Light Scattering by Agglomerate Particles with Varying Structure

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Using the discrete-dipole approximation (DDA) [e.g., 1], we compute light scattering by agglomerate particles with three different types of structure. All particles are generated with the same algorithm that is described, e.g., in [2]. The particles are of the same size but have different packing densities of \( \rho = 0.169, 0.236, \) and 0.336. We repeat computations of light scattering for three different refractive indices \( m = 1.313 + 0i, 1.5 + 0.1i, \) and 1.6 + 0.0005i, which represent water ice, organic material, and Mg-rich silicates, i.e., the most abundant species in comets. The size parameter \( x = \frac{2\pi r}{\lambda} \) (where, \( r \) is the radius of the circumscribing sphere) is varied from 1 to 36 for icy particles, 32 for organic particles, and 26 for silicate particles (except for \( \rho = 0.336, \) in which case the upper value of \( x \) is limited to 22 due to convergence limitations). In all the cases, we perform averaging of light-scattering properties over a minimum of 500 particles.

Our computations show that all agglomerates produce the negative polarization branch (NPB) at small phase angles \( \alpha \). This phenomenon accompanies back-scattering of sunlight by comets [e.g., 3]. Two quantities that characterize the NPB are the minimum of linear polarization \( P_{\text{min}} \) and the phase angle of the minimum \( \alpha_{\text{min}} \). However, different types of agglomerates reveal similar dependencies of parameters \( P_{\text{min}} \) and \( \alpha_{\text{min}} \) on \( x \). For instance, in all cases, the NPB is not observed at \( x < 4–8 \). The NPB appears in a narrow range of size parameters \( x_{\text{app}} = 5–8 \) and grows fast with size, reaching maximal negative polarization at \( x_{\text{max}} = 7–17 \). Such a dependence of the NPB on \( x \) can be responsible for the blue color of the negative polarization that was observed in comet 17P/Holmes [4]. The approximate relation \( x_{\text{max}} \approx 2x_{\text{app}} \) holds for all non-icy agglomerate particles. Finally, we note that \( \alpha_{\text{min}} \) reveals a clear tendency to decrease when \( x \) increases.

Keywords: light scattering; agglomerates; the negative polarization; comets.

References