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Enceladus' variable magnetospheric interaction: a hybrid simulation study

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We present hybrid simulations (kinetic ions, fluid electrons) of the interaction between the Enceladus plume and the torus plasma in Saturn's inner magnetosphere. For Enceladus, an accurate description of the geometry and the local ionization and ion chemical processes in the plume has a strong influence on the large-scale structure of the interaction region. For this reason, momentum loading due to charge exchange, mass loading due to electron impact and solar UV ionization as well as ion kinetic effects are combined by our model in a self-consistent way. As a first approach, we assume one upstream species of water group ions and one species of plume ions.

The first part of our study aims to understand basic physical processes involved in the Enceladus plasma interaction. The dependency of the large-scale interaction on the different ionization mechanisms in the plume is discussed: Electron impact and SUV ionization lead to an increase in the net mass of the plasma (mass loading), going along with the formation of a dense pick-up tail in the downstream region. In contrast to this, no net mass is added to the magnetospheric plasma when charge exchange is considered the primary ionization mechanism (momentum loading). Our simulations reveal a clear density enhancement downstream of Enceladus, possessing a highly asymmetric, three-dimensional structure. Moreover, depending on the extension of the neutral plume, a pronounced north-south asymmetry can be seen in the Alfven wing system that is triggered by the interaction.

In the second part, we present a quantitative analysis of time variability in Enceladus' plasma interaction, as observed by the Cassini spacecraft during the 2005 and 2008 flybys. We quantitatively discuss the influence of changes in plasma density and flow speed (sub-corotation vs. corotation) on the strength of the interaction. In addition, we provide constraints for the neutral density in the plume for all flybys by comparing our simulation results to Cassini MAG data.