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Jupiter's magnetic field & Io-related decameter radiation

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Abstract

The Io-dependent radio emissions from Jupiter ought to originate along magnetic field lines linking Io to the Jovian ionosphere. If these emissions occur at or below the electron gyrofrequency, they ought to be limited in frequency extent by the magnetic field magnitude at the foot of the Io Flux Tube (IFT), a subject of much interest since the 1980's. The lack of agreement between the frequency extent of Io-related decameter radiation and those predicted by Jovian magnetic field models has been hotly debated. In this study we show how the newly proposed magnetic field model (JRM09) can explained these radio emissions. Additionally, the beaming angle of the hollow cone of emission and the altitude of the generation of the decameter radio emissions are estimated and discussed.

1. Main text

Two main forms of decametric radio emissions are observed from Jupiter: S bursts and L emissions. The first one is very brief (ms) and intense (S bursts) comprising very discrete spectral components with very narrow bandwidth. The second emission is smoother, with longer duration (seconds) with a broad frequency bandwidth (L emissions). Statistical studies of the peak frequencies of the Io-related decameter radio emissions compared with the electron cyclotron frequencies at the foot of the Io field line have been performed by several authors (e.g. [4,6]), reporting a delay of up to 70^o between the two. Different hypotheses have been proposed to explain the delay including an Alfven-wave propagation through the Io plasma torus and the existence of an extended magnetotail for Io [4].

In addition, other options to reconcile the observations with a Jovian magnetic model include obtaining and constraining a magnetic model itself using the peak frequencies of the radio emission observations (e.g. VIPAL model [5]) as a constraint on the surface magnetic field magnitude. However, this kind of constraint may provide good agreement in specific locations where the constraint is applied but such models may lead to very inaccurate estimates of the field in other regions of Jupiter (e.g., regions lacking either direct observations or constraints).

Very recently, a new magnetic field model of Jupiter's planetary field has been proposed, JRM09 [2], using observations from the Juno spacecraft's first nine orbits. Juno is currently orbiting Jupiter every 53 days with the intention of collecting a dense global net of potential field data (among others) at close radial distances never measured before [3].

The JRM09 model represents a partial solution to a degree 20 spherical harmonic expansion, yielding coefficients through degree 10 with adequate resolution. This high-resolution model yields magnetic field magnitudes of up to 20 G along the IFT footprint, substantially higher than previous models. Using the JRM09 field model, we compare the observed frequency peak of Io-related decameter radiation with the gyrofrequency (f_c (MHz) = 2.8·B (Gauss)) at the foot of the Io field line predicted by the new model (Figure 1). This shows that all the L emissions and the S bursts can be explained by the cyclotron frequencies, except possibly for the few observations located around 60^o Io longitude where the field magnitude drops precipitously.

We note with interest that the observed maximum frequency of emission appears offset from that appropriate to the IFT foot, either vertically, or equivalently, in system 3 longitude. This may be related to a combination of lead angle, emission cone angle, and altitude of emission, to be determined.

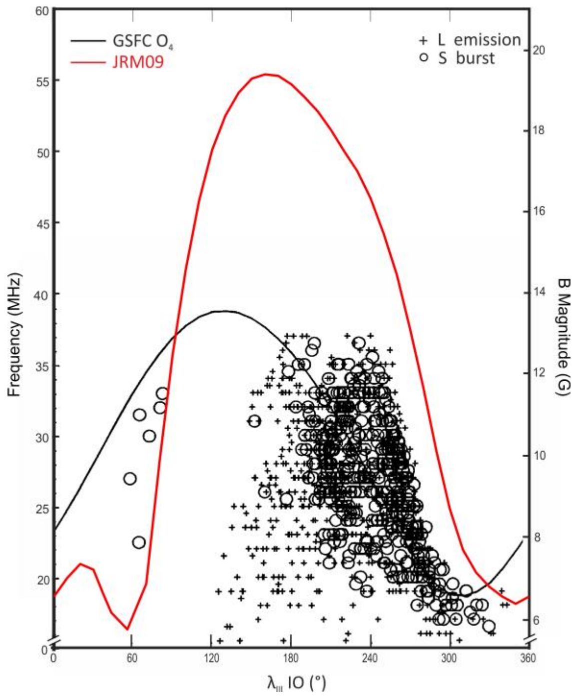

Figure 1. Comparison of the peak frequencies of the Io-related decameter radiation (S bursts and L emissions) and the gyrofrequency at the foot of the Io field line predicted by the GSFC O_4 [1] and JRM09 [2] magnetic field models.

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