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Plasma environment of Titan: A 3D hybrid simulation study

S. Simon (1), A. Boesswetter (1), T. Bagdonat (1) and U. Motschmann (1)

(1) Institute for Theoretical Physics, University of Braunschweig, Germany (sven.simon@tu-bs.de)

Titan possesses a dense atmosphere, consisting mainly of molecular nitrogen. Titan's orbit is located within the Saturnian magnetosphere most of the time, where the corotating plasma flow is superalfvenic, yet subsonic and submagnetosonic. Since Titan does not possess a significant intrinsic magnetic field, the incident plasma interacts directly with the atmosphere and ionosphere. Due to the characteristic length scales of the interaction region being comparable to the ion gyroradii in the vicinity of Titan, magnetohydrodynamic models can only offer a rough description of Titan's interaction with the corotating magnetospheric plasma flow. For this reason, Titan's plasma environment has been studied by using a three-dimensional hybrid simulation code, treating the electrons as a massless, charge-neutralizing fluid, whereas a completely kinetic approach is used to cover ion dynamics. The calculations are performed on a curvilinear simulation grid which can be adapted to the spherical geometry of the obstacle. In the model, Titan's dayside ionosphere is generated by solar UV radiation; hence, the local ion production rate depends on the solar zenith angle. Because the Titan interaction features the possibility of having the densest ionosphere located on a face not aligned with the ram flow of the magnetospheric plasma, a variety of different scenarios can be studied. The simulations show the formation of a strong magnetic draping pattern and an extended pick-up region, being highly asymmetric with respect to the direction of the convective electric field. In general, the mechanism giving rise to these structures exhibits many similarities to the interaction of the ionospheres of Mars and Venus with the supersonic solar wind. The simulation results are in agreement with data from recent Cassini flybys.