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Jupiter's magnetic field, beaming half-cone angle & source location of decametric radio emissions observed by Juno

Yasmina M. Martos (1,2), John E.P. Connerney (1,3), Masafumi Imai (4), William S. Kurth (4), and Stavros Kotsiaros (1,2)

(1) NASA Goddard Space Flight Center, Greenbelt, USA, (2) University of Maryland, College Park, USA, (3) Space Research Corporation, Annapolis, USA, (4) The University of Iowa, Iowa City, USA, (yasmina.martos@nasa.gov)

Abstract

The decametric radio emissions (DAM) originated in Jupiter's polar auroras have been observed from Earth since 1955 and from near-equatorial spacecraft such as Voyager. These emissions are produced along magnetic field lines at the local electron gyrofrequency. The DAM emissions related to the Jovian moon Io have received most attention since the 80s. It is expected that the maximum frequency of these emissions is bounded by the maximum magnetic field strength near the footprint of the instantaneous Io Flux Tube (IFT). However, the discrepancy between the observed peak frequencies of Io-related DAM (Io-DAM) emissions and the maximum local electron gyrofrequencies at IFTs computed considering past Jovian magnetic field models has been strongly debated.

Here, we present results from a detailed analysis of the peak frequencies and source location of the Io and non-Io-related DAM identified by Juno, as well as how the newly proposed magnetic field model (JRM09) can explained the Io-DAM. Additionally, the beaming angle of the hollow cone of radiation and the altitude of the generation of the decameter radio emissions are estimated and discussed in relation with the geometry of the magnetic field.

1. Main text

Past statistical studies [1] of the peak frequencies of the Io-DAM compared the electron cyclotron frequencies at the foot of the Io field line predicted by pre-Juno low resolution models, such as GSFCO4 and VIP4 [2,3]. They were not able to explain the full extent of the Io-DAM frequencies and reported a delay between the observed peaks and the predicted gyrofrequencies up to 70°. This made difficult to explain how DAM emissions were originated in longitudes where the magnetic field did not reach values close to the local electron gyrofrequency. Several attempts to reconcile the observations were made considering obtaining and constraining a magnetic model using the peak frequencies of the DAM observations (e.g. VIPAL model [4]) as a constraint on the surface magnetic field magnitude. However, such models may lead to very inaccurate estimates of the magnetic field in other regions of Jupiter (e.g., regions lacking direct observations).

In addition, DAM events have been observed from Earth or from near-equator spacecraft, limiting the observations to a specific range of latitudes of the observer. Since July 2016, Juno's polar orbit provides the opportunity of observing DAM emissions from higher latitudes than explored before.

Using magnetic field observations from Juno [5], the most advance Jupiter's magnetic field model was proposed recently, JRM09 [6]. The JRM09 model represents a partial solution to a degree 20 spherical harmonic expansion, yielding coefficients through degree 10 with adequate resolution. JRM09 model yields magnetic field magnitudes of up to 20 G along the IFT footprint, substantially higher than previous models [2,3].

In this study, we analyze data acquired by Juno radio and plasma wave instrument (Waves) to identify Io and non-Io-related DAM events since May 2016, and their relation to the observer as a function of Io phase, Central Meridian Longitude (CML) and latitude.

Using the JRM09 model [6], we compare all observed peak frequencies of Io-related DAM radiation with the gyrofrequency at the foot of the Io field line predicted by GSFCO4 [2], VIP4 [3] and JRM09 models. The observations can be only accommodated by the electron cyclotron frequencies predicted by JRM09 at the footprint, except possibly for some observations located around 60º Io longitude where the field magnitude drops precipitously. We note with interest that the observed peak frequencies seem to be truncated at 37 MHz. The delay between the predicted JRM09 North IFT slope at 300º of Io Longitude and the group of observed events is 15º, which is an indication of the lead angle between the IFT and the magnetic field line carrying the emissions, the altitude at which the DAM emissions are originated (0.9765 RJ) or a combination of both.

Additionally, we investigated Io-DAM events to estimate the emission half-cone angle, altitude of emission, and resonant electron energy. For this we considered the JRM09 magnetic field model and study its major hemispherical asymmetrical geometry effect in the observation of Io-DAM [7,8].

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