Photopolarimetric Phenomena at Scattering of Light by Aggregated Dust Particles

LUDMILLA KOLOKOLOVA[1], ELENA PETROVA[2], and HIROSHI KIMURA[3]

[1]*University of Maryland, College Park, USA*
[2]*Space Research Institute, Moscow, Russia*
[3]*Center for Planetary Science, Kobe, Japan*

Cosmic dust typically can be presented as aggregates of submicron particles. Scattering of light by such particles is complicated. However, development of numerical codes such as Discrete Dipole Approximation (DDA) [1] and the superposition T-matrix code [2] together with improving power of modern computers allows a detailed study of their light scattering properties. This allowed surveys of light-scattering properties of aggregates (e.g. [3, 4]; see also **https://www.cps-jp.org/~lisa/**) that showed how brightness and linear polarization change as characteristics of the aggregates (size of monomer, refractive index, packing density) change. However, the physics behind these changes usually is not discussed and this limits a justification of the results obtained in these surveys as well as applications of these results to the remote sensing of cosmic dust.

In this paper we consider physical phenomena that occur at the light scattering by aggregates and study how these phenomena affect their photometric and polarimetric characteristics. The simplest among these phenomena is diffuse multiple scattering between constituents. It results in suppressing the resonance structure typical for the phase function of single small particles, and in depolarization of the scattered light. However, the cooperative effects at electromagnetic scattering are more complex. An especially interesting phenomenon, so called coherent backscattering, happens in the backscattering domain, where the constructive interference of the light with conjugate optical paths becomes possible. This interference produces a narrow spike of brightness and a narrow negative polarization branch (polarization plane coincident with the scattering plane) at small phase angles. This effect is especially noticeable for fluffy aggregates when distances between the constituent particles are larger than or comparable with the size of particles. In the case of more compact aggregates the electromagnetic interaction becomes even more complex as it gets affected by near-field interactions and mutual shielding of particles [5]. These distort effects of coherent backscattering, particularly enhancing the negative component in polarization in a wide phase angle range and weakening the opposition surge in brightness. We show how the listed phenomena affect angular and spectral dependence of intensity and linear polarization. The influence of the size parameter of constituents, the refractive index, and the packing factor are considered and applications to the remote sensing of cosmic dust are discussed.

References

[1]. B. T. Draine, and P. Flatau, *J. Opt. Soc. Amer. A*, **11**, 1491 (1994).
[2]. D. W. Mackowski, and M. I. Mishchenko, *J. Opt. Soc .Amer. A*, **13,** 2266 (1996).
[3]. H. Kimura, L. Kolokolova, and I. Mann, *Astron. Astroph.*, **449**, 1243 (2006).
[4]. Y. Shen, B. T. Draine, and E. T. Johnson, *Astrophys. J.*, **696**, 2126 (2009).
[5]. E. V. Petrova, V. P. Tishkovets, and K. Jockers, *Sol. System Res.*, **43**, 100 (2009).