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Cassini-plasma interactions in the vicinity of Enceladus

Victoria Yaroshenko (1), Wojciech Miloch (2), and Hermann Lühr (1)

(1) Deutsches GeoForschungsZentrum, GFZ Potsdam, Germany (yarosh@gfz-potsdam.de), (2) Department of Physics, University of Oslo, Norway

The Cassini Langmuir Probe of the Radio and Plasma Wave Science instrument has measured an electron depletion in a region extended at least 50 moon radii away from Saturn's small but geologically active icy moon Enceladus [1,2]. The maximal imbalance between the electron and ion densities was observed in the dust-loaded plume, and up to date it is attributed to the electron attachment to abundant dust grains. We report results of a three dimensional particle-in-cell simulation of the plasma distribution formed around a charged spacecraft moving in the Enceladus torus and in the moon's plume. The self-consistent modeling of plasma particles around the orbiter revealed a significant dominance of water group ions over the electron population at the Cassini Langmuir probe (LP) position. The effect is significantly pronounced in the upstream direction due to the formation of a sizable plasma sheath causing an electron depletion up to 60%-75% near the spacecraft. In the dust-loaded plume the negatively charged dust becomes an additional factor favoring further electron depletion in the plasma distribution around the orbiter. It is remarkable how well the simulation results can qualitatively explain the profiles of the electron to ion imbalance registered by the Langmuir probe during the Cassini plume flybys E3 and E5. Our modeling therefore leads to an very important conclusion with broad implications for the interpretation of the Cassini LP data collected near Enceladus: it is demonstrated that a large imbalance between ion and electron densities observed by the Cassini LP (e.g. the registered electron/ion density ratio of less than 5 % [2]) may not represent the actual plasma conditions near the moon's plume. Instead, the large discrepancy may be artificially generated by the interactions of the charged spacecraft with Enceladus' plasma environment. In any case, the plasma perturbations associated with the moving Cassini orbiter appear to be an important factor for a reliable interpretation of the LP measurements.

[1] M. Morooka et al. , J. Geophys. Res., 116, A12221, (2011).
[2] M. Shafiq, et al., Planet. Space Sci., 59, 17, (2010).