EPSC Abstracts
Vol. 6, EPSC-DPS2011-1298, 2011
EPSC-DPS Joint Meeting 2011

Cassini UVIS Observations of Saturn's Faint, Narrow Ringlets

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Abstract

We present an analysis of faint ringlets in gaps in Saturn's main ring system using stellar occultation data from Cassini's Ultraviolet Imaging Spectrograph (UVIS). Several ringlets are detected, but due to their low optical depth they appear only in occultations of particularly bright stars or occultations at very low slant paths to the ring plane resulting in a relatively high slant path optical depth. We present our analysis of the ringlet characteristics including width, mean optical depth, and equivalent width. Some ringlets seen by other Cassini instruments are too faint to be detected in UVIS data.

1. Introduction

The Cassini orbiter's Ultraviolet Imaging Spectrograph (UVIS) has observed a number of stars in over 100 stellar occultations as they were occulted by Saturn's rings. These stellar occultations are at a radial resolution of less than ~20 m [1]. Faint and narrow ringlets in the Colombo, Encke, G1, Huygens, Jeffreys, Laplace and Maxwell gaps have been detected in ISS images, and are seen in UVIS stellar occultations data [2]. We have carried out a systematic search of UVIS occultation data for ringlets in these gaps. The following Ringlets have been observed in UVIS data: R1 in the G1 gap, R2 in the Colombo gap, R6 in the Huygens gap, R8 in the Jeffreys gap, R9 in the Laplace gap, and four faint ringlets found in the Encke gap [4]. This analysis characterizes these ringlets. A variety of azimuthal variations have been found in these ringlets in the UVIS data including ringlet width, optical depth, radial profile and distance from Saturn. The Encke gap ringlets are only seen in some occultations indicating they are azimuthally discontinuous as also seen in Cassini images. In addition to measuring the equivalent widths and positions of the more prominent ringlets, a rigorous statistical test is applied to measurements of the faint R5 and R3 ringlets in the Huygens and Maxwell Gaps respectively. We were unable to detect these faint, dusty ringlets with confidence.

2. Instrumentation and Methods

The Cassini UVIS instrument contains a high-speed photometer channel for observing stellar occultations of Saturn's rings. The effective wavelength for this channel is 150 nm, and has observed over 150 stellar occultations. These occultations together provide cuts of the ring plane at a variety of radial intervals, longitudes and viewing geometries [3]. Some of the structures in this report have been observed in previous Voyager observations [3] as well as data from Cassini ISS, VIMS, and RSS instruments.

We fit the signal within each gap around the location of a ringlet with a line to remove the effects of drifts in instrumental sensitivity [1]. This provides a measure of the unocculted star signal in that data slice. Since the photometer in the UVIS instrument is known to have an irregular ramping behavior defying modeling, each fit was made locally to data around each ringlet.

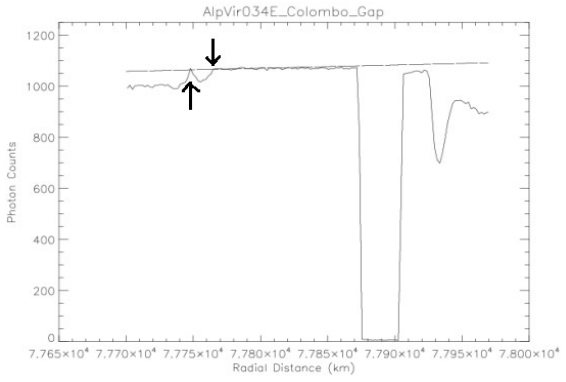

Figure 1: α Vir rev 34 egress profile of Colombo gap. Arrows point out distinct edges of R2 Ringlet, a 25.62 σ event.

This fit represents I_0 , the unocculted intensity in equation 1 for τ_n, the normal optical depth,

$$\tau_n = \mu \ln\left(\frac{I_0}{I-b}\right) \quad (1)$$

where I is the occulted intensity, b is the background signal, $\mu = |\sin(B)|$, and B is the line of sight slant angle made with the ring plane. The optical depth profile is then used to determine the equivalent width, which is the radial integral of the optical depth across the feature [3]. This gives a measure of the amount of material independent of variations in radial structure.

3. Results

Table 1: Ringlet Locations and Widths.

Ringlet	Average Radius (km)	Average Width (km)
R1	75937.11	16.9
R2	77757.69	15.6
R6	117905.59	1.9
R8	118957.17	1.1
R9	119945.21	29.6
E Inner	133492.52	7.5
E Mid	133588.73	6.3
E Out	133722.75	2.8
E 4th	133736.61	3.4

Table 2: Ringlet Equivalent Widths and Optical Depths.

Ringlet	E (km)	Mean τ	Max. τ
R1	0.13	0.01	0.14
R2	0.12	0.01	0.11
R6	0.66	0.27	1.18
R8	0.04	0.04	0.32
R9	0.08	1.4E-3	0.04
E Inner	0.3	0.07	0.62
E Mid	0.35	0.05	0.34
E Out	0.15	0.07	0.68
E 4th	0.03	0.01	0.09

References

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