Cassini VIMS Observes the Opposition Effect in Saturn’s Rings

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On May, 20, 2005 the Cassini spacecraft flew between the sun and Saturn on a trajectory such that the zero phase point passed through the rings. The Visual and Infrared Mapping Spectrometer (VIMS) recorded a number of spectral image cubes ($0.4< \lambda <5.2\mu$m) that showed the opposition effect (OE) at zero phase. The OE is a spike in the reflected intensity observed near 0^o phase when it is displayed as a function of phase angle. This is the first time the OE has been resolved for small areas on the rings.

Previous work has shown that the OE arises from two distinct processes, shadow hiding (SHOE) and coherent backscattering (CBOE). The SHOE process causes an OE by the elimination of shadows cast by regolith grains upon one another as phase angle decreases. The CBOE process causes an OE by constructive interference between photons traveling in opposite directions along the same path within the medium. SHOE is expected to dominate the contribution to the OE in absorbing media where multiple scattering of photons is not significant. CBOE is expected to dominate the contribution to the OE in highly reflective media with much multiple scattering.

Using the individual image cubes, a total of 32 areas containing 4 pixels each were selected that lay along the same ringlet as the opposition point and bracketed it in phase angle. Because water ice is a major component of the rings, the spectra are predominantly that of water. Within each spectrum 9 narrow spectral bands were chosen to reflect a variety of wavelengths and reflectance levels. In this way phase curves of the ringlet were obtained for each band.

Historically, the OE of Saturn's rings has been interpreted as a SHOE. We argue here that it is a CBOE because: 1) The theoretical CBOE function fit to the data is excellent. 2) The OE width is extremely narrow 3) The angular width of the peak increases with wavelength.

CBOE theory also predicts that the width depends on the transport mean free path (TMFP) in the medium. We find that the OE is caused by coherent interactions between sub-particles in the outer layers of the ring particles, and that these sub-particles are of the order of 10 μm in size.

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