

GROUND AND SPACE OBSERVATIONS OF JOVIAN DECAMETRIC EMISSIONS IN THE FREQUENCY BAND FROM 1 MHz TO 40 MHz

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Abstract

We report on statistical studies of Jovian decameter emission observed in the same period by the Nançay decameter array - NDA (France) and the WAVES experiment on board Wind spacecraft. The NDA tracks Jupiter during 8 hours around the meridian time transit while Wind/WAVES observes continuously. In order to compare the two sets of data, we restricted Wind/WAVES's record to the interval of time when the NDA meridian transit of Jupiter at Nançay (France) is mainly during the night. From the daily 8 hour observations performed by the NDA, in 1995 and 1996, we select two periods (March 21, 1995 to July 8, 1995) and (April 24, 1996 to August 12, 1996) which results in 1760 common observational hours. We establish a database which allows to characterize the observed parameters related to each event: the beginning and the end of emission time, the frequency range, the main polarization, the arc curvature and a label from 0 to 2 for increasing intensity. The combination of ground and space observations allows to analyze in terms of occurrence probability and polarization more than 200 events. We discuss our results and emphasize on the source occurrence areas in the diagram (CML, Io-phase) which is totally dependent on several parameters as frequency of observation, the Jovicentric declination of the Earth and observation conditions.

1 Introduction

It is well known that two coordinates are of great importance when studying Jovian radio emissions: the central meridian longitude (CML) which refers to the observer's position with respect to the planetary magnetic field and the Io's orbital position with respect to superior geocentric conjunction. On the CML and Io diagram several zones of

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enhanced occurrence probability have been labeled sources A, B, C, D (CML and Io phase coordinates for each source is mentioned in Carr et al. [1983]) which depend on Io and appears only in certain positions of the observer with respect to the Io satellite. The Io-controlled emissions are more intense and have spectral characteristics like typical shape of arcs [Boischot et al., 1981] with opposite curvature [Warwick et al., 1979b]. DAM is mainly polarized in the right-hand (RH) sense and sometimes in the left-hand (LH) sense. The first measurements of the Stokes parameters had been made by the spectropolarimeter associated to the Nançay Decameter Array (NDA) in a wide frequency band [Boudjada, 1991].

