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Juno's Magnetometer Investigation: Early Results

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Abstract

After nearly 5 years in space, the Juno spacecraft entered polar orbit about Jupiter on July 5 (UTC), 2016, in search of clues to the planet's formation and evolution. Juno probes the deep interior with measurements of Jupiter's magnetic and gravitational potential fields, and peers beneath the visible clouds at microwave frequencies to characterize water and ammonia abundance to depths of ~1000 atmospheres.

Juno's baseline mission plan [6] was designed, in part, to wrap the planet in a dense net of observations in close proximity, approximating measurements on a closed surface about the source (Fig 1), ideal for characterizing potential fields [8].

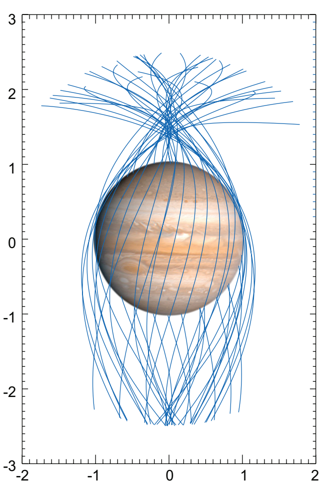

Figure 1: Juno wraps the planet in a dense net of observations, with 32 passes to within ~1.06 R_j.

Repeated periapsis passes will eventually wrap the planet with observations equally spaced in longitude (<12° at the equator), optimized for characterization of the Jovian dynamo. Such close passages are sensitive to small spatial scale variations in the magnetic field and a large number of such passes is required to bring the magnetic field into focus. The first few periapsis passes have revealed a magnetic field rich in higher harmonic content, suggestive of magnetic dynamo action not far beneath the surface [7,13]. It is perhaps not surprising that the field observed in close proximity to the planet is very different from that predicted by existing models, necessarily limited to low harmonic degree and order.

Juno was also required to duck beneath Jupiter's hazardous radiation belts, and orbit in a plane close to Jupiter's rotation axis, providing frequent transits of the northern and southern auroral ovals. These and other considerations led to a polar orbit with a period of 53.5 days and apoapsis at ~100 R_j radial distance, affording an unprecedented opportunity to explore Jupiter's polar magnetosphere [2]. Thus Juno is also instrumented to characterize particles and fields in the polar magnetosphere [11,12] and to acquire images and spectra of its polar auroras in the infrared [1] and ultraviolet [9]. Juno also carries a visible (and methane band) imager intended primarily for education and public outreach [10].

The magnetic field investigation (MAG) [8] is equipped with two magnetometer sensor suites, located 10 & 12 m from the center of the spacecraft at the end of one of Juno's three solar panel wings. Each contains a vector fluxgate magnetometer (FGM) sensor and a pair of co-located non-magnetic star tracker camera heads, providing accurate attitude determination for the FGM sensors. These cameras monitor the distortion of the mechanical appendage (solar array and MAG boom) in real time, allowing accurate attitude reconstruction for the FGM sensors to ~20 arcsec throughout the mission [8].

These heavily-shielded camera heads must recognize stars in the presence of penetrating radiation and in so doing also provide a record of penetrating radiation (primarily electrons with energies >10 MeV) with significant science value [3,4]. One of the star cameras also continuously monitors the presence of objects in the field of view that are not among the objects in an on-board star catalog (Non-Stellar-Objects) and stores this information for subsequent retrieval. This capability has allowed us to track ejecta from the spacecraft liberated by the high-velocity (~10 km/s) impacts of interplanetary dust particles (IDPs) detected during cruise from Earth to Jupiter [5]. The same autonomous tracking capability also affords an opportunity to detect and characterize objects in orbit about Jupiter, ranging in size from microns (detected via spacecraft ejecta) to meters (imaged as they transit the FOV).

