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Moon-Magnetosphere Interactions at Saturn: Recent Highlights from Cassini Observations and Modelling (invited)

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Since the arrival of the Cassini spacecraft at Saturn in July 2004, newly collected plasma and magnetic field data have greatly expanded our knowledge on the giant planet's magnetosphere and its multifaceted family of moons. More than 160 orbits around the planet have already been accomplished by Cassini, encompassing 85 close flybys of Saturn's largest satellite Titan as well as 20 encounters of Enceladus. This small icy moon had been identified as the major source of magnetospheric plasma and neutral particles during the first year of Cassini's tour in the Saturnian system. In addition, the spacecraft has paid visits to several of the other icy satellites in the inner and middle magnetosphere: Rhea (3 flybys), Dione (3 flybys) and Tethys (1 flyby).

The inner icy satellites and Titan are located within Saturn's magnetosphere for average solar wind conditions, revolving around the giant planet on prograde orbits in its equatorial plane. Since their orbital velocities are clearly exceeded by the speed of the at least partially corotating magnetospheric plasma, the moons are continuously "overtaken" by the magnetospheric flow. Thus, their trailing hemispheres are permanently exposed to a bombardment with thermal magnetospheric plasma. The characteristics of the resulting plasma interaction process depend on the properties of the moon itself as well as on the parameters (density, velocity, temperature, magnetic field strength) of the incident magnetospheric flow and the energetic particle population.

In this presentation, we shall review some recent advances in our understanding of the interaction between Saturn's moons and their plasma environment:

Enceladus: Electron absorption by submicron dust grains within the plume gives rise to a negative sign of the Hall conductance in Enceladus' plume. The resulting twist of the magnetic field, referred to as the *Anti-Hall effect*, has been observed during all targeted Enceladus flybys accomplished to date. We present an analytical model as well as advanced hybrid plasma simulations of these puzzling processes.

Titan: Due to the oscillatory dynamics of Saturn's magnetodisk current sheet, the magnetospheric upstream conditions near Titan's orbit are in continuous fluctuation. In consequence, the moon's ionosphere is permanently "contaminated" by *fossil magnetic fields*, even when being located inside Saturn's magnetosphere. We present Cassini MAG observations, illustrating the high variability of the ambient flow conditions near Titan's orbit.

Dione: An analysis of Cassini MAG data revealed Dione to possess a dilute, time-varying exosphere. Particle densities in this exosphere are controlled by a transient radiation belt, located at Dione's L shell. Based on an analytical model of the magnetic field perturbations, we impose quantitative constraints on the characteristics of Dione's transient exosphere.

Rhea: Although Rhea's dilute atmosphere is "magnetically invisible", the moon possesses a weak Alfven wing. In contrast to the situation at Enceladus, Titan or Dione, this structure is generated by the finite extension of Rhea's plasma wake along the corotational flow direction. We present recent Cassini observations and modelling results of this peculiar structure.

Finally, we briefly discuss some remaining puzzles on moon-plasma interactions at Saturn.