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Energetic ion depletions near the Galilean moons: atmospheric interaction and indications of the charge state

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Introduction

The flux of energetic ions (protons, oxygen and sulfur) near the Galilean moons were measured by the Energetic Particle Detector (EPD) on the Galileo mission (1995 - 2003). Near Galilean moons (such as Io and Europa) depletions of the energetic ion flux, of several orders of magnitude, are observed.

Such energetic ion depletions can be caused by the precipitation of these particles onto the moon's surface or charge exchange with the neutral atmosphere. To interpret the depletion features in the EPD data, a Monte Carlo particle tracing code has been developed [1]. The expected flux of the energetic ions is simulated under different scenarios including those with and without an atmosphere. By comparing the simulated distribution to the data the cause of the depletion features can be investigated.

Furthermore, the spatial extent of high-energy ion depletions depends on the gyroradius of the energetic ions. Thus, the observed depletion regions can constrain the charge state of the energetic ions.

Results

From a case study the Europa E12 flyby, the following results have been obtained from the comparison of the data and simulations:

- The simulation without the atmosphere can not reproduce the observed depletion of energetic proton flux in the energy range of 80-220 keV. This suggests that the observed depletion features cannot be solely attributed to the absorption by the surface, and therefore, this finding is a strong support that Europa possesses an atmosphere.

- An observed depletion feature for energetic protons (540-1040 keV) is neither consistent with simulation results of an atmosphere-less body nor an isotropic atmosphere. This difference between data and simulation support an active plume, as previously discussed in magnetic field data [2] .

- Simulations of the depletions of singly charged energetic oxygen particles (416-1792 keV) result in a larger depletion region compared to the spatial extent of the depletion in the Galileo measurements. This indicates that near Europa the energetic oxygen ions are multiple charged.

Additionally, a comparison is made of the energetic ion depletions during other flybys, namely, Europa flyby E26 and Io flyby I27. During E26, depletions of energetic protons (540-1040 keV) are consistent with the atmospheric Europa, while non-existence of the atmosphere cannot be excluded since the charge exchange cross section at these energies (540-1040 keV) is very low.

References

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