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Circular-polarization ratios for aggregates of spherical particles

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A basic strategy for observing a small solar-system object using radar is to measure the distribution of echo power in time delay and Doppler frequency for a circularly polarized transmitted wave, in the same and opposite senses of circular polarization. The measurement can be repeated for differing orientations and plane-of-sky directions of the object. The circular-polarization ratio μ is the ratio of the echo power in the same circular-polarization state (SC) to that in the opposite circular-polarization state (OC). The ratio μ is often the most important physical observable with the radar technique, as it provides the best indications for wavelength-scale complexity of the surface. At the typical transmitter frequencies of 2380 MHz or 8495 MHz, the wavelengths are 12.6 cm or 3.5 cm, respectively.

We model electromagnetic scattering from closely-packed random aggregates of spheres imitating the structure of an asteroid's regolith. Both scattering and absorption of the electromagnetic wave are treated. The Multiple-Sphere T-Matrix Method computer software (MSTM; D. W. Mackowski and M. I. Mishchenko, JQSRT 112, 1282, 2011) is utilized to study how different parameters affect the circular-polarization ratio, e.g., the size distribution and electric permittivities of the spherical particles forming the different aggregates. Our primary goal is to see if the computed circular-polarization ratios can be linked to the observational data of asteroids detected with radar.

The results of the simulations show striking structure for the circular-polarization ratio as a function of the size parameter and the electric permittivity of the medium. Also differences between aggregates of monodisperse and polydisperse spheres clearly exist: the aggregates consisting of polydisperse spherical particles, and hence, showing more complex structure and surface, result in circular-polarization ratios higher than the aggregates of monodisperse spherical particles, probably due to the increased significance of multiple scattering. Most importantly, the simulations show how the variations of the different parameters affect the ratio, indicating reasons for the variations in the observed data.

We have simulated circular-polarization ratios for aggregates of monodisperse particles, and are currently initiating simulations for aggregates of polydisperse spheres.