

OPPOSITION EFFECT OF THE SATURNIAN ICY SATELLITES: PHOTOPOLARIMETRY AT LOW PHASE ANGLES. I. Kulyk, Main Astronomical Observatory of National Academy of Sciences, Zabolotnogo str. 27, 03680 Kyiv, Ukraine, irinakulyk@yahoo.com

Introduction: Most surfaces of atmosphereless bodies exhibit two interesting optical phenomena at small phase angles, namely a strong brightness increase and negative values of the degree of linear polarization. Both of these effects have been observed for numerous airless bodies as well as for laboratory samples that simulate planetary regoliths [5, 6, 7]. Of particular interest is the appearance of a second narrow minimum of polarization at phase angles less than $1-3^\circ$ accompanying a nonlinear increase of the surface brightness. This brightness and polarization behavior at the narrow phase angle range near the opposition is called, respectively, the photometric and polarimetric opposition effects. Both phenomena recently found increased attention from the point of view of light scattering in random media and the possibility to derive properties of the regolith layers on these bodies [2, 4, 6, 8]. Negative polarization branches with two minimum have been recorded for Saturn's B-ring, Europa and some high-albedo asteroids [1, 4, 5]. However, up to now polarimetric observations conducted at small phase angles have been rare. Photopolarimetric observations of Saturn's satellites Enceladus, Tethys, Dione, and Rhea were carried out with the 2-m RCC telescope at the National Astronomical Observatory – Rozhen in order to enlarge the amount of the observational material of brightness and polarization of atmosphereless solar system bodies, to compare the polarimetric phase curve behavior of these Saturnian moons at low phase angles, to record the photometric and polarimetric opposition effects synchronously.

Results: The observations were fulfilled in the red and near infrared bands ($\lambda=694\text{nm}$ and $\lambda=889\text{nm}$) in two different phase angle regions (from 0.07° to 0.01° and from 5.6° to 5.2°).

The photometric phase curves of Enceladus, Tethys, Dione, and Rhea demonstrate a sharp increase of the satellites' brightness in the narrow backscattering domain of the phase angles (between 0.7° and 0.01°). The slopes of the low phase angle portions of the photometric phase curves are about 0.2 mag/deg , that is at the level of or even exceed the slope of Europa's phase curve at opposition. The amplitudes of the moons' opposition effects, measured by the total increase in the brightness as the phase angle decreased from 5° to 0° , are largely consistent with contribution of the coherent backscattering [4]. At the same time, the slight dependence of the relative strength of the moons' brightening on their albedos, which becomes noticeable at the near infrared, points out that a shadow hiding can also contribute to the opposition effects of these icy satellites. The comparison of moons' opposition surges with ones

exhibited by the european terrain materials is presented on Fig.1 [2].

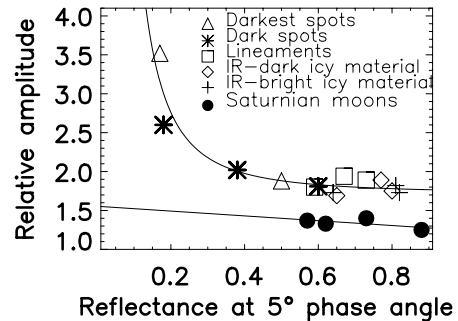


Fig.1. Relative amplitudes of the opposition surges of Saturn's icy satellites and the european terrain materials as a function of their average albedos at 5° phase angle.

The polarization measurements reveal a deep small-phase-angle minimum of the degree of linear polarization at 0.7° and then its steep increase towards zero phase angle for all four satellites. Both the photometric and the polarimetric phase curve of Dione are shallower as compared with other satellites in the phase angle range $0.07^\circ - 0.02^\circ$. The satellites' rotation curves confirm that the leading/trailing albedo asymmetry known from previous visual observations extends into red and near infrared and amount to 4%, 8%, 38%, and 18% for Enceladus, Tethys, Dione, and Rhea respectively.

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