al. (2012), this meeting. [5] Ejeta C., et al. (2011) *Astron. Astrophys., 537,* A23, 1-8. [6] Virkki, A., et al. (2012), this meeting.

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