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Ion Circulation and Precipitation at Ganymede

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Abstract

We modelled the interaction of the Jupiter plasma sheet ions (H^+, O^+ and S^+) with the magnetosphere of Ganymede, via a series of Monte Carlo simulations based on the magnetic and electric fields derived from an MHD model [1]. This approach allows to analyse the ion circulation and their precipitation to the moon's surface taking into account the finite gyroradius effect, which is energy dependent. The study spans over several ion energies (1, 5, 10, 50 and 100 keV) and considers Ganymede in 3 different orbital configurations, corresponding to the Galileo spacecraft G2, G8 and G28 flybys.

1. Introduction

Ganymede, is characterized by a tiny magnetosphere produced by an intrinsic magnetic moment, which is tightly linked to the Jovian magnetosphere and embedded in its energetic plasma environment. Since the plasma co-rotating with Jupiter impinges on Ganymede trailing side at subsonic speed, there is no bow-shock formation, oppositely as usually happens in the case of solar wind – magnetosphere interaction.

Hydrogen, oxygen and sulphur are the dominant ion populations of the Jupiter Plasma Sheet (JPS). We performed a series of Monte Carlo simulations for each ion species, at 1, 5, 10, 50 and 100 keV, in order to describe their circulation around Ganymede and their precipitation to its surface. Particle tracking is achieved on the base of the magnetic and electric field data derived via an MHD model [1], which has been shown to reproduce with high fidelity the magnetic field and plasma measurements on multiple Galileo flybys of Ganymede. The set of MHD simulations were computed for 3 different orbital configurations: namely, when Ganymede is above, within, and below the plasma sheet, as observed during the Galileo spacecraft flyby G2, G8 and G28, respectively.

We use a 20×20×20 R_G simulation box, centred on the moon (with R_G = 2634 km being the moon's radius). To mimic the ion flow of the JPS (co-rotating with Jupiter faster than Ganymede along its orbit) that overtakes and embeds the moon, we place a planar source surface perpendicular to the moon's orbit, located 3 R_G upstream of Ganymede (the standoff distance of Ganymede's magnetopause is ~ $2R_G$). The source surface is subdivided into 0.2 × 0.2 R_G cells, and 1000 test particles are randomly launched from each cell along the local JPS flow direction, simulating a total of about 10^7 ions in each run. The computed H^+, O^+ and S^+ ion fluxes are then scaled to the values observed by Galileo, in Ganymede's environment [2].

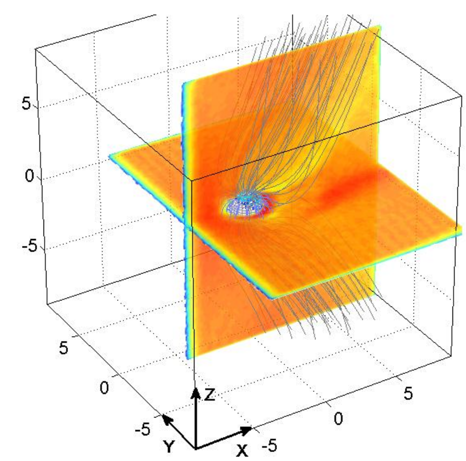

Figure 1: shows the simulation box, with computed O^+ flux at 10 keV and magnetic field lines from the MHD model (G8 flyby), in the standard "GphiO“ coordinate system.

6. Summary and Conclusions

The analysis of the H^+, O^+ and S^+ precipitation patterns shows that on the trailing hemisphere (-X direction) the ion precipitation takes place in relatively high latitudes, while in the leading hemisphere (+X direction) it extends to near-equator latitudes. As a rule, the precipitation regions widens as the ion mass and the energy increase, as the finite-gyroradius effect becomes more and more important. Under the assumption that the test particles can be reflected back from both the top and the bottom of the simulation box (to compensate the ion loss from the box itself) we found a significant increase of the ion precipitation on the Ganymede's surface, especially in the polar cap areas.

References

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