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VIS-IR spectral modeling of Rhea and Enceladus

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The Visual and Infrared Mapping Spectrometer (VIMS) onboard the Cassini spacecraft, is an imaging spectrometer that produces monochromatic images in 352 bands in the VIS-NIR region of the spectrum from 0.35 μm up to 5.12 μm. During the five years of Cassini mission in the Saturnian system the instrument produced a wide dataset regarding the planet itself, rings and moons.

In this work we have analyzed full disk spectra, acquired by 2008, of two icy moons: Rhea and Enceladus. The surface of these bodies is mainly composed of water ice, as indicated by the typical spectral features at 1.5 2.0 and 3.0 μm. However the spectra show peculiar reddening in the VIS towards the short wavelengths. This behavior is due to the presence of organic contaminants which absorb in that region. The reddening is minimized in the case of Enceladus, whose surface is composed almost of pure water ice, while is evident in the case of Rhea. In the IR range both satellites show negative slopes of the continuum, typical of water ice. The slope of the continuum in IR strongly depends on ice particles size, and weakly on the contaminants.

The aim of this work is to correlate these spectral features to physical properties of the surface in a quantitative way. We adopted Hapke spectral approach to model the reflectances of Rhea and Enceladus, and from a spectral fit we retrieved the percentage of contaminants and the grain size.

Various types of mixing have been examinated: intimate, intramolecular and surface mixtures. The only one able to reproduce the spectral behavior (reddening, continuum and water ice bands) of VIMS observations is the intramolecular mixing, which takes into account for the presence of contaminants inside the water ice particles. This kind of mixture is obtained as a weighted mean of optical constants of water ice and contaminant. Three types of amorphous carbon an two tholins are used as organic compounds endmembers.

The best fit is obtained with amorphous carbon in minimal percentage (typically 10^{-4} for Rhea and 10^{-6} for Enceladus) and a grain size respectively of 40 μm and 70 μm. In the models we used both crystalline and amorphous ice. This choice allows to have better fits at longer wavelengths (namely 3.5 μm).

The approach we developed in this work is applicable to the remaining icy moons of Saturn and represents a powerful tool to characterize the surface properties of the satellites, allowing an analysis of the distribution of organic compounds in the system, useful to study his evolution as well as the interactions that occur on the surface of these bodies.

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