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Saturn's Icy Moons: UV reflectance spectra and links to Enceladus' plume gases

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The inner moons of Saturn exhibit remarkable large-scale albedo and color variations. These albedo trends can be linked to a combination of processes including E-ring grain bombardment and charged particle bombardment [1, 2]. In this study we consider the process of neutral gas transport, which we propose is an important process, and we hypothesize that transport and deposition of plume neutral gases (and/or plume gases that have been ionized) may be particularly important at UV-visible wavelengths.

The discovery of the Enceladus plumes has revolutionized the way we think about Saturn's inner magnetosphere and its inner satellites. The focus of magnetospheric studies has been on the water group ions and neutrals coming off Enceladus. This makes sense since these are the dominant species and govern charge-exchange and other processes. For us, it is the trace species, such as ammonia, that are more interesting. Since there is no competition with the plumes as the source of ammonia, its detection on a surface tells us the relationship between the surface of a particular body and the plumes. The thrust of this work is to study the spectra of satellite surfaces to look for the presence of ammonia. Our experience with the analysis of UV data [3] has shown that even very minute amounts of ammonia will be apparent in our data. For instance, a visual comparison of the NH_3 spectrum in Fig. 1 and the Enceladus UV-visible spectrum in Fig. 2 strongly suggests the presence of NH3 on the surface of Enceladus.

We investigate the surface composition of Saturn's icy moons (Mimas, Enceladus, Tethys, Dione, Rhea) by creating composite spectra at UV-visible wavelengths (100-1000 nm) using data from the Cassini Ultraviolet Imaging Spectrograph (UVIS) and Imaging Subsystem (ISS). Our previous work on Enceladus [3] has shown that diagnostic absorptions are present in the UV-visible wavelength range that aren't detectable in the near-IR. In particular, the UV absorption edge of ammonia (at ~210 nm) is especially strong, as shown in Fig. 1, even when ammonia is present in very small amounts.

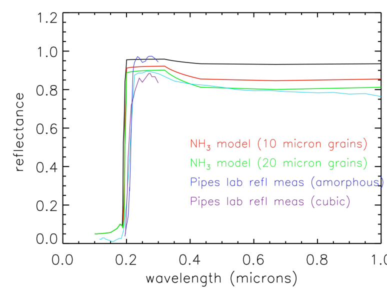

Figure 1: UV-Visible laboratory spectra and models of NH_3.

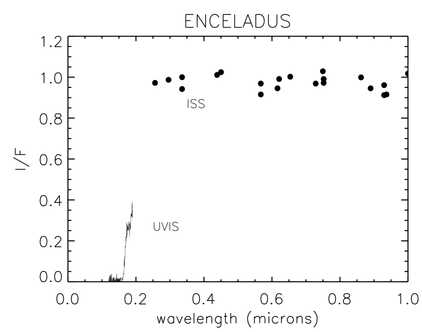

Figure 2: UV-Visible spectrum of Enceladus, combining Cassini UVIS and ISS data.

Ammonia and other compounds are present in Enceladus' plume gases [4], which are known to form a broad Saturn-encircling torus that encompasses all of Saturn's major satellites [e.g., 5]. We will model the transport of these plume gases [5] and investigate the UV-vis spectra of the moons to understand the deposition of the gases. Is ammonia from Enceladus' plume present on the surface of Rhea? Is more ammonia present on the leading hemisphere of Dione than the trailing hemisphere? Are the gas molecules ionized, or do they encounter the moons' surfaces as neutrals? These are the types of questions we probe through the study, which will tell us not only about the surface compositions of the moons, but about the fate of Enceladus' plume gases, and their effect on the system as a whole.

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References

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