MULTI-WAVELENGTH PHOTOMETRY OF THE ICY SATURNIAN SATELLITES: A FIRST LOOK.
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Introduction: The light reflected from planetary surfaces and measured by remote sensing instruments is affected not only by the composition of the surface but by the physical structure of the surface. The structure of the surface is characterized by both endogenic and exogenic processes. We investigate the effects of these processes on the surfaces of the icy Saturnian satellites using photometric studies at multiple wavelengths in the UV-IR region.

We model solar phase curves at many wavelengths using data from the Cassini Ultraviolet Imaging Spectrograph (UVIS) and Visual Infrared Mapping Spectrometer (VIMS). This is a powerful dataset because the combination of IR and UV wavelengths allows us to distinguish between large and very small grains, and to probe the particle interiors and surfaces. The investigation will provide critical insight into the evolution of the moon regoliths and an understanding of their current environments. *The full potential of using solar phase curves over a wide range of wavelengths to probe regolith structure has not yet been fully explored – this study addresses just that.*

Previous Voyager photometric studies generally included visible-wavelength filters; the VIMS coverage of 0.7 – 5 μm is a dramatic improvement and allows for important studies into structural characteristics of the regoliths that may be wavelength-dependent, such as the single-particle scattering function.

This is the first opportunity to explore far-ultraviolet (FUV) solar phase curves of any solar system body. The physical modeling of FUV phase curves, especially in combination with phase curves from NIR wavelengths, promises to result in a wealth of information about the physical structure and evolution of the regoliths of these bodies, because the short FUV wavelengths are sensitive to very small grains (essentially invisible at larger wavelengths) and probe generally the outer surfaces of larger grains, making FUV wavelengths very sensitive to exogenic processes that may weather the outer portions of the grains themselves.

Observations: The VIMS instrument is described by [1]. The VIMS disk-integrated phase curves are produced by summing the signal from each pixel and scaling all of the derived intensity measurements to account for spacecraft distance. The UVIS instrument is described by [2]. The far-UV channel of UVIS covers the 1115-1912 Å range. The detector format is 1024 spectral pixels by 64 spatial pixels. Each spectral pixel is 0.25 mrad and each spatial pixel is 1 mrad projected on the sky. Because the UVIS slit is a 1-D array, the UVIS disk-integrated phase curves are produced using two types of observations: 1) sub-pixel observations and 2) scans across the body. The first type is for distant observations when the moon is less than 1 mrad in diameter; in these cases, the integrated signal is used and corrected for spacecraft distance. Using scans, the brightness from all pixels throughout the scan is used as the disk-integrated signal.

We concentrate here on Enceladus and Dione, comparing two very different bodies. Enceladus is a remarkably bright object with known unusual photometric properties [3], while Dione provides an interesting comparison case, as a darker body in a different E-ring and charged particle environment. In later studies, we will expand our analysis to the other moons.

Results: Preliminary solar phase curves indicate that the surface scattering properties of the icy Saturnian satellites vary dramatically with wavelength, and depending on the moon, indicating intriguing differences in the physical properties of their surfaces. Preliminary phase curves are shown in Fig. 1. These will be refined as part of this study For instance, most of the points in the UV plots are averages in each observation; each of these can be expanded to produce a data point for each temporal record in the observation. Furthermore, several observations are not yet included in the UV phase curves. We have not yet corrected for orbital phase; this may explain some of the scatter in the data. These plots are shown to demonstrate the phase angle coverage and the overall differences in phase curve shapes that are measured – indicative of structural differences within the icy regoliths.

We utilize well-proven photometric models ([4] [5] [6] [7] [8] [9] [10]), promising new and functional results on the surfaces of the moons. Significant phase angle coverage is available for the moons in both instruments' data sets. Satisfactory modeling of solar phase curves requires full phase angle coverage: ideally, 0-180°. In general, larger phase angles are used to determine macroscopic roughness of the surface, while small phase angles are used to investigate the opposition surge. Intermediate phase angles are used to constrain the single-scatter albedo and phase function. It has been shown [11] show that if a disk-integrated dataset includes both small and large phase angles, then both the single-particle phase function and the macroscopic roughness term can be uniquely determined. If disk-integrated large phase angle observations are not available, then disk-resolved observations must be used to constrain the macroscopic surface roughness term.

Interpretation: Some of the most basic information about planetary bodies is derived from disk-integrated measurements over a wide range of solar phase angles. These include the geometric albedo and phase function, which includes information on surface roughness and the compaction state of the upper layers.

Investigation of the solar phase curves will lead to an understanding of the scattering properties of the surfaces and insight into their evolutionary history. In the Saturnian system, the combined effects of E-ring grain bombardment and charged particle bombardment are not yet well-understood. In comparison, the Jovian satellites are known to be significantly affected by charged particle bombardment, both structurally and chemically. As a result, the icy Jovian satellites are much darker than the icy Saturnian satellites, over UV-IR wavelengths. The icy Saturnian satellites are very bright compared to the Jovian satellites: is this due to a relative lack of charged particle bombardment? Or is it due to coating/bombardment by E-ring grains? Or does it tell us something about the inherent composition of the two systems? Basic but significant questions such as these will be probed in this study.

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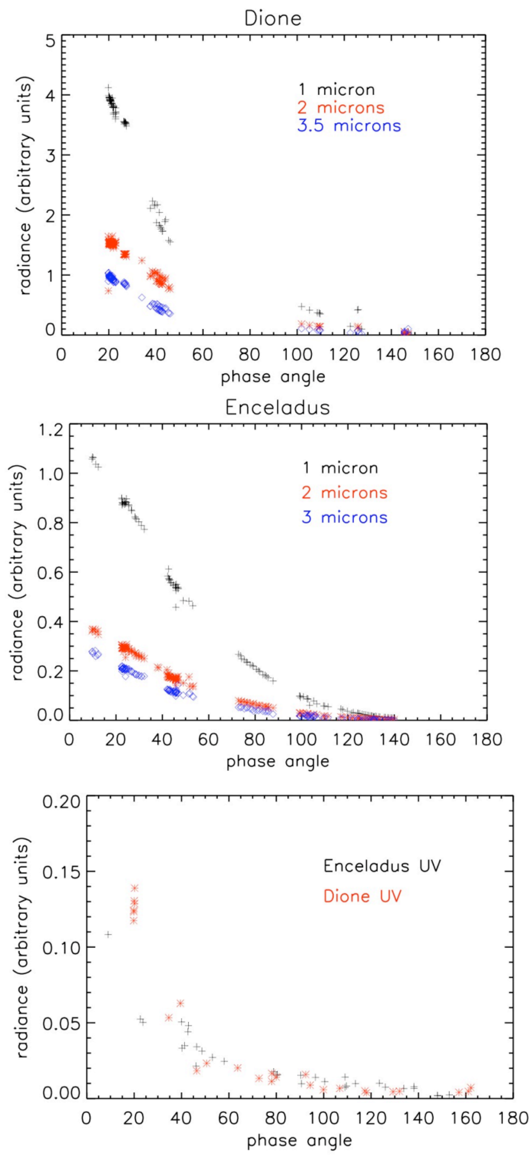

Fig. 1. Preliminary phase curves for Dione and Enceladus at several wavelengths. .