To explore the coupling dynamics among Saturn's atmosphere, ionosphere, and magnetosphere - Saturn's ring rain?!

Wei-Ling (Wendy) Tseng[1]

Group members: Luke Moore[2], Julie Moses[3], Bob Johnson[4], Randy Gladstone[1], Wing-Huen Ip[5]

1. Southwest Research Institute, San Antonio, TX, USA
2. Boston University, Boston, MA, USA
3. Space Science Institute, Houston, TX, USA
4. University of Virginia, Charlottesville, VA, USA
5. National Central University, Taoyuan, Taiwan

The Cassini spacecraft, which has explored the Saturnian system since 2004, has already discovered water ice plumes ejecting from Enceladus and liquid hydrocarbon lakes on Titan's surface. In addition, Cassini has confirmed the O_2 atmosphere of Saturn's main rings (Waite et al., 2005; Tokar et al., 2005). The mission will focus on the temporal variability in composition and spatial distribution in Saturn's atmosphere, ionosphere and magnetosphere, which are affected by seasonal and solar forcing, including investigating the coupling dynamics between Saturn's ionosphere and the main rings. In order to complement these efforts, we plan to determine the role of the O_2/H_2 atmosphere of the main rings in the coupling dynamics among Saturn's atmosphere, ionosphere, and magnetosphere. We start with investigating the dominant source of oxygen in Saturn's atmosphere and ionosphere: the ring O_2 atmosphere and/or the Enceladus water plumes?

Early models greatly over-predicted the peak electron density in comparison with the Pioneer and Voyager observations (i.e. Kliore et al., 1980; Tyler et al., 1981). Therefore, mechanisms for converting the long-lifetime H^+ ions into the short-lived molecular ions were introduced to reduce the modeled electron density to better fit the observed values. McElroy (1973) suggested that it was primarily due to charge exchange between H^+ and vibrationally excited H_2 forming H_3^+. Charge exchange between H^+ and charged icy dust (additional water/oxygen) from the rings, leading to H_2O^+/H_3O^+ formation, was proposed as well (Connerney and Waite, 1984).

Saturn's ring rain: O'Donoghue et al. (2013) used the Keck telescope to observe the H_3^+ ion density distribution in Saturn's ionosphere. Since water/oxygen derived from the charged icy dust could deplete H_3^+, they suggested that the observed latitudinal dependence of the H_3^+ infrared emission intensity indicated the evidence of the charged icy dust from the main rings precipitating into Saturn because of a symmetry about the magnetic equator rather than the geometrical equator. In addition, the quenched H_3^+ infrared emission intensity in the region mapped sequentially to the B-ring and A-ring are consistent with more water precipitation. An increase of the H_3^+ emission at the latitude mapped to the Cassini Division also agrees with the proposed theory of "ring rain" due to less dust there. However, they pointed out that the correlation between water influx and the H_3^+ emission in the instability region (1.52-1.62 Rs) was not well established.

Therefore, we will investigate the effect of the ring-originated O_2/O_2^+ deposition on Saturn to find out the cause for the latitudinal dependence for the ionospheric electron density distribution observed by Cassini RSS and the H_3^+ ion emission observed by the Keck observatory, with emphasis on north vs. south asymmetry.