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Hybrid simulation of the Ganymede's magnetosphere: comparison with the Galileo observations and predictions for the JUICE mission

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Abstract

Ganymede is a unique object: it is the biggest moon of our solar system, and the only satellite which has its own intrinsic magnetic field leading to the formation of a small magnetosphere. The magnetosphere of Ganymede being embedded in the Jovian magnetosphere, the environment of the Galilean moon presents the only known case of interaction between two magnetospheres (Kivelson et al. 1996). To modelize this peculiar interaction, we developped a 3D parallel multi-species hybrid model based on a CAM-CL algorithm (Mathews et al. 1994) which has been largely used for other magnetized or unmagnetized bodies such as Mars, Titan or Mercury.

In this model, ions have a kinetic description whereas electrons are considered as an inertialess fluid which ensure the neutrality of the plasma and contribute to the total current and electronic pressure. Maxwell's equations are solved to compute the temporal evolution of electromagnetic field. The Jovian magnetospheric plasma is composed of O+ and H+, and the intrinsic Ganymede's magnetic field is implemented at initialization as a dipolar field with a magnetic moment taken from (Kivelson et al. 2002). The planetary plasma included in the simulation is composed of ionospheric O+ and H+. In a first attempt, the ionospheric plasma is loaded at the initialization of the simulation with a total density at the surface and a scale height of 125 km in agreement with Paty and Winglee et al. (2004). In addition, neutral corona of atomic hydrogen and molecular hydrogen is included in the simulation. This neutral environment is partly ionized by solar photons, electron impacts and charge exchange reactions between the magnetospheric ions and the neutral coronae.

During different flybys of Ganymede by the spacecraft Galileo in 1996, the Galileo magnetometer measured the magnetic field of the moon. In order to compare the results of our model with the in-situ observations of Galileo, we consider the observations conditions of different flybys in the model. We also present predictions of the environment that should be encountered by the JUICE (Juice ICy Moon Exploration), in term of density, magnetic field, energy distributions and fluxes of impacting particles.

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