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Jovian Magnetospheric Plasma and Energetic Particle Interaction with Ganymede's Magnetic Field and Surface

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Abstract

The Galileo Orbiter flybys of Ganymede revealed a rich variety of features associated with the newly discovered intrinsic dipolar magnetic field of Ganymede. Dropouts in plasma flows clearly indicated transitions from Jovian to Ganymedian magnetospheric domains. Transitions from open polar to closed field lines were probed by directional distributions of energetic particles. Numerical modeling predicted strong magnetic shielding of the equatorial region against penetration by energetic electrons and protons below 10 MeV. We review comparisons of time histories, moments, and directional distributions for data from the Galileo Plasma Spectrometer (PLS) and Energetic Particle Detector (EPD) instruments to survey these magnetic and surface interaction features. The earlier numerical models for particle penetration to the surface in the open and closed field regions are updated from parameters provided by the combined analysis. Orbit phase variations and time-averages of penetrating particle energy fluxes are modeled for orbiting spacecraft such as the planned Juice Icy Moons Explorer (JUICE).

1. Introduction

The Galileo Orbiter flybys revealed the intrinsic dipole field of Ganymede both through direct magnetometer measurements [1,2] and via loss cone signatures in the energetic particle data. Open field lines with footpoints at one pole showed unidirectional loss cones, closed dipolar field lines dual surface footprints showed bidirectional loss cones [3,4,5]. Plots of angular distributions from low-energy EPD data show these unidirectional to bidirectional loss cone transitions with increasing magnetic field contributions from the intrinsic dipole. Although an early vacuum superposition model [6] for the internal and external field components indicated that strong corotational electric field could drive convective plasma flows into the mini-magnetosphere, the PLS data discussed here for comparison to EPD data clearly show density dropouts associated with reduced convective electric fields. The comparison of PLS and EPD data can be used to further elucidate the structure of the min-magnetosphere and its boundaries with the external jovian magnetospheric environment for constraints on improved modeling of the mini-magnetosphere.

2. Data Analysis and Modeling

We compare the time histories of PLS plasma moments and angular distributions from selected EPD channel fluxes for each Galileo flyby to survey the morphology of the Jupiter-Ganymede magnetospheric interactions. These PLS-EPD signatures are compared to an existing magnetic field model [7] with boundaries previously determined from EPD data and now additionally from PLS data. The EPD-derived mini-magnetospheric model, and limits on corotational electric fields from PLS data , are used to update the earlier modeling work [6] on jovian energetic particle penetration to the moon surface within the open and closed field line regions. Additionally we plan to compute penetrating particle fluxes versus orbital phase and as time averages for different Ganymede spacecraft orbits, as for JUICE.

3. Conclusions

Ganymede offers a fascinating opportunity to study the interaction of a mini-magnetosphere for a giant planet moon imbedded within the largest planetary magnetosphere of our solar system. Detailed comparisons of plasma and energetic particle signatures are available from the Galileo Orbiter flybys to define empirically the transitional layers for comparison to and constraints of Ganymede mini-magnetosphere models. Improved modeling of penetrating particle fluxes can also be used to parameterize the orbital phase and time-averaged irradiation environment for future missions to Ganymede such as JUICE. We finally consider low-altitude equatorial orbits as low-radiation vantage points for Jupiter system observation platforms.

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