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Physical Properties of Saturn's Rings Derived from Cassini UVIS Far Ultraviolet Reflectance Spectra

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Abstract

Saturn's main rings are known to consist mostly of water ice with a small amount of contaminant. The relative abundance and composition of the contaminant as well as the microphysical structure of the ice-contaminant matrix affects the scattering properties of the ring particles. We have performed an analysis of Cassini UVIS FUV reflectance spectra of Saturn's rings where we have derived the ring particle bond albedo, A_b, the ring particle phase function, and the average distance to scattering centers within the particle, which is characterized by the photon mean path length L. Constraining these physical parameters has implications for the composition and fractional abundance of materials comprising ring particles.

1. Introduction

Certain physical properties of the rings are affected by the composition and abundance of non-water ice material in the rings. Spectral modelling of the ring particle albedo between 0.30 and 4.05 μm suggests that the ring particle surface is consistent with 7% carbonaceous material intimately mixed with 93% water ice [1]. There appears to be greater reddening of the B ring below 0.5 μm than for the A ring, Cassini Division, and C ring, respectively, indicating more pure water ice in the B ring and more contaminated water ice in the C ring [2]. The relative abundance of contamination throughout the rings may help constrain time evolution models. Results from such modelling suggest that the darker rings are either less massive or younger, and probably both for the C ring [3].

Spectra in the FUV regime show an absorption feature at 165 nm that is characteristic of water ice with plateaus above and below the absorption edge from about 175-190 nm and 150-158 nm, respectively. Ratios of this spectra above and below the absorption feature suggests relative variations of water ice abundance across the rings that peaks in the B ring and is a minimum in the C ring [4], consistent with results by others [2]. Here we present retrieved values of A_b, the ring particle phase function which is characterized by the ring particle asymmetry parameter, g, and the photon mean path length, L.

2. Data

Since Saturn orbit insertion in 2004 the Cassini Ultraviolet Imaging Spectrograph (UVIS) has been periodically collecting reflectance spectra of Saturn's main rings. Observations consist of both lit and unlit side spectra from 110-190 nm over a wide range of viewing geometries. Calibrated radiances are divided by the solar irradiance, πF, resulting in I/F.

3. Model and Results

We compare lit side I/F averaged from 152-158 nm and from 175-185 nm to a radiative transfer model to retrieve A_b and g. For the C ring and the Cassini Division we employ the classical Chandrasekhar model [5]. For the A and B rings self-gravity wakes complicate the radiative transfer so we have replaced the scattering function from the classical Chandrasekhar equation with a self-gravity wake model for the A and B rings derived from stellar occultation's [6,7]. Figure 1 shows the data and model results for a region of the A ring.

We find A_b=0.06-0.09 at λ=175-185 nm with the lowest value occurring in the C ring and A_b=0.02 at λ=152-158 nm throughout the rings. Assuming a power law ring particle phase function, we find that g ranges from -0.66 to -0.77 at λ=175-185 nm and from -0.68 to -0.81 at λ=152-158 nm showing that the ring particles are highly backscattering in the FUV. We compare I/F from 152-185 nm with a spectral albedo model to retrieve L [8]. We found that L is positively correlated with phase angle with

L at zero phase angle from 2.0 to 2.5 microns and slopes from 0.11-0.36 microns/degree phase angle.

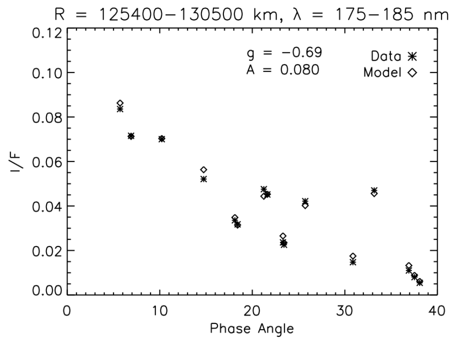

Figure 1: Comparison of model (diamonds) with data (stars) for a region of the A ring. The model was computed over a range of A_b and g, with the retrieved values taken from the minimum difference between model and data.

4. Summary and Conclusions

A_b depends on the relative abundance and composition of materials comprising ring particles with an increase in the abundance of non-ice material leading to a decrease in ring particle albedo. Based on this analysis the C ring is more contaminated than the A and B rings and Cassini Division, consistent with the results from investigations at other spectral regimes [1,2]. The zero-phase L values are twice the distance from the surface of a ring particle to the first scattering center. L is close to constant across the rings suggesting the outermost 1.25 microns of the ring particles have the same structural properties in all ring regions.

Acknowledgements

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