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Polarization of light scattered by planetary surfaces

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Scattering of light in a macroscopic particulate medium composed of microscopic particles constitutes an open computational problem in planetary astrophysics. 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.

The observations can be interpreted using a radiative-transfer coherent-backscattering Monte Carlo method (RT-CB, [**?**]) that makes use of a so-called phenomenological fundamental single scatterer [**?**]. For the validity of RT-CB, see [**?**]. With the help of laboratory experiments (e.g., Penttilä et al., present meeting) and exact theoretical methods (e.g., Markkanen et al., present meeting), the method can allow us to put constraints on the size, shape, and refractive index of the fundamental scatterers.

In the present work, we extend the RT-CB method for the specific case of a macroscopic medium of electric dipole scatterers. For the computation of the interactions, the far-field approximation inherent in the RT-CB method is replaced by an exact treatment, allowing us to account for, e.g., the so-called near-field effects. In this extended RT-CB method, the distance and direction of wave propagation is simultaneously simulated using the exact results. The extinction of waves emerging from the particulate medium is assessed analogously. The present method constitutes the first milestone in the development of a multiple-scattering method, where the so-called ladder and maximally crossed cyclical diagrams of the multiple electromagnetic interactions are rigorously computed.

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References

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