EPSC Abstracts
Vol. 12, EPSC2018-188, 2018
European Planetary Science Congress 2018

Juno Maps Jupiter's Planetary Magnetic Field

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Abstract

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, acquired during close periapsis passes that occur every ~53 days. Thus far, Juno has acquired 15 of the planned 34 orbits needed to complete its global map.

Juno's baseline mission plan [1,3] 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 [5].

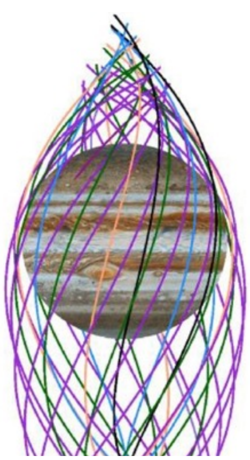

Figure 1: Juno wraps the planet in a dense net of observations, with 34 passes to within ~1.06 R_j.

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 9 periapsis passes revealed a magnetic field rich in higher harmonic content [7], suggestive of magnetic dynamo action not far beneath the surface [4,7,8]. 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.

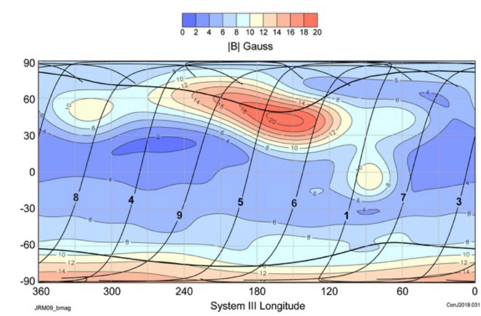

Figure 2: Magnetic field magnitude on the flattened surface of Jupiter computed using the JRM09 model magnetic field, based on Juno's first nine (numbered) orbits. Unlabeled curve shows the path of the Io flux tube footprint in both hemispheres.

The magnetic field investigation (MAG) [5] 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 [5]. They have also proven valuable in characterizing dust impacts on the Juno spacecraft as it transited the solar system en route to Jupiter [2].

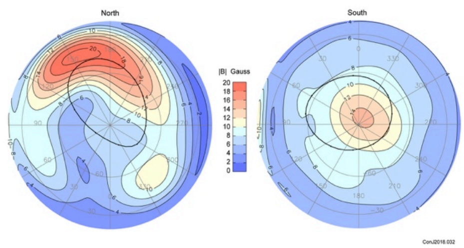

Figure 3: Orthographic projection of the magnetic field magnitude computed using the JRM09 magnetic field model on Jupiter's flattened surface. Ovals show the path of the Io flux tube footprint computed using the same model.

Jupiter's planetary magnetic field is modeled using a spherical harmonic representation of the internal magnetic field, combined with an explicit model of the field due to external currents (Jovian magnetodisc) [7]. Thus far in the mission, global coverage remains rather sparse, so we solve the inverse problem using generalized inverse methods that allow a partial solution to a high-degree spherical harmonic expansion for the internal field. Thus far, spherical harmonic coefficients through degree and order 10 can be resolved, using a basis model through degree 20, required to follow spatial variations on the field observed during close passage.

Jupiter's magnetic field at current resolution is remarkable in its hemispherical asymmetry, with the northern hemisphere characterized by abundant non-dipolar fields and the southern hemisphere very dipolar in appearance (see figure 3). The field geometry also dictates interesting charged particle motions in close proximity to the planet, with drift shells lacking closure external to the planet at equatorial field strengths of ~2 Gauss. We present an overview of the magnetic field observations obtained during the first two years of Juno's mapping mission in context with prior observations and those acquired by Juno's other science instruments.

References

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