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Charge exchange in the Enceladus plume and water torus

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The water plume at Enceladus' south pole ejects ~ 300 kg/s of neutral H_2O molecules into Saturn's inner magnetosphere (Hansen et al. 2006; Burger et al. 2007). 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 (Johnson et al. 2006).

The primary process responsible for removal of H_2O molecules is charge exchange with magnetospheric ions. Johnson et al. (2006) point out that the large abundance of H_3O^+ in the plasma (Tokar et al. 2006), implies charge exchange and ion-neutral reactions are occurring at relative velocities much smaller than the co-rotation velocity. Neutrals created through charge exchange at velocities less than $\sqrt{2}$ times the orbit speed are gravitationally bound to Saturn and are a possible source of secondary tori (Johnson et al. 2006), such as the OH cloud observed by HST (Shemansky et al 1993) and O cloud observed by UVIS (Esposito et al 2005).

We investigate H_3O^+ forming reactions in two regions of the Enceladus torus system. First, as Burger et al. (2007) show, mass loading within the Enceladus plume reduces the flow speed of the plasma to approximately 10 km/s within and immediately downstream of the plume. Second, in the water torus far from Enceladus, the ion thermal velocity approaches the flow velocity implying that a fraction of the ion population has low speeds relative to the orbiting neutrals. This allows for the production of H_3O^+ at larger distances from Saturn and for charge exchange occurring without escape from the system (Johnson et al. 2005,2006). We compare the relative reaction rates in these

two regions to determine the relative importance of charge exchange within the plume and within the torus for forming the secondary tori observed by HST and Cassini.

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