Impact of Coherent Backscattering on the Near-infrared Spectra of Icy Bodies and Rings

LUDMILLA KOLOKOLOVA[1], BONNIE BURATTI[2], and VICTOR TISHKOVETS[3]
[1] *Department of Astronomy, University of Maryland, USA*
[2] *Jet Propulsion Laboratory, USA*
[3] *Institute of Radioastronomy, Kharkiv, Ukraine*

Near-infrared spectra of satellites of the outer planets, KBOs, and rings are the main source of information about the ice in these bodies due to the deep ice absorption bands centered at 1.5, 2.0 and 2.9 micron. The depth and shape of these bands allow not only comparing the ice content in different icy bodies but also estimate the size of the icy regolith or ring particles [1, 2]. However, such distant objects as the outer planets and KBOs can be observed only at small phase angles, often smaller than 3°. At these phase angles the coherent backscattering effect (CBE) dominates the light scattering characteristics of icy bodies [3].

The CBE results from the interference of the light that experienced multiple scattering in the medium and had the same but opposite optical path, i.e. was scattered on the same particles but in the opposite order. The CBE usually manifests itself by a steep opposition spike at small phase angles. Since the CBE spike is formed by multiply scattered light, it is more pronounced if more opportunities for multiple scattering occur, e.g. in the case of less absorbing particles. Strong dependence of the CBE on absorption was confirmed by numerous theoretical and laboratory simulations. However, it was not noticed until recently that this should have serious consequences for the spectra. Since the steepness of the CBE spike depends on the absorption, it should be different for the wavelengths within and outside of the absorption bands. As a result of this different steepness, the depth of the absorption bands should be different at different phase angles. Neglecting this effect may result in misinterpretation of the spectra and misleading conclusions about compositional and particle size differences of icy bodies studied at different phase angles.

We checked presence of this effect in the Cassini VIMS data for icy Saturn’s satellites Rhea and Iapetus and found the predicted strong phase angle dependence of the depth of the absorption bands (Fig. 1). We modeled the spectra of Rhea using the approach to CBE described in [4]. Some results are shown in Fig. 2; see [5] for more results. One can see that the CBE correctly reproduces the observed phase angle variations of the spectra and also that these variations depend on the size of particles and their packing. Thus, the variations in the absorption bands produced by the CBE not only allow us to improve interpretation of the spectra but also provide a promising approach to study size and packing of the regolith and dust particles.

Keywords: Spectra; absorption bands; coherent backscattering; Cassini; icy satellites; KBO; rings.

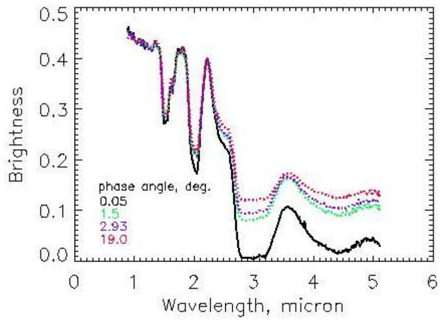

Figure 1. Spectra for Rhea (left) taken at several phase angles (the smallest phase angle data are shown by solid line and the largest phase angle data are shown by dotted line). The spectra were shifted to match the continuum at the short wavelengths

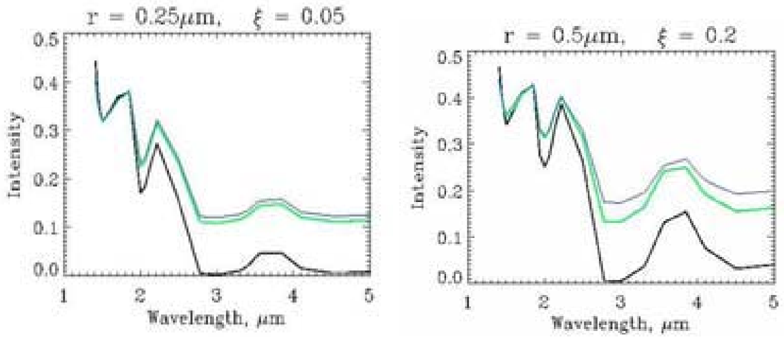

Figure 2. Some results of the computer modeling of the spectra of Rhea using the approach by [4]. The radius of particles, r, andtheir packing, ξ, are indicated on the top of each figure. The results are shown for the phase angle 0.05° (black curve, the deepest absorption band), 1.5º (green line, next deepest band) and 19º (blue line, the most shallow absorption band).

References

[1] R. Clark et al. *Icarus,* **193,** 372 (2008).
[2] P. Nicholson et al**.** *Icarus,* **193**, 182 (2008).
[3] B. Schaefer et al. *Astron. J.,* **137**, 129 (2009).
[4] V. Tishkovets and M. Mishchenko *J. Quant. Spectrosc. Radiat. Transfer,* **110,** 139 (2009).
[5] L. Kolokolova et al. *Astroph, J, Let.,* **711**, L71 (2010) .