EPSC Abstracts
Vol. 5, EPSC2010-452, 2010
European Planetary Science Congress 2010

Enceladus' Influence on the Saturn System

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The vast cloud of water product neutrals (H_2O, OH, O) orbiting Saturn has been modeled extensively since the discovery of the OH "torus" in the early 1990s. Its source, Enceladus' South polar plumes, was only discovered in 2005. The water vapor is ejected supersonically from these plumes, easily escaping Enceladus' meager gravity to end up in Saturn orbit. The H_2O vapor subsequently spreads throughout the Saturn system through a variety of processes (Fig. 1), processes that had been modeled even before the discovery of the plumes. These models seemed to explain the torus breadth, but recent observations [1] have found that the cloud is much broader than previously thought. The O portion of the cloud, for instance, has been detected out to 25 RS. At around the same time a new spreading process was suggested [2]. These developments prompted us to revisit the problem and develop a new model of the Enceladus torus.

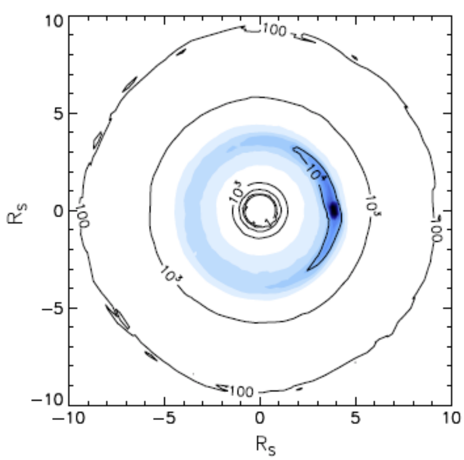

Figure 1: The "torus" of gas that orbits Saturn. The contours denote water group neutral (H_2O, OH, O) densities in Saturn's equatorial plane. The gas' source, Enceladus, is the dark spot on the right-hand side at about 4 R_S.

The spreading processes identified before 2009 are:

1) Charge exchange: water group ions that "cororate" with Saturn travel much faster than orbiting neutrals. Water group neutrals occasionally exchange charge with ions, and the relatively slow neutral is replaced by a fast former ion. The resulting neutral moves fast enough to travel far beyond Enceladus' orbit, often fast enough to escape Saturn's gravity entirely

2) Dissociation: when H2O is dissociated by solar photons or magnetospheric electrons, the molecular fragments leave with high speed.

Farmer [2] suggested that collisions between the cloud's constituent molecules could, alone, account for most of the OH torus' breadth. Given the new O observations it seemed that another spreading process was necessary to successfully model the cloud, so we built a model that included all three processes [3]. The results (Fig. 2) showed that all three processes are needed to successfully model the cloud.

The Enceladus torus is so broad that it could potentially affect the whole Saturn system, from Saturn itself to Titan. The model allows us to estimate the rate at which Enceladus torus gases are deposited onto other moons, the rings, Saturn's upper atmosphere, and Titan's upper atmosphere. I will discuss ongoing work to model and detect Enceladus' influence on these bodies. In particular I will focus on the far ultraviolet reflectance of the icy moons and its relationship to modeled gas fluxes. Hendrix et al. [4] recently found evidence for ammonia absorption on Enceladus itself, likely from the plume, which is known to contain trace amounts of NH_3 and other species. Based on what we know of the water group torus, these trace species should also be transported to Saturn's icy moons and, if so, should be apparent in their spectra.

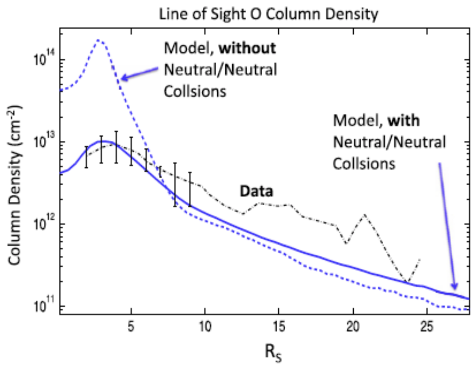

Figure 2: Line-of-sight atomic oxygen column density as a function of distance from Saturn. The observations were system-wide scans taken far from Saturn. Two model results are shown for comparison. Due to its vast extent, the torus supplies significant quantities of Enceladus plume material to all of Saturn's major moons.

References

[1] Melin, H., Shemansky, D.E., Liu, X.: The distribution of atomic hydrogen and oxygen in the magnetosphere of Saturn. Planet. Space Sci. 57, 1743–1753, 2009.

[2] Farmer, A.J. Saturn in hot water: Viscous evolution of the Enceladus torus: Icarus 202, 280–286, 2009.

[3] Cassidy, T. A., Johnson, R. E.: Collisional Spreading of Saturn's Neutral Torus. Icarus, in press, 2010.

[4] Hendrix, A. R., Hansen, C. J., Holsclaw, G. M.: The Ultraviolet Reflectance of Enceladus: Implications for Surface Composition, *Icarus* **206**: 608-617, 2010.