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Hybrid simulation of moon-magnetosphere interactions at Saturn: Tethys and Enceladus

H. Kriegel (1), S. Simon (1,2), U. Motschmann (1), J. Saur (2), F. M. Neubauer (2), and M. K. Dougherty (3)

(1) Institute for Theoretical Physics, TU Braunschweig, Germany (h.kriegel@tu-bs.de), (2) Institute of Geophysics and Meteorology, University of Cologne, Germany (simon@geo.uni-koeln.de), (3) Blackett Laboratory, Imperial College, London, UK

The interaction of the Saturnian moons Tethys and Enceladus with the corotating plasma of the inner magnetosphere has been studied by applying a three-dimensional hybrid simulation code. The hybrid approach treats the electrons as a massless, charge-neutralizing fluid, while ions are represented by macroparticles. Therefore, the model is able to fully resolve effects that are associated with the finite ion gyroradius.
Since Tethys possesses neither an intrinsic magnetic field nor a substantial ionosphere, the surface is directly exposed to the impinging plasma. Plasma absorption leads to the formation of an extended density cavity in the downstream region, expanding above and below Tethys along the magnetic field lines. The resulting deficit of plasma pressure is compensated by a compression of the field lines at the wakeside. By confronting our simulation results with Cassini magnetometer data from the so far only targeted flyby in 2005, we demonstrate that these key features of the Tethys plasma interaction are quantitatively reproducible within the framework of the hybrid model.
Based on the data from seven Cassini flybys between 2005 and 2008, Enceladus was found to be the major mass loading source in the Saturnian magnetosphere. The newly generated particles originate mainly from an extensive water plume, centered in the south polar region. As implied by Cassini magnetometer measurements, this plume acts as an obstacle to the corotating plasma flow, giving rise to field line draping and to the formation of a magnetic cavity. In our simulation study, we analyze how particle absorption at the surface of Enceladus and mass loading in the plume region contribute to the overall structure of the interaction region in isolation and collectively. By comparing the model results to Cassini magnetometer measurements, we also demonstrate that both the locations of the active regions and the total mass loading rate exhibit a strong time variability.