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Remote Sensing of Aggregated Aerosols Using Photopolarimetry

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Atmospheres of Titan, Jupiter, Earth and some other cosmic bodies contain aerosols structured as aggregates, i.e. clusters of small particles. Scattering of light by aggregates differs significantly from the scattering by solid regular (e.g. spheres, spheroids) and irregular particles due to the electromagnetic interaction between constituent particles in the aggregates. Polarization is especially sensitive to the electromagnetic interaction that makes polarimetry one of the main techniques capable to study compositional and structural properties of the aggregated aerosols. This paper reviews recent achievements in laboratory and theoretical modeling of light scattering by aggregates and considers how polarimetric observations allow one to identify aggregated aerosols through studying angular and wavelength dependence of linear polarization. It is shown how polarimetry helps to find out the structure and porosity of aggregates, and the size and composition of their constituent particles. This can be done successfully only when angular and spectral polarimetric data are considered together, and when they are combined with the photometric data (e. g. albedo, color). Combining photopolarimetric observations in the visual with the thermal infrared data is also a promising way to more accurately determine the characteristics of the aggregates, especially their porosity. Successful measurements of circular polarization in a variety of space environments raised a question about the remote sensing capability of this polarimetric characteristic. We briefly consider mechanisms that can produce circular polarization, including multiple scattering in asymmetric media and alignment of particles, with a special emphasis on the circular polarization resulted from optical activity of the particle material. Circular polarization produced by the optically active particles is especially strong when the particles are aggregates as it gets enhanced by the electromagnetic interaction between the constituent particles. The most well known optically active material is organics of biological origin. Thus, circular polarization of the light scattered by aggregates that contain biological or prebiological materials can be used at a search for signatures of life in the Solar system and in the atmospheres of extrasolar planets.