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 $x = 2\pi r/\lambda$ (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 α. 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_{min} and the phase angle of the minimum α_{min}. However, different types of agglomerates reveal similar dependencies of parameters P_{min} and α_{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 $x_{app} = 5$–8 and grows fast with size, reaching maximal negative polarization at $x_{max} = 7$–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 $x_{max} \approx 2\, x_{app}$ holds for all non-icy agglomerate particles. Finally, we note that α_{min} reveals a clear tendency to decrease when x increases.

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

References

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