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Jupiter's magnetic field morphology: Implications for the dynamo

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Abstract

Now that the NASA Juno Mission has collected magnetometer data from over eight evenly spaced pole-to-pole passes, we can examine Jupiter's global magnetic morphology. The two hemispheres are distinctly different, with a strong localized band of flux in the north, compared to a smoother and weaker dipolar flux in the southern hemisphere. Low flux over the North Pole, and a large spot of equatorial flux (the Great Blue Spot) are also apparent. We discuss the implications of these observed features for Jupiter's dynamo and interior.

1. Introduction

As of late 2017, the NASA Juno Mission [1, 2] has collected magnetic field data from 8 orbital passes. Due to Juno's near polar orbit around Jupiter, the roughly equal longitudinal spacing of the orbits and, most importantly, the close approach distance to Jupiter's dynamo (within about 20% of the planetary radius) these data provide an unprecedented view of an active dynamo. The initial results reveal an unexpected field morphology [3, 8].

2. Field Morphology

Before data collected by the NASA Juno Mission, models of Jupiter's magnetic field [4, 9] closely resembled Earth's field—a strong, tilted dipole. Juno data might have been expected to reveal progressively smaller-scale structure in the field, with the same overall structure. However, the morphology we now see is striking and unexpected. Figure 1 shows maps of Jupiter's magnetic field from a model, JRM09 [3]. Several distinctive features are visible, with important dynamo implications [8]. We describe them below.

First, at the top of the nominal dynamo region, we see large-scale field organization. Flux emerges from Jupiter's northern hemisphere in a relatively narrow band around 45 degrees N, and stretches across about 270 degrees of longitude. In contrast, in the southern hemisphere we see flux re-enter over a large diffuse region, in which the maximum radial flux is only a third of that seen in the northern hemisphere. Elsewhere (except near the equator), the radial field is much weaker. We see strong evidence of locally reduced (and possibly reversed) flux near the North Pole (see also [5, 6, 7]).

At the equator we see an extraordinarily intense and localized spot of negative flux (the Great Blue Spot, first seen by [7]), in which the radial flux is three times stronger than any other negatively signed flux. While the JRM09 model accounts for Jupiter's magnetodisc field, we note there may be additional unmodeled auroral currents or external field effects. However, these are unlikely to affect the overall morphology described here.

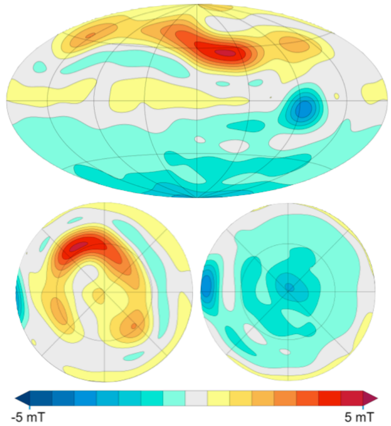

Figure 1: This figure shows the radial magnetic field from the degree 10 spherical harmonic model JRM09 at 0.85 RJ (with Jupiter radius RJ = 71492km). The upper map is centered on 180° W (System III 1965 coordinates). The left (right) maps show the northern (southern) hemisphere in a Lambert azimuthal equal-area projections.

3. Conclusions

In our presentation, we discuss the initial dynamo implications of Jupiter's magnetic field morphology. However, the full 32 orbits planned for Juno will be necessary to reveal these features more fully.

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