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Polarimetric characterisation of Saturn's moon Iapetus

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Abstract

One way to constrain the surface properties of atmosphereless solar system objects is to investigate the properties of the polarized light scattered from their surfaces. Using FORS2 instrument of the ESO VLT, we have carried out a series of polarization measurements of Saturn's moon Iapetus, with an accuracy of $\sim 0.1\%$, over the maximum phase angle range accessible from the ground ($\sim 6.0^\circ$), and over a broad spectral range (400 - 900 nm); thereby identifying the polarimetric characteristics of the bright surface material on its trailing side and, that of the dark material on its leading side. While our linear polarizatiom measurements of Iapetus' two hemispheres show an opposite trend of phase angle dependence, the polarization values measured for the two hemispheres around similar phase angles (between $\sim 3 - 6.0^\circ$) differ by a factor of three. Aimed at providing a quantitative assessment of the polarization observed for Iapetus, we have also carried out simulation of the scattering and absorption properties of light by a medium consisting of spherical volume of randomly positioned monodisperse particles. To this end, we used the numerically exact solutions of the Maxwell equations employing the multiple sphere T-matrix method [1]. The modeling entails physical characteristics of the particulate surface such as, porosity of the particulate medium; the number of constituent particles; the size, and optical properties of the scatterers. Our modeling indicates that, a particle size of $\sim 0.10 \leq r \leq 0.20 \mu m$ is dominating both the dark and bright material of Iapetus.
Moreover, utilizing the scattering matrix parametrization for single-particle scattering with double Henyey-Greenstein (2HG) scattering phase function, to characterize the resulting multiple scattering, we have carried out coherent backscattering simulations for a spherical random media of scatterers [2], with the goal to obtain polarimetric phase function of Iapetus. The geometric albedo values of Iapetus' hemispheres, retrieved from this model, differ by a factor of five, i.e., 0.42 for the bright hemisphere, and 0.08 for the dark hemisphere.
The circular polarization measurements of Iapetus' two hemispheres, performed at one phase angle for each, show no indication for the detection chiral signatures on Iapetus [3]. Furthermore, the reflectance spectra of Iapetus' two hemispheres, extracted from its respective spectro-polarimetric observations is feature less, with the leading side being redder than the trailing one; besides, no noticeable phase reddening effect has been found within the phase angle range of observations covered (from $\sim 0.50^\circ$ to 6.0°).

References

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