EPSC Abstracts
Vol. 6, EPSC-DPS2011-723, 2011
EPSC-DPS Joint Meeting 2011

Interaction of Saturn's Moons and its Rings: Insights from *Cassini* VIMS data

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Abstract

Recent results from the *Cassini* Visual Infrared Mapping Spectrometer (VIMS) are used to show the interactions between the moons and rings of Saturn. The innermost rings are tied to the main ring system while the medium sized satellites are tied primarily to Saturn's E-ring. VIMS data shows no current plume activity on Dione or Tethys.

Summary

One of the main goals of the Cassini Mission is to understand the interactions between Saturn's system of rings and its moons. The saturnian system is unique in that there is substantial interaction between the rings and both small and the medium-sized satellites. At least three kinds of processes occur: feeding, accretion, and confinement of ring particles by the small inner satellites; deposition of E-ring particles – which themselves originate from Enceladus – onto Mimas, Tethys, Dione, and Rhea; and the accretion of particles from the Phoebe ring from the leading side of Iapetus and perhaps Hyperion and even Titan. In addition, the main confinement mechanism of the rings and ringlets is resonances between the satellites.

The optical properties of the "shepherd" satellites and the coorbitals are tied to the A-ring, while those of the Tethys Lagrangians are tied to the E-ring of Saturn. The color of the satellites becomes progressively bluer with distance from Saturn, presumably from the increased influence of the E-ring; Telesto is as blue as Enceladus [1].

The giant Phoebe ring [2] and its coating of the leading side of Iapetus – may be a paradigm for other outer planet satellites. There is evidence that Oberon is being coated with an unseen ring of dust created by the outer irregular retrograde moons of Uranus, while Callisto may be the "Iapetus of the Jovian system" [3].

The study of the optical properties of the moons of Saturn offers clues to their interactions with the ring system, but the coating of satellites makes it difficult to understand geologic processes in terms of the optical properties of the surface.

Mimas

Evidence for the interaction of the E-ring with the main satellite system of Saturn is shown by the gross albedo patterns on the moons: the leading sides of Tethys, Dione, and Rhea are brighter, while the trailing sides of Mimas and Enceladus are brighter, as predicted by a dynamical model of the E-ring [4]. Another indicator of accretion of the E-ring is the particle sizes on the surfaces of the satellites. Although there have been no targeted flybys of Mimas during the *Cassini* mission, during the closest nontargeted flyby by Cassini on February 13, 2010, when the Cassini spacecraft approached within 9500 km of Mimas, maps of the moon were obtained by VIMS. Water ice absorption bands in the central peak and crater rim of Herschel are deeper than those in the surrounding regions. These results indicate the water ice grain size decreases as the distance from the apex of motion increases (Figure 1). Because the E-ring is composed of very small particles (smaller than those that result from gardening by impact processes), these results strongly suggest preferential accretion by the E-ring on the trailing side of Mimas.

Figure 1. A map of Mimas showing the band depth at 2 μm. The leading side is on the left side of the map. These results are consistent with a mean particle size of 20-80 μm for the leading side and 10-50 μm for the trailing side.

VIMS Plume Searches

Another recent set of VIMS data that was analyzed is the observations at extremely large (>150º) solar phase angles. There are recent reports that Tethys and Dione may be outgassing in a manner similar to that of Enceladus, albeit in a less extreme form [5]. One efficient way to search for plumes on satellites is to seek a forward scattered signal from plume particles. The most sensitive wavelength seems to be 2 µm, near the center of a water-ice absorption band. Analysis of the large solar phase angle phase curve of Mimas, Tethys, and Dione, fails to reveal a forward scattered component in observations obtained at 2.0 µm (see Figure 2). The upper limit on water vapor production for Mimas and Tethys is one order of magnitude less than the production for Enceladus. For Dione, the upper limit is two orders of magnitude less, suggesting this world is as inert as Rhea**.** Of course, it is possible we never observed the moons in the correct orientation to discover the plumes: When viewing geometries conditions are unfavorable, no plumes appear even on Enceladus.

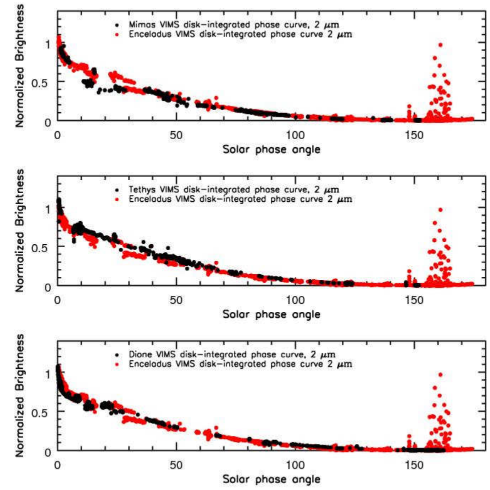

Figure 2. *The integral solar phase curves of Mimas,Tethys, and Dione, shown with the phase curve of Enceladus. The moons lack any trace of a phase curve with the huge peak in the forward sattered direction exhibited by Enceladus.*

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Acknowledgements

This research was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under contract to the National Aeronautics and Space Administration.