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Polarimetry of Solar System Objects: Observations vs. Models

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Abstract

The overarching goals for the remote sensing and robotic exploration of planetary systems are: (1) understanding the formation of planetary systems and their diversity; and (2) search for habitability. Since all objects have unique polarimetric signatures inclusion of spectrophotopolarimetry as a complementary approach to standard techniques of imaging and spectroscopy, provides insight into the scattering properties of the planetary media.

Specifically, linear and circular polarimetric signatures of the object arise from different physical processes and their study proves essential to the characterization of the object. Linear polarization of reflected light by various solar system objects provides insight into the scattering characteristics of atmospheric aerosols and hazes? and surficial properties of atmosphereless bodies. Many optically active materials are anisotropic and so their scattering properties differ with the object's principal axes (such as dichroic or birefringent materials) and are crystalline in structure instead of amorphous, (*eg*., the presence of olivines and silicates in cometary dust and circumstellar disks? Titan, etc.). Ices (water and other species) are abundant in the system indicated in their near - infrared spectra. Gas giants form outside the frost line (where ices condense), and their satellites and ring systems exhibit signature of water ice? clathrates, nonices (Si, C, Fe) in their NIR spectra and spectral dependence of linear polarization. Additionally, spectral dependence of polarization is important to separate the macroscopic (bulk) properties of the scattering medium from the microscopic (particulate) properties of the scattering medium. Circular polarization, on the other hand, is indicative of magnetic fields and biologically active molecules, necessary for habitability. These applications suffer from lack of detailed observations, instrumentation, dedicated missions and numericalretrieval methods. With recent discoveries and results of main belt comets, asteroids with ring system, lunar studies, planned exploration of planetary satellites that may harbour sub-surface oceans, there is increasing need to include polarimetric (linear, circular and differential) as an integral observing mode of instruments and facilities. For laboratory measurements, there is a need to identify simulants that mimic the polarimetric behaviour of solar system small bodies and measure their polarimetric behavior as function of various physical process they are subject to and have undergone radiation changes of their surfaces.

Therefore, inclusion of polarimetric remote sensing and development of spectropolarimeters for ground-based facilities and instruments on space missions is needed, with similar maturation of vector radiative transfer models and related laboratory measurements.
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