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Investigation of the Photochemistry in Saturn's Ring Shadowed Atmosphere: Production Rates of Key Atmospheric Molecules

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Abstract

Cassini has been orbiting Saturn for well over six years. During this epoch, the ring shadow has moved from covering a relatively large portion of the northern hemisphere to covering a small region just south of the equator (see Figure 1). For example, at Saturn Orbit Insertion (SOI; July 1, 2004), the ring plane was inclined by ~24 degrees relative to the Sun-Saturn vector. At this time, the projection of the B-ring onto Saturn reached as far as 40ºN along the central meridian (~52ºN at the terminator). At its maximum extent, the ring shadow can reach as far as 48ºN (~58ºN at the terminator). The net result, is that the intensity of both ultraviolet and visible sunlight penetrating into any particular northern/southern latitude will vary depending on Saturn's tilt relative to the Sun and the optical thickness of each ring system (see Figure 2).

Previous work [1] looked at the variation of the solar flux as a function of solar inclination, i.e. season (see Figure 3). The current work looks at the impact of the oscillating ring shadow on the photodissociation and production rates of key molecules in Saturn's stratosphere and upper troposphere over time. Beginning with methane, the impact on production and loss rates of the long-lived photochemical products leading to haze formation are examined at several latitudes over a Saturn year. We also look at the impacts on phosphine abundance, a disequilibrium species whose presence in the upper troposphere is a tracer of convection processes in the deep atmosphere. Comparison to the corresponding rates for the clear atmosphere and the effect of dynamical mixing will be presented.

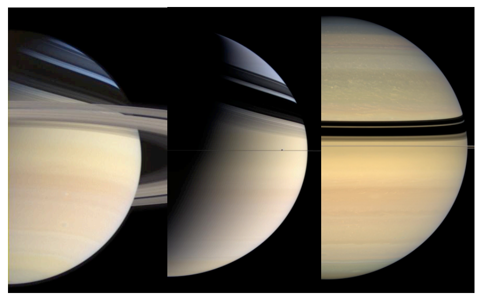

Figure 1. Saturn's atmosphere changes in response to the changing inclination of the ring plane relative to the Sun. (a) Saturn image taken on December 14, 2004. (b) Saturn image taken on March 16, 2006. (c) Saturn image taken on April 23, 2008. Images are courtesy of NASA/JPL/Space Science Institute.

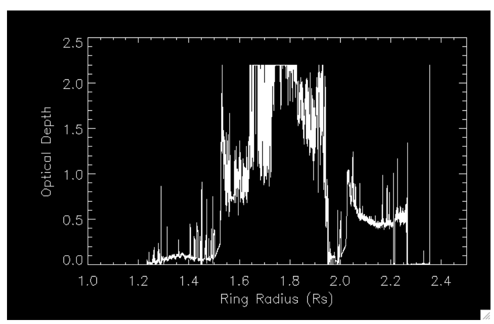

Figure 2. The optical depth of Saturn's rings in the ultraviolet (Josh Colwell, *pers. comm.*) The rings act like a periodic Venetian blind that will shield atmospheric molecules from solar photons.

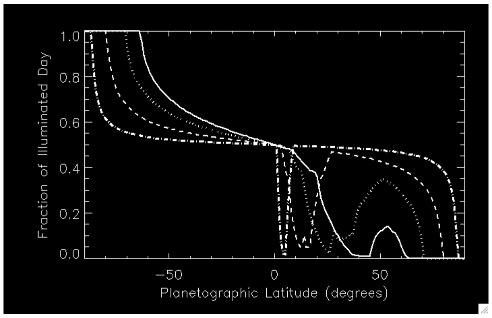

Figure 3. This plot illustrates the fraction of Saturn's day that is illuminated by the Sun as a function of solar declination, i.e. season. The curves correspond to sub-solar points of 26.7ºS (solid), 19.6ºS (dotted), 10.7ºS (dashed), and 3.5ºS (dot-dashed). Ultimately, this will determine the flux of photons allowed to enter the atmosphere relative to those of a clear, un-shaded atmsphere.

Acknowledgements

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References

[1] Edgington, S.G., A.A. Simon-Miller, R. Achterberg, G. Bjoraker, P. Romani, F.M. Flasar, J. Colwell, 2006. Adaptation of a 2-D Photochemical Model to Improve Our Understanding of Saturn's Atmosphere. *Bull. American. Astron. Soc.*, 38, 499 (#11.23).