Juno reveals new insights into Io-related decameter radio emissions

Yasmina M. Martos\textsuperscript{1,2}, Masafumi Imai\textsuperscript{3}, Jack Connerney\textsuperscript{1,4}, Stavros Kotsiaros\textsuperscript{5} and William Kurth\textsuperscript{6}

yasmina.martos@nasa.gov

1. Introduction and Juno data

2. Beaming cone half-angle & energy of the resonant electron

3. Io DAM emissions observability & relation to the Jovian magnetic field

4. Conclusions

5. Acknowledgements and References

\textsuperscript{1} NASA Goddard Space Flight Center, \textsuperscript{2} University of Maryland College Park, \textsuperscript{3} National Institute of Technology (KOSEN), \textsuperscript{4} Space Research Corporation, \textsuperscript{5} University of Denmark, \textsuperscript{6} University of Iowa
1. Introduction and Juno data

Juno is currently orbiting Jupiter every 53 days with the intention of collecting a dense global net of potential field data at close radial distances never measured before [1]. For our study we analyze the data from the Waves instrument (inset) along the entire orbit to identify Decametric Radio Emissions (DAM). We also make use of the latest Jovian magnetic field model [2].

Here, we study Io-related DAM events from each source location (A, B, C, D). We estimate the energy of the resonant electrons responsible for the wave-particle interactions, the beaming cone half-angles, and compare our results with previous studies. We also quantitatively explain why groups of arcs originating in the northern hemisphere are more frequently observed than those originating in the south.
2. Beaming cone half-angle & energy of the resonant electron

The beaming cone half-angle $\Theta(f)$ is measured from the local magnetic field vector at a radio source and the observer’s position. If we assume the theoretical treatment of a relationship between the beaming cone half-angle and the loss cone electron distribution as proposed by [3], we can estimate the energy of the resonant electron once the beaming angle calculated by the geometry is obtained. Then the Io-related modeled arcs are computed.

Martos et al. (2020)
2. Beaming cone half-angle & energy of the resonant electron

Modeling of Io-related DAM emissions corresponding to the northern hemisphere. Left panel: B source events. Right panel: A source events. The energy of the resonant electrons (E_e = 10-15 keV) is much higher than previously proposed \([3,4]\) (E_e = 0.64 keV). AFT: Active Flux Tube. IFT: Io Flux Tube. \(\delta\): Lead angle.
3. Io DAM emissions observability & relation to the Jovian magnetic field

Groups of arcs originating in the northern hemisphere are much more commonly observed than those originating in the southern hemisphere. We provide several explanations for this fact relating the magnetic field geometry and intensity, Alfvén wave and particle propagation from Io to Jupiter, and observation geometry.

a) Equatorial pitch angles at Io’s orbit and considering mirror points at the Io footprint. b) is the magnetic field magnitude at the Io footprint. c) Beaming cone half-angle as a function of the local gyrofrequency. Note the constant values found for the northern hemisphere and centered in ~180°. The magnetic field model predicts that this ‘plateau’ can be found for a large portion but this situation is rarely the case for the southern hemisphere. For an observer adequately located at ~75.5° of beaming cone half-angle for the emission of a specific radio source, an observer would be able to measure a specific frequency of 20 MHz for about 130° of Jovian rotation. This value is in reality higher since the wall thickness of the cone of emission is 1° and the observer is able to measure arcs if these are located within the wall.

Martos et al. (2020)
3. Io DAM emissions observability & relation to the Jovian magnetic field

Beaming cone half-angle values for a radio source of 20 MHz and a fixed geometry between Earth (at 5 AU) and Io in vertex late configuration, with a rotating Jupiter to investigate the influence of the asymmetrical geometry of the magnetic field into the observability of DAM. Earth’s latitude varies between -3 and 3°. The northern hemisphere generally shows less variable beaming cone half-angles from one AFT (or Jovian longitude) to the next than the southern hemisphere. Note that the beaming cone half-angles shown in this graph for the southern hemisphere refer to the acute angle between the radio wave and the magnetic field vector.

Martos et al. (2020)
4. Conclusions

In this study we selected main Io-DAM events and made use of the most recent Jovian magnetic field model to model the observed discrete arcs. The forward modeling yielded very good fits to the observations and constrained the resonant electron energy and the beaming cone half-angle, providing new insights into Jovian auroral radio emissions. The beaming angle is larger for the B events than the others and the AFTs projected on the surface of Jupiter coincide with the high magnetic field region in the northern hemisphere. Remarkably, the estimated resonant electron energies are much higher (up to 50 keV) than inferred from previous studies (up to 3 keV) for this kind of DAM emission, but compatible with in situ observations made by JADE and JEDI on the Juno spacecraft. Also, we quantitatively provided the explanation why a larger number of groups of arcs originating in the northern hemisphere are observed with respect to the ones originating in the southern hemisphere. The asymmetry of the magnetic field geometry and strength are the main responsible for this phenomenon.
5. Acknowledgements and References

This study has been conducted and supported by the Juno Mission to Jupiter.


