APPLICATION OF THE MULTIPLE-SCATTERING MODELING PIPELINE FOR SPECTROSCOPY, POLARIMETRY, AND PHOTOMETRY.

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Introduction: Electromagnetic scattering is a fundamental physical process that allows inferring characteristics of an object studied remotely. This possibility is enhanced by obtaining the light-scattering response at multiple wavelengths and viewing geometries, i.e., by considering a wider range of the phase angle (the angle between the incident light and the light reflected from the object) in the experiment. Planetary environments and their terrestrial analogues represent numerous examples of scattering media composed of particles. There is a fundamental difficulty, however, in bridging the gap between the light-scattering theory and experiment: while existing theoretical models can be used reliably to simulate scattering by a fixed finite object or random particles [1], thorough experimental work has mostly been performed with light scattered from surfaces, see e.g. [2-4].

Bridging the gap between theory and experiments: We present the application of the newly developed data-processing and analysis pipeline to analyze the reflectance spectra and photometric and polarimetric phase curves of close-packed random media. In the software suite, light-scattering characteristics of the sample are modeled using novel multiple scattering methods for close-packed random media, such as a geometric optics method SIRIS4 [5] and the radiative transfer with reciprocal transactions R^2T^2 [6]. The R^2T^2 method solves the ensemble-averaged Foldy-Lax equation involving the ladder and maximally crossed diagrams as well as the near field corrections. The near field corrections are implemented in terms of the incoherent volume element containing all the scattering diagrams that do not cancel out in the near-zone [6]. The incoherent scattering parameters of the volume elements are solved exactly by the fast superposition T-matrix method [7]. The latter enables us to extend the applicability of the radiative transfer to close-packed random media [6].

A case study: Application of the software suite to the defined close-packed random media is followed by comparison with experimental results. Among suitable planetary analogue samples for the experimental study are, for example, macroscopic agglomerates formed by ballistic hit-and-stick deposition [8]. The agglomerates consist of monodisperse SiO_2 spheres. The light-scattering characteristics of the agglomerates are thoroughly measured with the our newly developed scatterometer [9]. The scatterometer comprises a new acoustic levitation system with remote orientation control for reliable manipulation of mm-sized samples. The system therefore allows conducting robust measurements of light scattered by the sample held in place by sound. The absence of interfering sample holder in the setup (enabled by levitation) allows non-destructive non-contact measurement of the sample in all orientations [9]. The obtained measurement data, in turn, provide more complete presentation of the Mueller matrices of the studied scatterers. The results obtained by studing the agglomerates composed of monodisperse SiO_2 spheres demonstrate, that application of the software suite for analyzing optical properties of close-packed random media matches well with the experimental results.

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