Geophysical Research Abstracts
Vol. 13, EGU2011-5108-1, 2011
EGU General Assembly 2011

Plasma IMS Composition Measurements for Europa, Ganymede and the Jovian System

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NASA and ESA are planning the joint Europa Jupiter System Mission (EJSM) to the Jupiter system with specific emphases on Europa and Ganymede from these respective space agencies. The Japanese Space Agency, JAXA, is also planning an orbiter mission to explore Jupiter's magnetosphere and the Galilean satellites. As per the 2010 Joint Jupiter Science Definition Team Report to NASA, the Particle and Plasma Instrument (PPI) and Ion Neutral Mass Spectrometer (INMS) have numerous complementary goals and requirements. The overlap of requirements will be discussed. For NASA's Jupiter Europa Orbiter (JEO), using Astrobiology Instrument Development (ASTID) funds, we are developing the 3D Ion Mass Spectrometer (IMS) designed to measure both major and minor ion species within the high radiation environment of Jupiter's magnetosphere with principal focus on Europa. The IMS covers the energy range from 10 V to 30 kV, wide field-of-view (FOV) capability and 10 - 60 sec time resolution for major ions as required. This instrument development has two main goals which can also be applied to the other Galilean moons, 1) measure the plasma interaction between Europa and Jupiter's magnetosphere and 2) infer the global surface composition to trace elemental and significant isotopic levels. The first goal supports the magnetometer (MAG) measurements, primarily directed at detection of Europa's sub-surface ocean, while the second goal gives information about transfer of material between the Galilean moons, between the moon surfaces, and vertically between subsurface layers putatively including oceans. The measurement of the interactions for all the Galilean moons can be used to trace the in situ ion measurements of pickup ions back to either Europa's or Ganymede's surface from the respectively orbiting spacecraft. The IMS instrument would maximally achieve plasma measurement requirements for JEO and EJSM while moving forward our knowledge of Jupiter system composition and source processes to far higher levels than previously envisaged.

The surface composition and the cold outgased exospheric material confined near the surface are probed by the IMS by measuring pickup ions accelerated up to spacecraft altitudes of $\sim$ 100 - 200 km by the magnetospheric electric fields extending down to the surface. Using a 3D hybrid model of the moon-magnetosphere interaction based on PPI measurements, one is able to construct 3D global model of electric and magnetic fields around these bodies. Pickup ion trajectories can then be traced back down to the surface. In the case of Europa we show that Europa's ionosphere is dominated by pickup ions with 100 - 1000 eV temperatures and excursions to a "classical" cold ionosphere for the INMS are expected to be infrequent. We also expect field aligned polar ion outflows driven by ionospheric electrons via polarization electric field for Europa; the IMS will observe such outflows and thus sample the ionosphere below spacecraft orbit altitude $\sim$ 100 km. As per the PPI design for the strawman science payload of JEO, optimum science data return is assured when IMS is operated in conjunction with plasma electron and energetic ion-electron sensors. The spatially and temporally varying orbital radiation environment of Europa also requires continuous monitoring of penetrating radiation fluxes to support PPI and other instrumental measurements.