The Enceladus Water Plume and Its Interactions with the Saturnian Plasma. M.H. Burger[1], C. Paty[2], E.C. Sittler[1], R.E. Johnson[3], [1]NASA/GSFC, Greenbelt, MD, 20771, Matthew.Burger@gsfc.nasa.gov; [2]Southwest Research Institute, San Antonio, TX; [3]University of Virginia, Charlottesville, VA

Introduction: The water plume at Enceladus' south pole ejects ~300 kg/s of neutral H_2O molecules into Saturn's inner magnetosphere [1][2]. The low plasma density and cool electron temperatures result in low loss rates which give this material time to spread out in their orbits around Saturn to form a full neutral water torus at Enceladus' orbital distance. Because the ejection speed from Enceladus is slow compared to the orbital velocity, this torus is closely confined to Enceladus' orbital distance [3] (Figure 1).

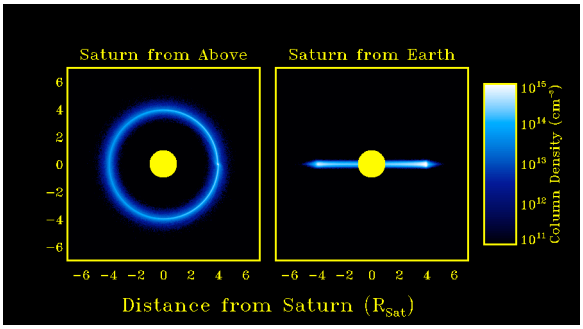

Figure 1: Enceladus water torus as seen from above Saturn's north pole (left) and from Earth (right). The brightness enhancement seen at the rightmost point in the torus is due to increased water density in the Enceladus plume.

Mass loading of material in the Enceladus plume was reported by both the Cassini Plasma Spectrometer (CAPS) [4] and Cassini Magnetometer (MAG) [5]. The dominant mass loading process is charge exchange between water molecules in the plume and the ambient plasma ions [2]. Acceleration of the fresh pickup ions slows the plasma as it flows through the plume region. Johnson et al. [3] point out that the large abundance of H_3O^+ in the plasma [4] implies charge exchange and ion-neutral reactions are occurring at relative velocities much lower than the co-rotation velocity (26 km/s). Neutrals created through charge exchange at velocities less than $2^{1/2}$ times the orbit speed are gravitationally bound to Saturn and are a possible source of secondary tori [3], such as the OH cloud observed by HST [6] and atomic oxygen cloud observed by UVIS [7].

Mass Loading Near Enceladus: We use a Monte-Carlo model of neutrals escaping from the south pole to populate the neutral torus. H_2O ejected from the surface are ionized through charge exchange reactions, electron impact ionization, and photoionization. Because the latter two processes are slow and charge exchange dominates, there is little net change in the plasma ion content, although the region near the plume is a region of enhanced plasma mass loading due to production of fresh pickup ions through charge exchange and ion-neutral reactions. These reactions can alter the plasma composition through the addition of H_2O^+ created from the neutral H_2O and the removal of O^+ and OH^+ which are neutralized and continue on trajectories at their original velocity but unaffected by Saturn's magnetic field.

The acceleration of pickup ions from the neutral velocity (approximately Enceladus' orbital speed of 13 km/s) to full magnetic field co-rotational speed (39 km/s) produces a perturbation in the magnetic field as field lines drape around the ionized obstacle [5][8]. Our estimate of the mass loading rate in a water plume with a source rate of 300 kg/s, consistent with the stellar occultation observations by UVIS [1], is ~2-3 kg/s, in agreement with modeling of the mass loading required to produce the observed perturbations in the MAG data [8]. We are extending the modeling analysis of Burger et al. [2] to understand the effects on plasma flow velocity, density, temperature, and chemistry as it flows through the H2O plume.

Modeling Neutral Tori: As shown by Johnson et al. [3], the large H_3O^+ fraction in the Saturnian magnetosphere requires a low velocity collisions between ions and neutrals. There are two regions in which these reactions can occur: near Enceladus in the water plume or farther from Enceladus (although still at Enceladus' orbital distance) in the water torus. Although slowing might be expected in the plume due to the enhanced mass loading, Khurana et al. [8] have shown that no significant slowing occurs. In the torus, the large ion temperatures produce thermal velocities comparable to the bulk flow velocity such that a fraction of the ions will have a low velocity relative to the neutrals. We explore the charge exchange rate in the torus between water group ions and H_2O neutrals necessary to produce the OH and O clouds which have been observed between 3 and 10 R_S from Saturn.

References: [1] Hansen, C.J. et al. (2006), *Science, 311,* 1422-1425. [2] Burger, M.H. et al. (2007), *JGR*, in press. [3]Johnson, R.E. et al. (2006), *ApJ, 644*, L137. [4] Tokar, R. L. (2006), *Science, 311*, 1409. [5] Dougherty, M.K. et al. (2006), *Science, 311*, 1406-1409. [6] Shemansky, D.E. (1993), *Nature, 363,* 329-331. [7] Esposito, L.W. (2005), *Science, 307*, 1251. [8] Khurana, K.K(2007) *JGR,* in press.