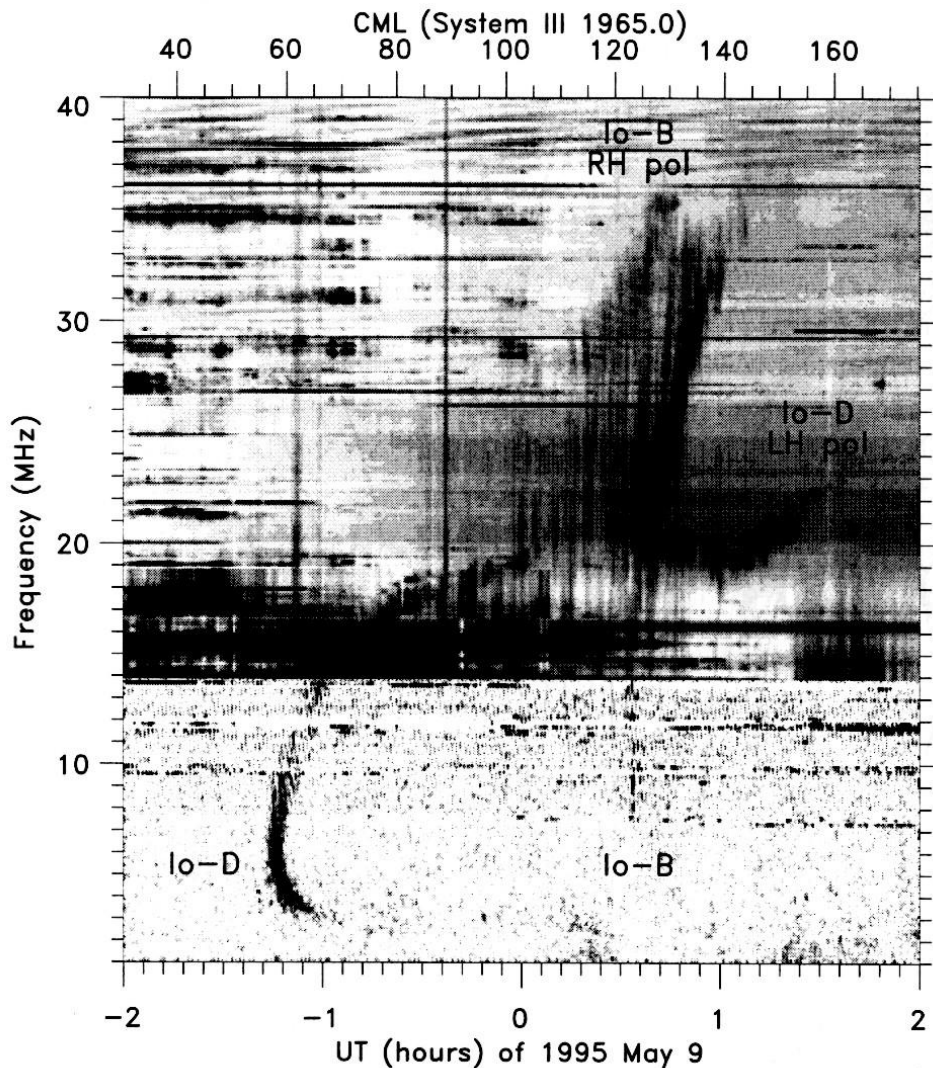


Figure 1: Dynamic spectrum of Jovian DAM arc-shaped patterns obtained by combining Wind/WAVES and NDA observations [from Lecacheux et al., 1998a].

Recently two groups of authors have compared data acquired from Wind spacecraft and from Earth. Kaiser and Garcia [1997] compared Wind spacecraft data to Florida data

during a different period of time (1968–72) when the Jovicentric declination of the Earth (D_E) was comparable. They found a greater number of intense controlled emissions (Io–C and Io–D) and interpreted their result as a D_E effect which makes more visible the Southern hemisphere. Lecacheux et al. [1998a] combined NDA observations with simultaneous Wind/WAVES observations which cover the frequency range from 1 MHz to 13.8 MHz. Using two representative Io–controlled events (Io–B/D and Io–C), they have shown that it is necessary to introduce refraction effects to explain the discrepancy between observations and the apparent emission angle deduced from a hollow conical radiation beam. Figure 1 shows a dynamic spectrum of Jovian DAM arc-shaped patterns obtained by combining Wind/WAVES and NDA observations [from Lecacheux et al., 1998a].

2 Observations

2.1 Wind/WAVES observations

The WAVES experiment on board Wind spacecraft is a plasma wave and radio instrument covering the frequency range from near DC to 14 MHz [Bougeret et al., 1995]. Our analysis concerns the data recorded by the RAD2 receiver which covers the frequency range from 1.075 to 13.825 MHz with a band pass of 20 kHz. The acquisition time is 20 ms with a standard cycle obtained every 16 seconds. Figure 2 shows the Jovian DAM events observed by the Wind/WAVES in the plane (CML, Φ_{Io}).

One can see that it is not possible to separate between the occurrence areas of controlled and not controlled sources. However the Io–C and Io–B–D areas are slightly visible whereas the AA' sources are not visible.

2.2 Nançay Decameter observations (NDA)

2.2.1 Nançay Decameter Array (NDA)

The Nançay antenna array consists of two subarrays, one sensitive to the right-hand circular (RHC) radiation, the other one to the left-hand circular (LHC) emission. Each subarray consists of 72 conical helix antennas with a gain of about 25 dB [Boischot et al., 1980]. The survey receiver is a spectro-analyser with an instantaneous bandwidth of 300 kHz and a sweeping time of 0.5 second. The array can track Jupiter during 8 hours around the meridian transit in the frequency band from 10 to 40 MHz. On the diagram shown in Figure 3 one can localise the Io–A/A', C and B/D sources. The maximum around $\Phi_{Io} \approx 315^\circ$ is unusual whereas the other bumps results from D, B, A' and A/C sources. The NDA occurrence in CML is in average about 10%.

