LIGHT SCATTERING BY HIGHLY ABSORBING IRREGULARLY SHAPED PARTICLES.

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Introduction: Organic material is an abundant component of cosmic dust. Optical properties of the organic material strongly depend on the dose of UV radiation and ion bombardment. For instance, at wavelength of λ=0.5 μm, the processing of organic material in a form expected in the diffuse interstellar medium yields m=1.57+0.14i [1]. Heavier processing changes the refractive index to m=1.86+0.45i. Thus, the organic material is transient between dielectric and conductor ones. Using our own implementation of the discrete dipole approximation (DDA) [see, e.g., 2], we study light scattering by irregularly shaped particles composed of such a material.

Model of particles: We generate irregularly shaped model particles by damaging a perfect sphere with the following simple algorithm. The spherical volume is filled with a regular cubic lattice that is considered as the initial matrix of the irregular particles. All cubic cells forming this initial matrix are divided into two groups: cells belonging to the surface layer and cells internal to the surface layer. Among the surface dipoles we choose randomly 100 cells that are considered as seed cells of empty space. In the set of internal dipoles, we randomly choose 21 and 20 seed cells of material and empty space, respectively. Each cell distinct from the seed cells is marked with the same optical properties as that of the nearest seed cell. Images of particles generated in this way can be found in [2].

We consider particles at four size parameters x=5, 10, 20, and 30 ($x=2\pi r/\lambda$, r is the radius of initial matrix, λ is the wavelength). In the first case, the radius of initial matrix is 16 cells, in the second case it is 32 cells, and in the two last cases it is 64 cells. The real part of refractive index m has been fixed at 1.5. Excluding the case of x=30, the imaginary part is varied from 0 to 1.3. For the largest particles the convergence of calculations cannot be reached at Im(m)=0. For all particle sizes, a large imaginary part of the refractive index did not cause problems with the convergence.

Results: We have found that at all particle sizes the degree of positive polarization changes with Im(m) non-monotonically. For low absorptions, the degree increases together with the absorption until some maximal value. Further increasing Im(m) results in a decrease of the degree. The inflection occurs at Im(m) varying from 1 (x=5) to 0.5 (x=30); at that the linear polarization degree is as high as 70–80%. When Im(m)>0.5, the angular profile of linear polarization becomes bimodal and further increasing Im(m) makes this effect more explicit. This feature is the most pronounced in the case of the smallest particles as increasing particle size tends to wash it away. Note, a similar bimodal profile of polarization curve was found in laboratory measurements of hematite particles [3].

References:

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