On the non-monotonic variation of the opposition surge morphology with albedo exhibited by satellites’ surface

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Abstract

We used well know phase functions of satellites and rings around the giant planets of our Solar System to study the morphology of the opposition effect (at phase angles alpha < 20 degrees, see Déau et al. 2009, Planetary and Space Science, vol. 57, p.1282–1301). To avoid the effect of the variable finite size of the Sun, we use a deconvolution morphological model to retrieve the morphological parameters of the surge (A and HWHM). These parameters are found to have a non-monotonic variation with the single scattering albedo, similar to that observed in asteroids (Belskaya and Shevchenko, 2000, Icarus, vol. 147, p.94–105), which is unexplained so far. The non-monotonic variation is discussed in the framework of the coherent backscattering and shadow hiding mechanisms.

1. Introduction

When the source of light is directly behind the observer, such that the phase angle approaches 0° a phenomenon called the opposition effect is observed. Coherent backscattering and shadow hiding mechanisms may cause this effect. The opposition effect is characterized by two morphological features on optical phase curves: (i) a surge i.e. a non-linear increase in the scattered brightness of the surface when phase angles approaches 0° (this is described by the amplitude and the angular width of the surge) and (ii) a linear decrease in the scattered brightness of the surface for phase angle values in the range 10° to 50° (this is described by the phase coefficient or the slope of the linear part S). While the slope of the linear part of asteroids shows a monotonic variation with albedo [1], the amplitude A and the angular width HWHM of the asteroids’ surge are known to exhibit a non-motonic variation with albedo. We then investigate the behavior of the surge morphology (A and HWHM) with albedo of other planetary surfaces (satellites and rings of giant planets).

2. From the opposition phase curves to A and HWHM

We used previously published phase functions of satellites and rings around the giant planets of our Solar System to study the morphology of the opposition effect, see Fig. 1 and [1]

Figure 1: Opposition phase curves of the surface of satellites and rings from [2].

To avoid the effect of the variable finite size of the Sun, we use a deconvolusion morphological model to retrieve the morphological parameters of the surge (A and HWHM), see [2].

3. Comparison to asteroids

Regarding the amplitude of the surge, a separate examination of low- and high-albedo objects can lead to conflicting fits: (i) for low and moderate albedo...
objects, [4] and [5] found a monotonic increase of the amplitude with increasing albedo; (ii) for high albedo objects, the results of [4] suggest a monotonic decrease of the amplitude with increasing albedo.

According to [5], the increase of the amplitude of the surge with the albedo for the dark asteroids is opposite to trend expected for shadow hiding mechanism. For them, it is the evidence that another mechanism is responsible for the increase of A with the albedo for dark asteroids. In particular, they 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.

[6] proposed that the shadow hiding accompanying single scattering could influence the coherent backscattering mechanism by blocking its reciprocal components.

For all of these explanations, we distinguish two trends: either the coherent backscattering and the shadow hiding have independent domains of preponderance with respect to the phase angle; either the coherent backscattering and the shadow hiding are coupled, whatever the phase angle range. New multi-wavelength observations (because the shadow hiding is wavelength independant) are necessary to determine the actual origin of the non-monotonic variations of A and HWHM.

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References