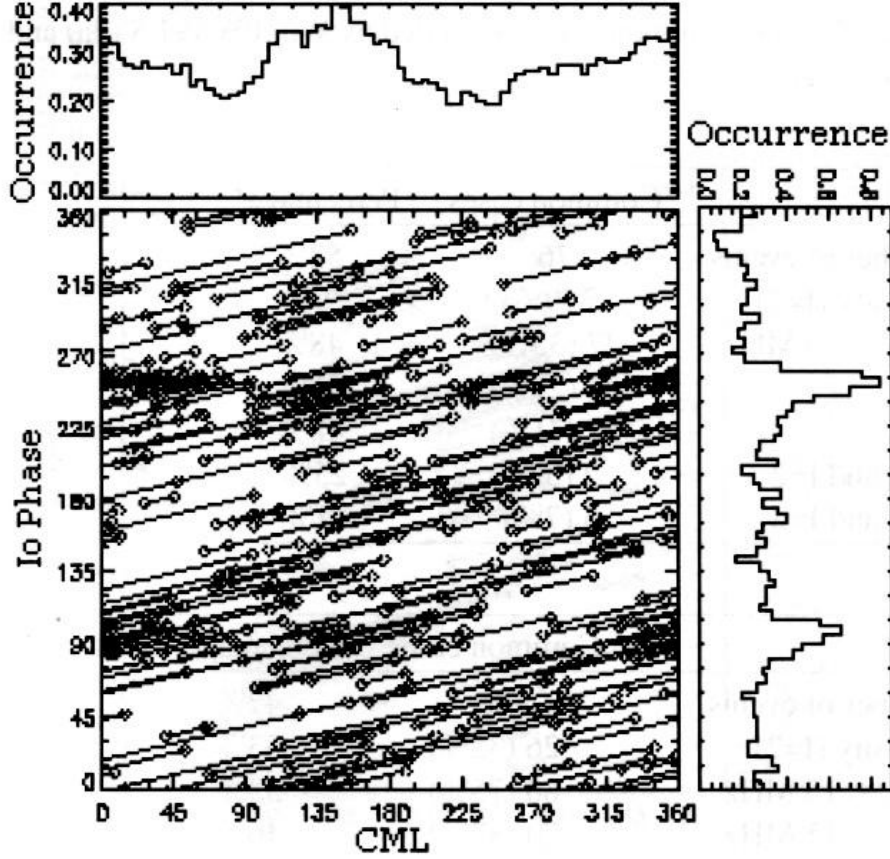


Figure 2: Wind/WAVES observations: Occurrence of the Jovian decametric emissions in the (CML, Φ_{Io}) plane.

2.2.2 NDA polarization measurements

The polarization occurrence probabilities obtained with the NDA are shown in Figures 4 and 5 for the right-hand and left-hand polarizations, respectively. The main emissions with right-hand polarizations are associated to the Io-B region and to another area with a CML between 200° and 270° corresponding to Io-A/A' and non-Io-A.

The weak occurrence probability of Io-A and Io-B sources as we find is mainly due to the small values of D_E which change from -3.0° to -1.8° during the considered period, March 21 to July 08, 1995 and April 24 to August 12, 1996. It is important to note that the Io-B source is shifted towards bigger values of Io-phase and covers part of the Io-D source, and also the absence of Io-C emission with right-hand polarization (see Figure 4) and only the left-hand component is observed (see Figure 5) contrary to previous studies [e.g. Boudjada and Genova, 1991]. Otherwise we have found two maxima of occurrence probability at Io-phase equal to 95° and 250° with LH polarizations. They have lower occurrence probability and they appear in Io-controlled (Io-C and Io-D) and non-Io-controlled (non-Io-C) regions. The slight enhanced occurrence around

