EPSC Abstracts
Vol. 6, EPSC-DPS2011-1282, 2011
EPSC-DPS Joint Meeting 2011

Particle Size Variations in Saturn's Rings from Occultation Statistics

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Abstract

The size of particles in Saturn's rings can introduce an excess variance in stellar occultation data if the particles (or clumps of particles) are not small compared to the size of the field of view [1, 2]. We present an analysis of Cassini UVIS stellar occultation data of Saturn's rings showing distinct particle populations between different regions and ringlets in the ring system.

1. Introduction

Cassini UVIS stellar occultation data follow Poisson counting statistics in the absence of intervening ring material, or when the ring material can be approximated by a continuous medium with some finite optical depth. When particles or clumps of particles approach the scale of the spot of a single integration period, the variance increases. The Cassini UVIS High Speed Photometer (HSP), with an integration period as short as 1 ms, has an effective sampling size that is ~10-20 m. The HSP data show an excess variance for most regions in the rings. We present an analysis of HSP occultation data statistics that shows significant differences in the excess variance between different ring regions and also between different occultation geometries with respect to the ring plane.

2. Data

As an initial approach to the large number of occultations (>100), we select those occultations where the elevation angle of the line of sight to the ring plane, *B*, is large. This greatly reduces the dependence on azimuthal viewing angle ϕ that could be caused by non-axisymmetric structures such as self-gravity wakes [3]. Among our findings are that the C ring plateaus have a qualitatively different behavior than the rest of the C ring (Figure 1), and that there is a region at the inner edge of the B ring that is distinguishable from the rest of the B1 region.

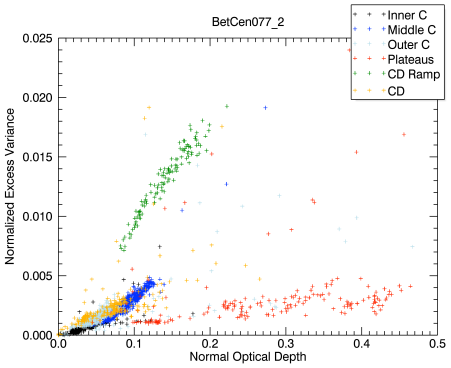

Figure 1: The excess variance as a function of optical depth for several regions in the C ring as well as the Cassini Division (CD) for an occultation of the star Beta Centaurii (Rev 77) [4]. The C ring plateaus (red points) show a significantly lower excess variance than the other C ring regions.

3. Model

In order to quantify our results, we developed a simple Monte Carlo model to generate synthetic occultation data for arbitrary ring particle size distributions.

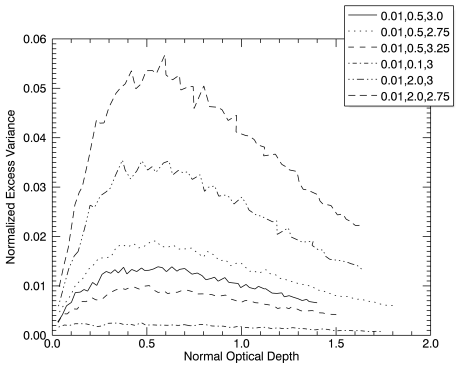

Figure 2: Model curves showing excess variance as a function of optical depth for 6 different size distributions. The three numbers in the legend provide the lower and upper sizes of the particle size distribution and the differential power-law size distribution index. Particle sizes are normalized to the size of the integration area.

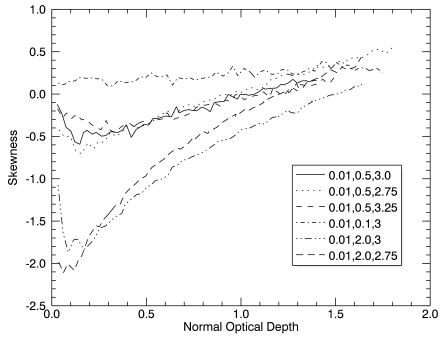

Figure 3: Skewness of simulated occultation data corresponding to the same size distributions for which excess variance is shown in Figure 2.

For a given size distribution we generate synthetic data over a range of optical depths, τ, and compute the excess variance, $\Delta\sigma^2$, for each synthetic dataset (Figure 2). The resulting curves of $\Delta\sigma^2$ as a function of τ can then be compared to the data to provide some insight into the particle size distribution.

4. Summary and Conclusions

The curves are not unique because a variety of particle size distributions can produce the same statistical properties in the data. In addition to the excess variance we also examine the skewness of the data which provides another constraint on the particle size distribution (Figure 3). Significant differences are seen between regions that point to underlying differences in the particle or clump size distribution. For example, while we cannot uniquely constrain the C ring plateau size distribution, we can state that it is characterized by smaller particles than what is observed in the rest of the C ring. We will present the latest results of our analysis and modeling.

Acknowledgements

This research was supported by NASA through the Cassini project at JPL and by the NASA Cassini Data Analysis Program grant number NNX10AF20G.

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