MAGNETOSPHERE IMAGING INSTRUMENT (MIMI) ON THE CASSINI MISSION TO SATURN/TITAN

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Abstract. The Magnetospheric Imaging Instrument (MIMI) is a neutral and charged particle detection system on the Cassini Orbiter spacecraft designed to perform both global imaging and in situ measurements to study the overall configuration and dynamics of Saturn's magnetosphere and its interactions with the solar wind, Saturn's atmosphere, Titan, and the icy satellites. The processes responsible for Saturn's aurora will be investigated; a search will be performed for substorms at Saturn; and the origins of magnetospheric hot plasmas will be determined. Further, the Jovian magnetosphere and Io torus will be imaged during Jupiter flyby. The investigative approach is twofold: (1) Perform remote sensing of the magnetospheric energetic ($E > 7$ keV) ion plasmas by detecting and imaging charge-exchange neutrals, created when magnetospheric ions capture electrons from ambient neutral gas. Such escaping neutrals were detected by the Voyager l spacecraft outside Saturn's magnetosphere and can be used like photons to form images of the emitting regions, as has been demonstrated at Earth. (2) Determine through in situ measurements the 3-D particle distribution functions including ion composition and charge states ($E >$ 3 keV/e). The combination of in situ measurements with global images, together with analysis and interpretation techniques that include direct "forward modeling" and deconvolution by tomography, is expected to yield a global assessment of magnetospheric structure and dynamics, including (a) magnetospheric ring currents and hot plasma populations, (b) magnetic field distortions, (c) electric field configuration, (d) particle injection boundaries associated with magnetic storms and substorms, and (e) the connection of the magnetosphere to ionospheric altitudes. Titan and its torus will stand out in energetic neutral images throughout the Cassini orbit, and thus serve as a continuous remote probe of ion flux variations near 20 R_S (e.g., magnetopause crossings and substorm plasma injections). The Titan exosphere and its cometary interaction with magnetospheric plasmas will be imaged in detail on each flyby. The three principal sensors of MIMI consists of an Ion and Neutral Camera (INCA), a Charge-Energy-Mass-Spectrometer (CHEMS) essentially identical to our instrument flown on the ISTP/Geotail spacecraft, and the Low Energy Magnetospheric Measurements System (LEMMS), an advanced design of one of our sensors flown on the Galileo spacecraft. The INCA head is a large geometry

factor ($G \sim 2.4$ cm^2 sr) foil time-of-flight (TOF) camera that separately registers the incident direction of either energetic neutral atoms (ENA) or ion species (≥5° full width half maximum) over the range 7 keV/nuc < E < 3 MeV/nuc. CHEMS uses electrostatic deflection, TOF, and energy measurement to determine ion energy, charge state, mass, and 3-D anisotropy in the range $3 \leq E \leq 220$ keV/e with good (~0.05 cm^2 sr) sensitivity. LEMMS is a two-ended telescope that measures ions in the range $0.03 \leq E \leq 18$ MeV and electrons $0.015 \leq E \leq 0.884$ MeV in the forward direction (G ~ 0.02 cm^2 sr), while high energy electrons (0.1–5 MeV) and ions (1.6–160 MeV) are measured from the back direction ($G \sim 0.4$ cm^{2}sr). The latter are relevant to inner magnetosphere studies of diffusion processes and satellite microsignatures as well as cosmic ray albedo neutron decay (CRAND). Our analyses of Voyager energetic neutral particle and Lyman-α measurements show that INCA will provide statistically significant global magnetospheric images from a distance of ~60 R_S every 2–3 hours (every ~10 min from ~20 R_S). Moreover, during Titan flybys, INCA will provide images of the interaction of the Titan exosphere with the Saturn magnetosphere every 1.5 min. Time resolution for charged particle measurements can be <0.l s, which is more than adequate for microsignature studies. Data obtained during Venus-2 flyby and Earth swingby in June and August 1999, respectively, and Jupiter flyby in December 2000–January 2001 show that the instrument is performing well, has made important and heretofore unobtainable measurements in interplanetary space at Jupiter, and will likely obtain high-quality data throughout each orbit of the Cassini mission at Saturn. Sample data from each of the three sensors during the August 18 Earth swingby are shown, including the first ENA image of part of the ring current obtained by an instrument specifically designed for this purpose. Similarily, measurements in cis-Jovian space include the first detailed charge state determination of Iogenic ions and several ENA images of that planet's magnetosphere.

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