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Jupiter's Magnetic Field and Magnetosphere at the Midpoint of Juno's Mapping Mission

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Abstract

The Juno spacecraft entered polar orbit about Jupiter in July 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 occurring every ~53 days. As of this date, Juno has acquired 22 of the planned 34 polar orbits in the baseline mission plan. We present the current status of Jupiter's magnetic field and magnetosphere at the midpoint of Juno's mapping mission.

1. Introduction

Juno's mission plan [1,3] wraps Jupiter in a dense net of vector magnetic field observations, approximating knowledge on a closed surface about the source (Fig 1), ideal for characterizing a potential field [5].

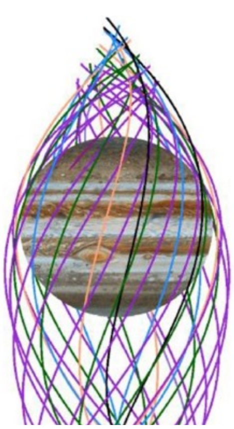

Figure 1: Periapsis portion of Juno's 34 polar orbits, passing to within ~1.06 R_j of the planet's surface.

The mission plan was designed to acquire this global coverage systematically, first mapping the planet with 8 equally spaced polar passes separated by 45° longitude, then 16 passes separated by 22.5°, and finally 32 passes separated by 11.25° (with spares).

2. Magnetic Field Models

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 head units (CHU), providing accurate attitude determination for the FGM sensors.

Close passages over Jupiter's cloud tops 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 (8 with science observations) provided enough coverage to constrain spherical harmonic coefficients of the internal field to degree and order 10, extracted from a 20 degree spherical harmonic representation [7] via application of a generalized inverse methodology that allows partial solution of underdetermined inverse problems. This model ("JRM09", for Juno reference model after 9 orbits) revealed a complex magnetic field rich in harmonic content, suggestive of magnetic dynamo action not far beneath the surface [3,7,10].

With 17 periapsis passes separated by 22.5° longitude, we can at the mid-point of Juno's mapping mission extend the spherical harmonic model to degree and order 12 (Figure 2).

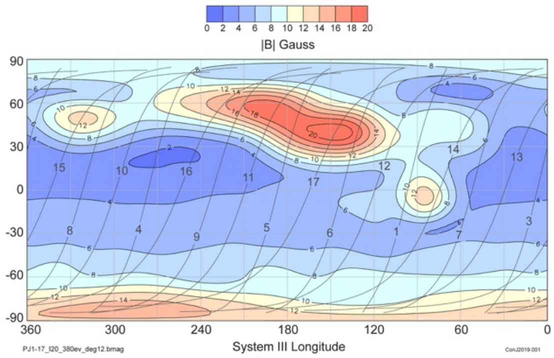

Figure 2: Magnetic field magnitude on the flattened surface of Jupiter computed using a degree and order 12 spherical harmonic expansion, based on Juno's first 17 (numbered) orbits.

Jupiter's magnetic field at current resolution is unlike that of any other planet, evidencing a complexity that portends great insight into the dynamo process in general [11] and the dynamics of Jupiter's interior in particular**.** A dramatic hemispherical asymmetry is evidenced in a very non-dipolar magnetic field in the northern hemisphere, and a dipolar magnetic field south of the equator, where an enigmatic "Great Blue Spot" [7, 10, 11] resides within an equatorial band of opposite polarity (see figure 3).

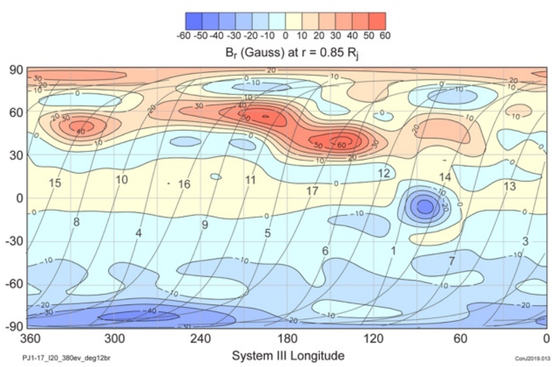

Figure 3: Radial magnetic field computed using a degree 12 spherical harmonic model of the field contoured on a surface at 0.85 Rj.

Jupiter's magnetic field is likely sculpted by differential rotation of its belts and zones [12], extending to depths of few thousand km [8,9] where the electrical conductivity of its molecular hydrogen atmosphere grips field lines [4].

3. References

[1] Bagenal, F., Adriani, A., Allegrini, F., et al. (2013): Magnetospheric science objectives of the Juno mission, *Space Sci. Rev*., doi 10.1007/s11214-014-0036-8.

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

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

[4] Cao, H., and Stevenson, D. J. (2017): Zonal flow magnetic field interaction in the semi- conducting region of giant planets. *Icarus* 296, 59-72.

[5] 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.

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

[7] Connerney, J.E.P., Kotsiaros, S., Oliversen, et al., (2018). A new model of Jupiter's magnetic field from Juno's first nine orbits. *Geophysical Research Letters, 45,* doi: 10.1002/2018GL077312.

[8] Guillot, T., Miguel, Y., Militzer, B., et al., (2018): A suppression of differential rotation in Jupiter's deep interior. *Nature, 555,* 227-230, doi: 10.1038/nature25775.

[9] Kaspi, Y., Galanti, E., Hubbard, W.B., et al. (2018): Jupiter's atmospheric jet-streams extend thousands of kilometers deep. *Nature,* 555, 223-226, doi:10.1038/nature25793.

[10] Moore, K. M., Bloxham, J., Connerney, J. E. P., et al. (2017): The analysis of initial Juno magnetometer data using a sparse magnetic field representation, *Geophys. Res. Lett.*, *44,* doi: 10.1002/2017GL073133.

[11] Moore, K. M., Rakesh, Y., Kulowski, L., et. al. (2018). A complex dynamo inferred from the hemispheric dichotomy of Jupiter's magnetic field, *Nature*, 561, 76-78, doi:10.1038/s41586-018-0468-5.

[12] Moore, K. M., H. Cao, J. Bloxham, D. J. Stevenson, J. E. P. Connerney, and S. J. Bolton (2019): Time-variation of Jupiter's internal magnetic field consistent with zonal wind advection, *Nature Astronomy*, doi:10.1038/s41550-019-0772-5.