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Trajectories of charged nanograins in the plume of Enceladus: Modelling and Cassini/CAPS observations

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Abstract

Plumes in the south pole of Enceladus are produced through active cryovolcanic processes and contains both gaseous and dusty components. The Cassini-Huygens mission has confirmed that these plumes are a major source of gas and dust for Saturn's magnetosphere. On two separate encounters with Enceladus on 12 March and 09 October 2008 (E3/E5) the sensors of the Cassini Plasma Spectrometer (CAPS) were oriented such that they directly sampled the plume material. High-energy negatively (positively) charged particles were measured by electron (ion) sensor on CAPS which were entering the instrument at the ram velocity of the spacecraft through the plume, thus facilitating a measurement of the mass of the particles. Jones et al. (2009, submitted) studied the energy and resulting mass spectrum of the plume particles detected by CAPS and concluded that the particles were nanometre-sized grains thus bridging the gap between previously detected gaseous species and larger micron-sized ice grains observed by other instruments. Jones et al. also studied fine-scale structuring inside the plume and concluded that discrete plume sources, inferred from remote sensing observations, were the origin for this fine structure.

Previous theoretical work on grain motion has concentrated on the trajectories of the larger ice grains. In this study we examine the motion of the charged nanograins discussed by Jones et al. and solve the equation of motion, for both negatively and positively charged grains, emerging from discrete vents on Enceladus. We take into account the gravitational field from both Saturn and Enceladus, the background magnetospheric field, and the motional electric field introduced by the azimuthal convection of Saturn's magnetospheric plasma and its stagnation in the vicinity of the plume. We show that the stagnation of the flow near the plume is important in preventing the dispersion of the plume in the immediate vicinity of Enceladus. We also present preliminary results of a Monte Carlo model of the plume resulting from a number of discrete vents and compare these results with CAPS observations.