We present an overview of the magnetic field observations obtained during the first few polar orbits in context with prior observations and those acquired by Juno's other science instruments. We also discuss observations of dust particles encountered both during cruise from Earth to Jupiter and near the Jovian equator. Juno transits the Jovigraphic equator at high speed (60 km/s) and collisions with dust grains vaporize both the grain and part of the Juno spacecraft at the impact site, creating a hot, ionized gas and particulate ejecta. The MAG investigation camera head tracks particle ejecta of sufficient size, if passing through the FOV, while the Waves records the electrical response of the spacecraft, awash in the expanding plasma cloud. The Waves investigation is capable of detecting the numerous impacts of micron-sized dust particles, likely moving inward from Jupiter's ring [14], whereas the camera head detects ejecta liberated by (presumably) less numerous and more massive dust particles.

References

[1] Adriani, A., Filacchione, G., Di lorio, T., et al.: JIRAM, the Jovian infrared auroral mapper, *Space Sci. Rev.,* doi 10.1007/s11214-014-0094-y.

[2] Bagenal, F., Adriani, A., Allegrini, F., et al.: Magnetospheric science objectives of the Juno mission, *Space Sci. Rev*., doi 10.1007/s11214-014-0036-8.

[3] Becker, H.N., Alexander, J. A., Adriani, A. et al.: The Juno Radiation Monitoring (RM) Investigation, *Space Sci. Rev.,* doi: 10.1007/s11214-017-0345-9, 2017.

[4] Becker, H. N., Santos-Costa, D., Jørgensen, J. L., et al.: Observations of high energy electrons in Jupiter's innermost radiation belts and polar regions by the Juno radiation monitoring investigation: Perijoves 1 and 3, *Geophys. Res. Lett.*, doi: 10.1002/2017GL073091, 2017.

[5] Benn, M., Jorgensen, J. L., Denver, T., et al.: Observations of interplanetary dust by the Juno magnetometer investigation, *Geophys. Res. Lett*., in press, 2017.

[6] Bolton, S. J. and the Juno Science Team (2010). The Juno mission. *Proceedings of the International Astronomical Union Symposium,* No**. 269:** 92-100.

[7] Bolton, S. J., Adriani, A., Adumitroaie, V., et al.: Jupiter's interior and deep atmosphere: the first pole-to-pole pass with the Juno spacecraft, *Science*, doi: 10.1126/science.aal2108, 2017.

[8] Connerney, J. E. P., Benn, M., Bjarno, et al. (2017) The Juno Magnetic Field Investigation, *Space Sci. Rev.,* doi: 10.1007/s11214-017-0334-z.

[9] Gladstone, G. R., Persyn, S. C., Eterno, J. S., et al.: The untraviolet spectrograph on NASA's Juno mission, *Space Sci. Rev*., doi: 10.1007/s11214-014-0040-z.

[10] Hansen, C. J., Caplinger, M. A., Ingersoll, A., et al.: Junocam: Juno's outreach camera, *Space Sci. Rev.,* doi: 10.1007/s11214-014-0079-x.

[11] Mauk, B. H., Haggerty, D. K., Jaskulek, S. E., et al.: The Jupiter Energetic Particle Detector Instrument (JEDI) Investigation for the Juno Mission, *Space Sci. Rev.*, doi: 10.1007/s11214-013-0025-3.

[12] McComas, D. J., Alexander, N., Allegrini, F., et al.: The Jovian auroral distributions experiment (JADE) on the Juno mission to Jupiter, *Space Sci. Rev.,* doi:10.1007/s11214-013-9990-9.

[13] Moore, K. M., Bloxham, J., Connerney, J. E. P., et al.: The analysis of initial Juno magnetometer data using a sparse magnetic field representation, *Geophys. Res. Lett.*, in press, 2017.

[14] Connerney, J. E. P., Adriani, A., Allegrini, F., et al., Jupiter's Magnetosphere and Aurorae Observed by the Juno Spacecraft During its First Polar Orbits, *Science,* 10.1126/science.aam5928, 2017.