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Opposition Surges on Icy Moons: Observations by Cassini VIMS and ISS between 0.2 and five microns

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The opposition effect is the surge in brightness that most airless bodies exhibit as they become fully illuminated to an observer. Important information about the physical nature of the surface, including the constituent particle sizes and their size distribution, the compaction state of the upper regolith, and composition are embedded in the effect. Models that describe the surge in terms of physical parameters have been developed during recent decades. The acquisition of “true opposition” is rare and fleeting (and for objects in inclined orbits, nearly unattainable), so testing and application of the models has been hampered. During the 9 years of the Cassini-Huygens mission, a wealth of data at and near opposition has been collected for the 6 main icy satellites of Saturn: Mimas, Enceladus, Tethys, Dione, Rhea, and Iapetus, including some recently obtained key data for Enceladus and Mimas. Furthermore, the combined spectral range of the Imaging Science Subsystem (ISS) and Visible Infrared Mapping Spectrometer (VIMS) cameras spans 0.20-5.1 microns, which includes many spectral regions not observable from the ground. This extraordinary coverage in solar phase angle and in spectral range provides in essence a laboratory in which to test models of the opposition effect. Although these moons are bright in the visible region, where multiple scattering complicates the modeling, they are dark in many regions of the infrared, enabling a more robust analysis. Some satellites have data for both leading and trailing sides, allowing an investigation of alteration effects such as meteoritic and magnetospheric bombardment and accretion of E-ring particles. Small particles accreted onto their surfaces from the E-ring appear to become “invisible” at the longer wavelengths. All of the moons exhibit a very steep curve at solar phase angles less than one degree, suggesting that coherent backscatter is present. However, this “supersurge” is present even at wavelengths where there is little multiple scattering: since coherent backscatter is a phenomenon that depends on multiple scattering, it does not fully explain the small-angle surge. One of our most significant findings is that the wavelength dependence of the width and amplitude of the opposition surge does not follow a trend that clearly applies to every moon.

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