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MODELING NEAR-EARTH-OBJECT SURFACE PROPERTIES USING THE RADAR SCATTERING PARAMETERS

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ABSTRACT

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 circular-polarization ratio (μ_C) is the ratio of the echo power in the same circular-polarization state to that in the opposite circular-polarization state relative to the transmitted signal. The radar albedo (σ) is the integrated echo power in a specific polarization state, that is, a measure of reflectivity of the target using radar. The observed values are to some extent taxonomic-class dependent, varying from μ_C = 0.10 (G class) to μ_C = 0.83 (E class), and from σ = 0.06 (P class) to σ = 0.27 (M class).

Earlier, we have computed μ_C as a function of the refractive index (m) and the size parameter (x) of the material using the superposition T-matrix method for aggregates of spheres (Virkki et al., JQSRT, in press, DOI:10.1016/j.jqsrt.2012.08.029). The behavior of μ_C in backscattering comprises two sets of bands of maxima: the primary band, following the extinction efficiency of a sphere with the same size parameter as the monomers of the aggregate; and the secondary bands, a result of bi-sphere resonances between the monomers. Of these two sets, the primary band has substantial relevance for radar applications in planetary science. Our goal is to relate the computed μ_C and σ for aggregates of spheres to the observational data of asteroid regoliths measured using radar, so including both μ_C and σ is important. While earlier we have concentrated mainly on μ_C, now we intend to concentrate on σ.

We use the electric permittivities measured near microwave frequencies (approximately at 450 MHz) for various rock types known to exist on the Moon and select from them the types that are also known to exist in asteroids. We mix the selected materials in terms of the refractive indices of the spheres, using truncated power-law (r^{-3}) size distribution for 30 spheres (the number of spheres has little effect to x). An example mix of three minerals includes olivine peridotite (dunite, $m = 2.5 + 0.002i$), anorthosite ($m = 2.6 + 0.002i$), and an average value for basalts (e.g., amygdaloidal basalt, $m = 2.7 + 0.003i$). This mix is compared to the case of mere anorthosite in order to see the effect of deviation in the refractive indices. For μ_C, we obtain the curve that can be seen in Fig. 1. The results for this sample show a distinctive peak near $x = 1$ and little variation due to 5 % deviations in refractive indices. Smaller refractive indices yield lower and wider peak, of which maximum can be found at higher values of x. The corresponding σ is still work in progress, as obtaining it is less simple than obtaining μ_C.

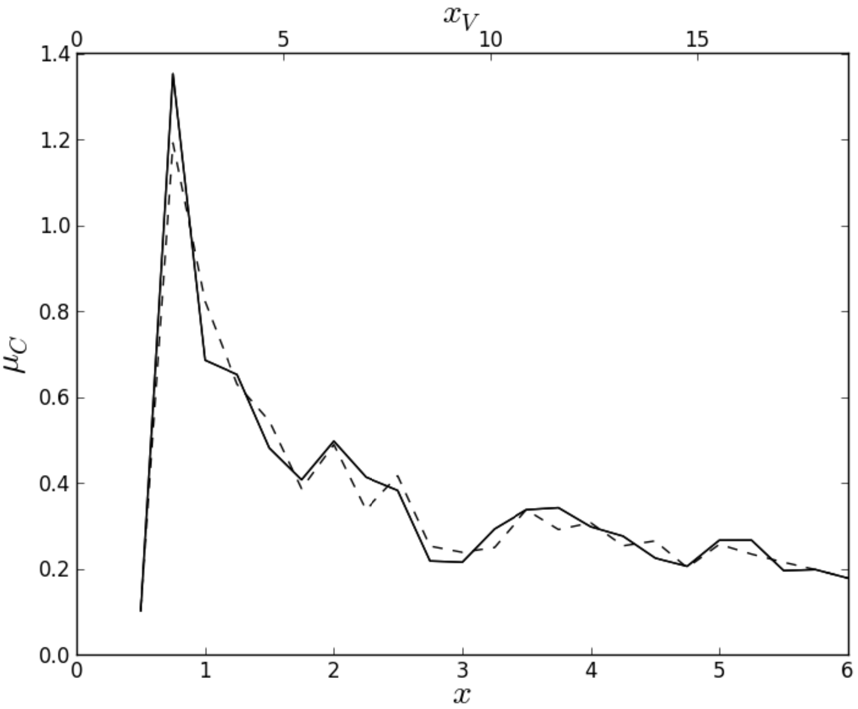

Figure 1. The circular-polarization ratio (μ_C) as a function of the effective size parameter of the spheres (x) and the size parameter of an equal-volume sphere (x_V) for an example aggregate (solid line, see the text), compared to the case using only anorthosite (dashed line).