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Opposition effect of Saturn’s rings: *relevant* hints of ring physical properties

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Abstract

We present here a summary of our previous modeling of the Saturn’s rings opposition effect using Cassini/ISS data [1]. The opposition effect is characterized by a surge in the intensity of any grainy surface, when the phase angle approaches zero degree. This effect can be used to constrain the nature of the regolith and the filling factor of the ring layer. We have used several opposition effect models to derive the physical properties of the rings [1], and we are about to publish the results of this work [2]. A recent work of Degiorgio et al. 2011 (EPSC-DPS meeting #7320), hereafter [3], was drawn to our attention. This work uses some methods (data processing, and physical modeling) similar to [1], and found similar results to [1], without citing [1]. One of the co-authors of [3] being the PhD advisor of [1], it seems unlikely that the works of [1] were unknown to [3]. Moreover, [3] failed to acknowledge the reference works on the Saturn’s rings like [4,5,6,7]. This is particularly concerning since the results of [4,5,6,7] explicitly disprove the conclusions of [3]. The present communication dispels the misconceptions and inaccuracies exposed in [3].

1. Known ring physical properties

Before the arrival of the first NASA missions at Saturn (Pioneer 11, Voyager 1 and 2, Cassini), we thought that the rings of Saturn were uniform, dynamically stable, and thick of several kilometers [8,9]. When Voyager 1 and 2 spacecrafts observed the Saturn main rings at high resolution, the data analysis completely renewed our understanding of the rings. The scattered signal and the differential extinction of stellar occultations were used to determine size distributions for several main ring features [for a review, see 7]. These results were confirmed by the stellar occultation of 28-Sgr by the rings [7]. Since then, it is widely accepted that the rings are composed of "ring particles", which follow a power law size distribution [7]. Many N-body numerical simulations of rings [4,5,6] can reproduce most of the behaviors of the rings due to macroscopic effects (quadrupole asymmetry, tilt effect). All these works have invalidated the previous view of the rings (homogeneous, uniformly sized, and very thick) [8,9]. Moreover, Cassini/VIMS data found "regolith grain" sizes of a few microns [7]. As a result, our actual vision of the Saturn's rings is a layer of a few meters thick, composed of particles (with a power law size distribution), covered by micron-sized regolith grains [5,7].

2. Summary of previous modeling of Cassini/ISS opposition effect [1,2]

The previous work of [1] aimed to better characterize the nature of both regolith and ring particles. To achieve this goal, [1] used the brand new ISS opposition data and develop an accurate geometric extraction to produce the first opposition phase curves of the main rings with Cassini/ISS. For the modeling, [1] used various and different models to fit the Saturn rings opposition surge [9,10,11,12,13,14]. The work of [1] demonstrated that either the coherent backscattering alone or a combination with the shadow hiding can reproduce the observations, then providing some ring physical properties (filling factor D and vertical height) consistent with previous other studies [4]. In particular, the vertical height that we found with the angular width of the shadow hiding of model [13] was consistent with the thickness of the rings simulated by N-body code [4], when considering the power law size distribution of Zebker [7]. However, the study of [1] demonstrated that the shadow hiding alone (with model [9] or [13]) could reproduce the observations, only by providing unrealistic values for the output parameters. For example, with model [9]: a) the filling factor D of the ring layer decreases with optical depth, see Fig. 1, which contradicts [4] ; b) the ratio H/R (i.e. ring layer thickness over ring particle size) increases with optical depth, see Fig. 2, which contradicts [6]. [1,2] explained theses unrealistic values with the assumptions of the models of [9] and [13] (i.e. the uniform size distribution), which force the medium to be very diluted to reproduce the surge.

3. Summary of [3]’s recent work

We now summarize of the work of [3] and dispel the misconceptions and inaccuracies exposed in it:

1) [3] were interested in a single region in the C ring ("P8 ringlet") and assumed this region representative of the entire C ring.

2) Surprisingly, [3] did not cite any recent work on the Saturn's rings like [1,4,5,6,7], but strangely cited pre-Voyager analysis [8,9] as references for the ring's macroscopic characteristics.

3) For their "P8 ringlet" region, that was fit with an optical depth of 0.22, [3] found a volume filling factor D=0.0008 with model [9] and D=0.0006 with model [13]. These values are 10 times smaller than estimations of ring layer from N-body simulations from [4]. Moreover [3] found H/R=354 with model [9] and H/R=431 with model [13], values considered as too high from dynamical simulations, see [6].

4) For their "P8 ringlet" region, [3] claimed that the "ring filling factor D and H/R ratio have reasonable values and might be only a few-meters thick with a population of cm-sized particles". We totally disprove this statement; because several works have inferred the effective size of the ring particles in the C ring to be 1 or 2 meters, see [7]. If [3] were using up-to-date values of the size distributions of the ring particles, they would have see that H/R=354 or 431 implies a ring thickness of 354 or 431 meters for 1-meter effective size, which is unrealistic. In addition, [3] never demonstrated that uniform "cm-sized particles" distribution was suitable for the C ring.

5) One of the most striking references in [3] was an anterior and incorrect reference of our work (while the correct reference should be [1]) and the lack by many occasions to make any reference to [1], which seems to suggest that [3] are the first to do the research presented. In particular, [3] wrote "*Unlike [1]*..." where *[1]* = Deau et al. 2006, AAS Planet. Sci. Meet. Abs.,38,51.01, suggesting to the reader that *[1]* never worked on that field. However [1] did the same work, as shown in Figs. 1 and 2, and the results of [3] for model [9] (D=0.0008 and H/R=354) are clearly consistent with [1], see Figs. 1 and 2.

4. Conclusion

We have demonstrated that [3] did not cite the relevant papers on the rings of Saturn [1,4,5,6,7] that would disprove their own work. Moreover, we have proved that the work of [3] seems actually to be a poor copy of [1], because their work has taken some results of [1] as theirs, without citing [1] properly and even worse, without really understanding the results of [1]. Therefore, we advise the authors of [3] to read carefully [1], which is downloadable online from the NASA/ADS website, as well as all the recent works on the rings of Saturn [5,6,7]. The work of [3] does not bring anything new, except many misconceptions about Saturn's rings. Consequently, we recommend [3] to either cite [1] properly or at least try to produce an original work.

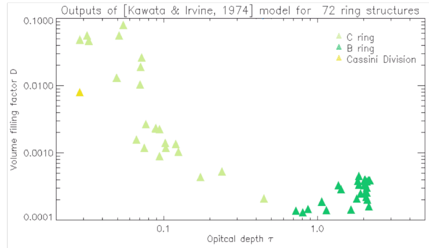

Figure 1: Volume filling factor D of the ring layer from the opposition phase curves (phase angle <3º) with model [9]. Adapted from [1] page 193.

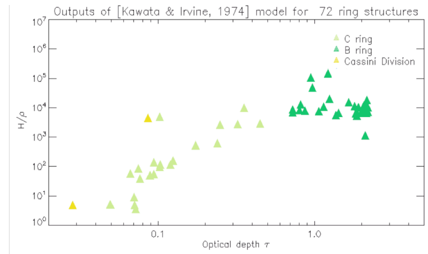

Figure 2: Ratio thickness/particle radius (H/R) of the ring layer from opposition phase curves (at phase angle <3º) with model [9]. Adapted from [1,2].

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