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S/2009 S1: B-ring Propeller or Impact Plume? Probably the Former.

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Abstract

We compare two competing hypotheses to explain a shadow-casting object observed by Cassini in 2009 in Saturn's B ring.

1. Introduction

In 2009 July, close to Saturn equinox, the Cassini spacecraft imaged an isolated shadow-casting object[1]. Although multiple observations are typically required to confirm the reality of an object, the presence of a shadow allowed us to confirm the object and obtain a provisional designation of S/2009 S1 from the IAU. Based on the length of the shadow, we reported a diameter of ~300 m, assuming the object is spherical. We did not explain the apparent absence of a propeller-shaped disturbance like those associated with embedded objects of similar size in the A ring [2].

2. Analysis

Our initial analysis[3] showed that the shadow best matches a roughly spherical object, as opposed to a more flattened ellipsoid. Moreover, the bright feature at the base of the shadow is marginally resolved and is canted in a direction consistent with Keplerian shear. Because the bright feature is resolved, its in-plane dimensions could be estimated, yielding a few km, much larger than the diameter of the spherical shadow caster. These results led us to suggest that the bright feature is the "missing" propeller.

Here we evaluate an alternate hypothesis that was not discussed by [3]: that the observed object is an impact plume, presumably observed relatively shortly after impact. That interpretation would also explain the absence of a propeller-shaped disturbance, and would also be consistent with Keplerian shear.

Our analysis is not complete, but at present it favors the propeller hypothesis. First, as noted in [3], the B ring should have a much larger viscosity than the A ring. Therefore, propeller disturbances in the B ring should be smoothed out downstream far more rapidly via collisions than in the A ring. Thus, the dimensions of the observed feature do not immediately rule out a propeller disturbance, even though it is much shorter than those seen for bodies of similar size in the A ring.

Second, the observed Keplerian shear corresponds to about 1 hour of orbital evolution from a presumed initially spherical impact cloud. Until the impact ejecta re-impact the ring 1/2 orbit (~6 hr) after the initial event, the particles should evolve on smooth trajectories and the cloud should remain roughly ellipsoidal, though its dimensions will evolve as the trajectories of the ejecta particles diverge. The inferred compound object (spherical body surrounded by a flat bright feature) is not consistent with this shape, and could only arise, if at all, after the ejecta re-impact the ring.

3. Summary and Conclusions

To complete the analysis, we are 1) looking more closely at the orbital evolution of the impact cloud, 2) refining our shadow analysis to treat a cloud with an opacity profile instead of a solid object, and 3) performing simulations of propeller formation in a self-gravitating disk to compare with the observed feature.

References

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