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Opposition effect of dark asteroids: diversity and albedo dependence

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Abstract

Based on the analysis of magnitude phase dependences of 33 low albedo asteroids we found that the opposition effect tends to increase with albedo increasing. The trend is opposite to that expected for the shadow hiding mechanism. We assume that the coherent backscattering mechanism can play a noticeable role in the forming of opposition effect of dark asteroids. The asteroids which do not show non-linear opposition brightening in their magnitude phase dependences should be the darkest objects among asteroids.

1. Introduction

As it was shown low albedo asteroids display a greater diversity in the magnitude phase angle behaviors as compared to moderate and high albedo asteroids [1]. Last years we carried out special observational program devoted to enlarge the number of dark asteroids for which magnitude phase curves were measured [2,5,6]. As a result, the data sample has been considerably increased. Three more dark asteroids, namely 190 Ismene, 588 Achilles, and 1021 Flammario, were found to display an absence of opposition peak at small phase angles. Here we discuss possible reasons of a diversity of opposition effect behaviors among low albedo asteroids.

2. Results

Phase curves of 33 low albedo asteroids were analysed using the same approach described in [1]. The amplitude of the opposition effect was defined as an increase in magnitude at a phase angle of 0.3 deg relative to the extrapolation of the linear part of the phase curve. About 20% of all studied low albedo asteroids revealed practically linear phase angle dependences down to subdegree phase angle with an amplitude ≤0.06 mag. On the other hand, about 40% of asteroids displayed wide opposition effect starting at the phase angle 6-7 deg with amplitude of 0.15-0.25 mag. The rest of the low albedo asteroids showed a narrower opposition effect starting at the phase angle of about 4 deg and reaching 0.1-0.13 mag. The typical magnitude phase curves measured for low albedo asteroids are shown in Figure 1. One can see that asteroid 190 Ismene does not reveal non-linear opposition brightening while for 50 Virginia and 303 Josephine the OE amplitudes reaches 0.12 and 0.2 mag, respectively.

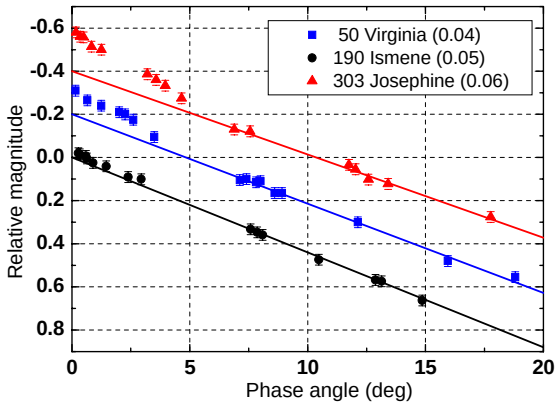

Figure 1: The magnitude phase dependences of 50 Virginia [3], 190 Ismene [5], and 303 Josephine [5]. Albedos of the asteroids [7] are given in parentheses.

There is no apparent albedo dependence of the OE amplitude for these three asteroids. However, we need to take into account possible uncertainties in asteroid albedo determinations by indirect methods. A trend between the OE amplitude and surface albedo is well-seen when considering the whole data-set of 33 low-albedo asteroids (Fig. 2). The OE amplitude tends to increase when albedo increases. The trend is opposite to that expected for the shadow hiding mechanism alone. This constitutes unequivocal evidence that a non-linear increase in brightness at small phase angles is caused by other

physical mechanisms. We assume that an increase of a portion of light substance in the surface layer of dark asteroids causes increasing contribution of the coherent backscattering mechanism in the forming of OE. The asteroids which do not show non-linear opposition brightening in their magnitude phase dependences should be the darkest objects among asteroids. Their magnitude phase behaviors are formed by the shadow hiding mechanism alone.

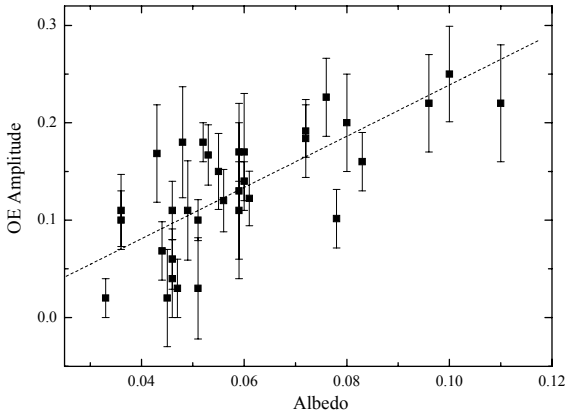

Figure 2: Dependence of the OE amplitude of asteroids on albedo. For references on opposition effect data see [1-3,5, 6]. Albedo was plotted according [4,7].

3. Conclusions

The observed differences in the OE amplitudes of low albedo asteroids are connected first of all with differences in their albedo even though they are small. It seems that other factors play secondary role. The darkest asteroids do not show non-linear opposition brightening in their magnitude phase dependences. An increase of albedo results in increasing contribution of the coherent backscattering mechanism in the forming of opposition effect.

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