Linear Polarization of Fluffy Particles

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Cometary circumnuclear haloes reveal a deep negative polarization branch (NPB) at small phase angles that can reach approximately -6% [1]. The origin of the NPB of independently scattering particles contributing to these haloes remains unclear. In simulations of fluffy agglomerates containing 0.2 μm grains, the NPB is not so deep, suggesting the absence of fluffy dust particles [1]. Using the discrete-dipole approximation (DDA), we study the light scattering by agglomerate particles at various packing density. We consider one irregularly shaped particle divided into 30 random fragments [2] and illuminate at wavelength λ=0.5 μm. The particle size is 1.9 μm and the size of an average fragment is 0.35 μm. We expand the particle by moving the fragments from the center of particle. The expansion factor β is varied from 1 to 2.4, changing the packing density ρ from 1 to 0.1. We examine particles having two refractive indices: m=1.5+0.01i and m=1.5+0.1i. In the first case, the non-expanded particle shows an NPB of -8.2%; whereas, in the second case no NPB is present. In the case of Im(m)=0.01, exploding the particle decreases the amplitude of the NPB, but at a modest rate. For instance, at β=2, when the agglomerate is six times fluffier (i.e., ρ=0.16) than that of β=1, the amplitude of the NPB is -6.1%. At Im(m)=0.1, the expansion of the agglomerate rapidly leads to the appearance of a NPB. Its amplitude reaches a maximum of -4.3% at β=1.8 (ρ=0.22). Further expansion decreases the NPB, but, at β=2.4 (ρ=0.1), it remains as low as -1.3%. The deep NPB of the fluffy agglomerates results from the size of the constituent grains, which in our simulations have a size parameter of x=2. The scattering cross section of such grains is visibly larger than their geometrical cross section, enhancing the multiple-scattering component that contributes to the NPB. The deep NPB of circumnuclear haloes can be produced by fluffy particles whose granular sizes are larger than Rayleigh-sized.

Keywords: comets; circumnuclear halo; negative polarization; interpretation.

References

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