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Polarimetry of Jupiter’s atmosphere and the surfaces of the Galilean satellites: its significance and the advantages of a space experiment

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Polarimetry was proved to be a powerful remote-sensing tool to investigate planetary atmospheres and surfaces by deriving physical properties of scatterers (shapes, sizes, refractive indexes), opacity of clouds, and packing density of regolith. To determine the listed parameters accurately and unambiguously, it is necessary to measure at least three Stokes parameters in wide phase and spectral ranges [1]. Though the ground-based observations of Jupiter and its satellites are restricted to small phase angles, very important results have been obtained with polarimetry.

Polarimetric observations of Jupiter have shown dependence of the degree of linear polarization P on phase angle (α) and wavelength. In opposition, P increases from zero at equator to 7–8% in the polar regions [2]. The observations (1981–2007) revealed seasonal variations of the north-south asymmetry of polarization and anti-correlation between P and insolation in the polar regions (polarization is higher in colder hemisphere) [2]. The factor sensitive to the temperature changes can be the stratospheric aerosol haze, the presence of which (with higher concentration in the polar regions) is suggested by the modeling and observations [3].

The polarization opposition effect for Galilean satellites at $\alpha < 2^\circ$ was discovered [4]. This phenomenon relates to the coherent backscatter enhancement that is an ubiquitous effect in nature.

Numerous examples of outstanding results obtained from polarimetry of different Solar system bodies suggest the idea on advantages of measurements of polarization as well as intensity.

For Venus, which can be observed from the Earth in a wider phase range, size and refractive index of cloud droplets were determined from polarimetric observations resulting in important conclusion about sulphuric acid composition [5]. The properties and variability of haze and cloud particles were analyzed from *Pioneer-Venus* polarimetry [6].

Variations of sizes of dust aerosols in the Martian atmosphere during dust storms and the presence of ice clouds were found from ground-based polarimetry of Mars and from the polarimetric experiment onboard *Mars-5* [7]. Even a single polarimetric observation of Mars by HST in 2003 in UV bands allowed detection of the new type of clouds in the Martian stratosphere [8].

In application to the lunar and other regolith-like surfaces, deviations from the Umov effect allow one to study the structure of the lunar religolith. The parameter $P^k_{max} \cdot A$ (where P_{max}, A, and k are the maximal polarization degree, albedo, and the parameter describing the linear regression of the correlation $P_{max} - A$) bears significant information on the particle characteristic size and packing density of the regolith. There are anomaly areas on the lunar surface visible only with polarimetric imagery [9,10].

The so far accumulated experience can be applied to and extended in the future investigations of Jupiter’s system by EJSM spacecraft. Space-borne polarimetric measurements would be able to cover complete phase range that would strongly improve capabilities of the technique. Recently developed methods allow the light scattering by particles of complex shapes and structures to be calculated and the vector radiative transfer equation for optically thick media to be solved; there are also approximations for dealing with closely packed particulate media. These new methods and increased power of computers would enable effective interpretation of polarimetric observations.

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