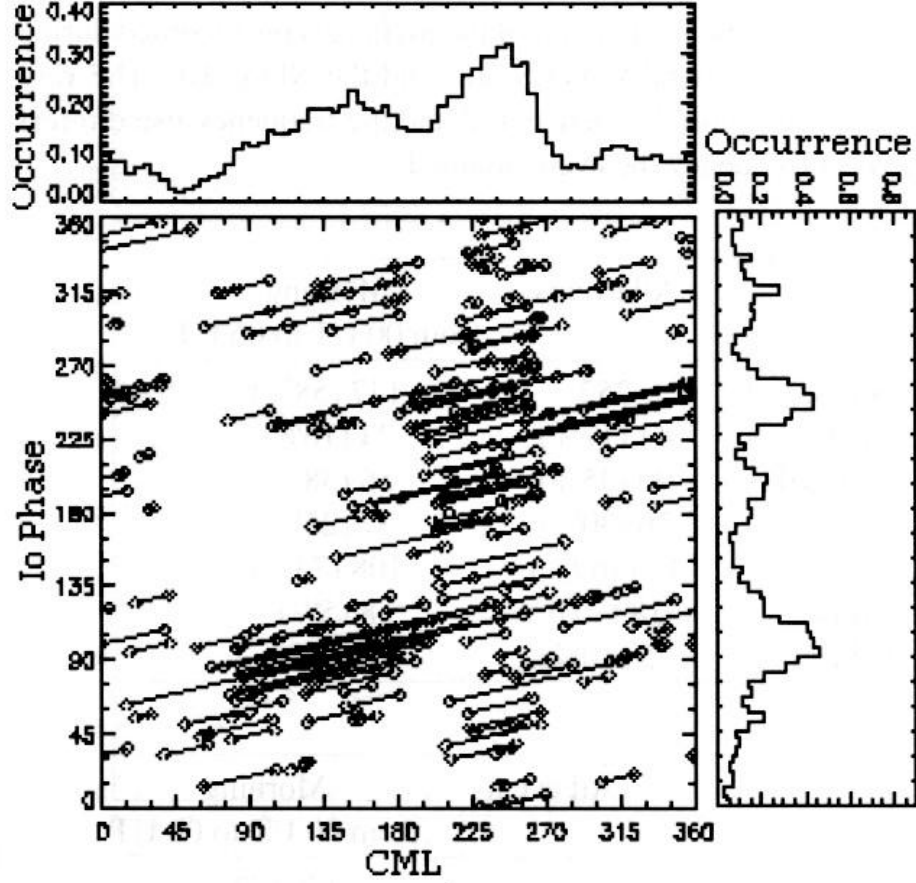


Figure 3: Nançay Decameter Array (NDA) observations: Occurrence of the Jovian decametric emissions in the (CML, Φ_{Io}) plane.

$\Phi_{Io} \approx 315^\circ$ appears on both polarization diagrams.

3 Discussion

In the $CML-\Phi_{Io}$ diagram, the Wind/WAVES events are associated to controlled and not controlled emissions and it is not possible to separate between them according to their occurrence area. From NDA events, we mainly report on the emissions related to Io-controlled occurrence areas. With regard to previous studies, we note the absence of the great arc with right-hand polarization associated to Io-C regions. One could explain this disappearance by the Jovicentric declination of the Earth effect which allows to observe more the Southern hemisphere than the Northern hemisphere of Jupiter. If this assumption is true the other emissions (Io-A, Io-B and not controlled emissions with right-hand polarizations) also should not be visible from the Earth. This study shows that the complementarity of space and ground observations should be the answer to avoid the

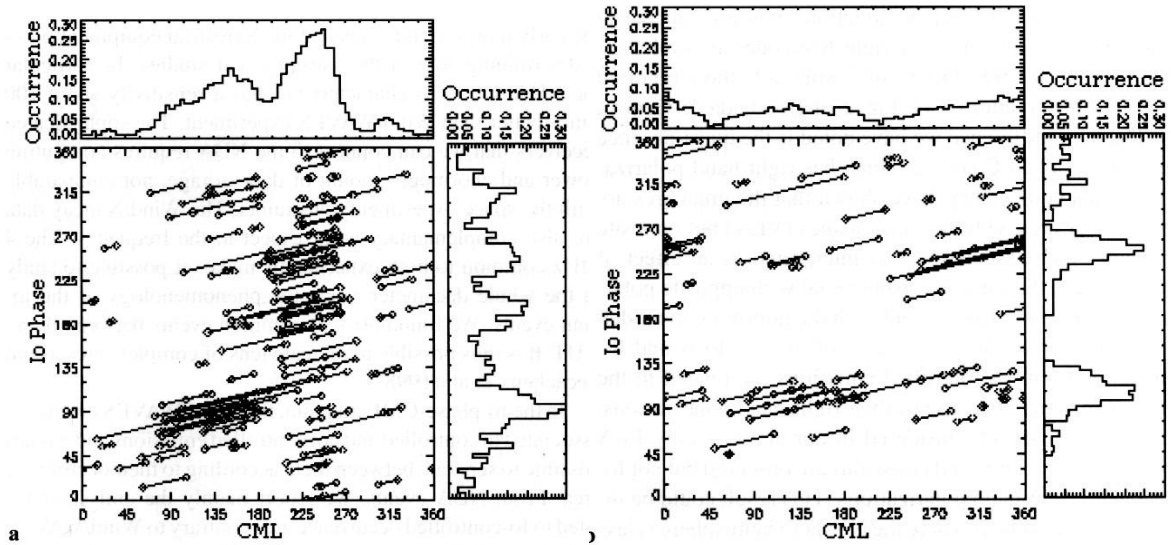


Figure 4: Nançay Decameter Array (NDA) observations: Occurrence in the (CML, Φ_{Io}) plane of the Jovian decametric emissions with right-hand (left panel), and left-hand (right panel) polarizations.

Earth observation conditions in particular due to man made interference and the diurnal Earth effect. The high sensitivity of the NDA partly compensate the absorption produced by the ionosphere, since the occurrence is of about the same order in the middle of the night.

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