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Cassini UVIS Solar Occultations as Probes of Particle Size Distribution in Saturn's F Ring

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Abstract

We analyze solar occultation data from Cassini's Ultraviolet Imaging Spectrograph (UVIS) [1] in order to measure the particle size distribution in Saturn's F ring. We extend the work done by Becker et al. (2018) for observations done through the end of mission, using their computational model to analyze light curves produced as Saturn's F ring occults the Sun during Revs 181 through 279 [2]. We consider both the attenuated signal and the light diffracted by the particles in the ring during the occultation to determine the size distribution of sub-centimeter ring particles.

1. Introduction

Throughout the ring system, particle accretion is countered by collisional and tidal disruption and Keplerian shear. The presence of sub-centimeter particles, which have short lifetimes due to these processes, is indicative of ongoing dynamics in the rings. Sub-centimeter-sized particles efficiently diffract light at ultraviolet wavelengths, thus producing signatures of diffraction in the occultation data. The shape and intensity of the diffraction signatures are indicative of the sizes of the particles that produce them. The UVIS wavelength bandpass, 51.2 – 180 nm, contains the shortest wavelengths of the Cassini instruments, making it most sensitive to the smallest particles in the rings.

2. Methods

We extend the work done by Becker et al. (2018) for observations done through the end of mission, using the Becker et al (2018) computational model that reconstructs the geometry of a UVIS observation and produces a synthetic diffraction signal for a given truncated power-law particle size distribution. We implement this model for the light curve due to attenuated and diffracted sunlight by particles in Saturn's F ring during solar occultations.

Table 1: UVIS solar occultation observations showing possible diffraction signatures.

Occultation	UVIS diffraction signature?
Rev 239 (E)	yes
Rev 241 (I)	maybe
Rev 241 (E)	no
Rev 243	maybe
Rev 245	no
Rev 249 (I)	maybe
Rev 249 (E)	yes
Rev 254 (I)	yes
Rev 254 (E)	no
Rev 257	yes
Rev 261	yes
Rev 265	yes
Rev 267	yes
Rev 269	maybe
Rev 271	yes
Rev 279	maybe

The spacecraft and ring geometry during each solar occultation event are used as inputs into the model, enabling the direct comparison of the synthetic light curves produced by the model with the observed light curve produced as Saturn's F ring occults the Sun during Revs 181 through 279 (example, Figure 1). Half of the solar occultations analyzed show a tentative detection of diffracted light that surpasses the unocculted solar signal (Table 1).

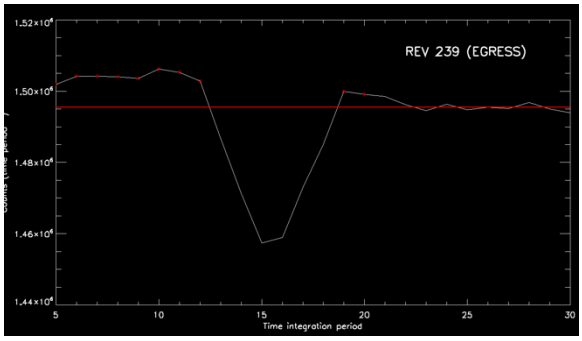

Figure 1: Solar occultation profile behind Saturn's F ring. Red asterisk marks a tentative detection of diffracted light that surpasses the unocculted solar signal (red line).

We measure the size distribution of the particles that fill the broad, ~500 km region surrounding the F ring core, noting differences that occur during solar occultations for which diffraction was detected and placing a lower limit on the minimum particle size for occultations during which diffraction was not detected.

3. Summary and Conclusions

We present the analysis of 16 solar occultations in UVIS EUV data, with emphasis on features produced by diffraction by micron-sized particles in Saturn's F ring. The detections of small particles in the UVIS data are indicative of ongoing collisions in the F ring. We will discuss the correlation of small particle detections with known collisional events in the F ring.

Acknowledgements

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References

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[2] Becker, T. M., Colwell, J. E., Esposito, L. W., Attree, N. O., Murray, C. D., 2018. Cassini UVIS Solar Occultations by Saturn's F ring and the detection of collision-produced micron-sized dust. Icarus 306, 171-199.