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Phase angle effects in brightness and polarization for different classes of small Solar system bodies

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Abstract

We review the available observational data on magnitude and polarization phase angle dependences of small Solar system bodies from different dynamical groups, including Near-Earth objects, main belt asteroids, Trojans, Centaurs, and transneptunian objects (TNOs). Diversities and similarities in phase angle behaviours of atmosphereless small bodies orbiting at different distances from the Sun are discussed. We focus on observed correlation of phase curve parameters with albedo and interrelations between photometric and polarimetric phase curve characteristics.
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1. Introduction

Study of phase angle effects in brightness and polarization of atmosphereless Solar system bodies give a first look into top-most surface properties. A sharp increase in brightness and the negative branch in the degree of linear polarization are common phenomena observed at small phase angles for different types of Solar system bodies. Both phenomena are considered to have similar physical nature and their joint analysis is of a great value to better understand light-scattering mechanisms and to improve basis for data interpretation in terms of physical characteristics of the surface regoliths.

2. Results

For main-belt asteroids a strong correlation was found between the linear slope of magnitude-phase dependences defined in the range of 5–25° and the geometric albedo [1]. A twofold increase in the amount of high-quality observational data has confirmed strong albedo dependence of the phase slope (Fig.1). An existence of such correlation suggests that albedo is the main factor influencing the slope of main-belt asteroid phase curves (at least up to 25°).

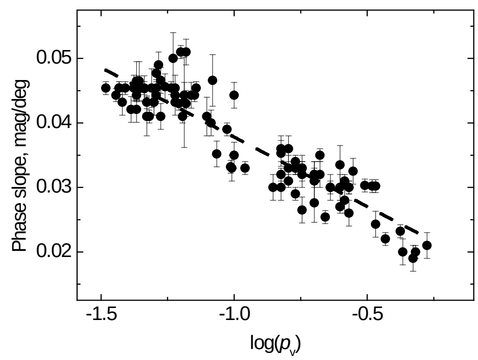

Figure 1: Correlation between slope of asteroid phase curves and albedo.

The value of opposition effect amplitude (defined as an excess in magnitude relatively to linear approximation of phase curve at zero phase angle) depends on albedo in more complicated way (Fig.2).

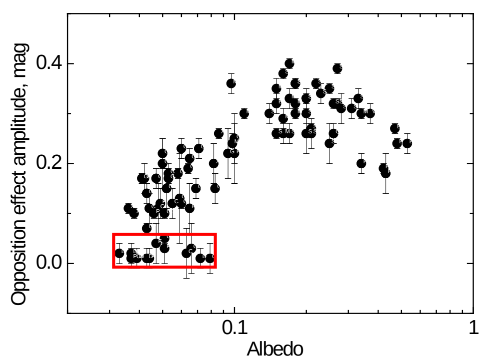

Figure 2: Dependence of the opposition effect amplitude of asteroids on albedo. Several asteroids (in the red rectangle) have not revealed non-linear opposition surge.

Some of low-albedo asteroids show linear phase-angle magnitude dependences down to very small phase angles. The only plausible explanation of such effect is an assumption of extremely low surface albedo of asteroids not showing opposition effect [2]. These asteroids belong mainly to the primitive P and D types. Moreover, magnitude-phase dependences of the P-type asteroids belonging to the main belt, Hilda and Cybele groups, and Trojans are found to be indistinguishable within the errors of measurements [3, 4]. Phase curves of Centaurs measured at small phase angles differ from those for asteroids and show greater diversity. For TNOs a very narrow opposition effect is inherent [5].

The parameters characterizing brightness opposition effect and negative polarization branch have a tendency to correlate. The negative polarization branch of low albedo asteroids becomes less deep when the opposition effect amplitude decreases. Correlations of polarimetric parameters with albedo are successfully used for asteroid albedo determinations (see e.g. [6]). That is not the case for TNOs and Centaurs for which correlation between polarization and albedo is rather weak [7]. The distinct feature of their polarization behavior is a pronounced negative polarization at small phase angles (except for largest dwarf planets). Their polarization minimum is shifted toward small phase angles as compare to main-belt asteroids and Jupiter Trojans [8].

3. Conclusions

The magnitude and polarization phase angle dependences measured for different classes of small Solar system bodies revealed many interesting features and interrelationships. Their interpretation in terms of physical parameters of surface properties is still in progress. The measured observational features need to be taking into account to improve theoretical models of lightscattering by planetary surfaces.

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