

# INTERFEROMETRIC OBSERVATIONS AT 16.7 AND 22.2 MHZ AT THE OBSERVATORY LUSTBÜHEL, GRAZ

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## Abstract

A Jupiter radio station has been deployed at the Observatory Lustbühel, Graz, and since October 1986 the sporadic radio bursts of Jupiter are measured in the decameter wave length range at the frequencies 16.7 and 22.2 MHz. The basic feature of the receiver station is the interferometric system with two Yagi antennas placed at a 80 m east–west baseline. First results are presented and future aspects will be addressed.

## 1. Introduction

After the discovery by Burke and Franklin (1955b) of the non–thermal radio emission of Jupiter in the decametric (DAM) wavelength regime, more than three decades of ground–based observations of DAM led to a detailed knowledge of the phenomenology of this Jovian radio component (Carr et al., 1983), the locations and the characteristics of the respective sources. A number of catalogues summarizes the occurrence and temporal variations as well as the Io–controlled behavior of all DAM sources under varying Earth–Jupiter visibility conditions (Thieman, 1979; Leblanc et al., 1981; 1983).

Even in view of the impressive discoveries of Jovian radio science made by the respective spacecraft there are still advantages for ground–based observations, which are not yet equalled by space–borne measurements, as there is mainly the continuity of observation. This and other facts were the reason to deploy a Jupiter radio station at the Observatory Lustbühel, at the eastern outskirts of Graz, located at Northern latitude  $47^{\circ}04'38,2''$  and Eastern longitude  $15^{\circ}26'55,7''$ .

As will be shown in the subsequent sections both the equipment and the site of the radio station are able to detect and identify Jovian radio bursts, as a first step towards temporal high resolution studies of L– and S–bursts.

## 2. The interferometry system

For the identification of extraterrestrial radio sources one needs high resolution directional antennas. In the case of the Jovian decametric waves the frequency band which can be

observed by ground-based stations ranges from about 5 MHz (under optimum conditions) to about 40 MHz, but realistically between  $15 \text{ MHz} < f < 35 \text{ MHz}$ . At the corresponding wavelengths even strongly beaming antennas exhibit a poor angular resolution. Therefore, a special technique is used in order to improve the angular resolution: the method of interferometry.

As schematically shown in Figure 1 the Jupiter radio station at the Observatory Lustbühel, Graz, consists of two Yagi antennas with a baseline distance of  $d=80 \text{ m}$  in east–west–direction. This interferometric system (Mostetschnig and Rucker, 1985) enables the reception of DAM radio bursts at frequencies  $f=16.7 \text{ MHz}$  and  $f=22.2 \text{ MHz}$ .

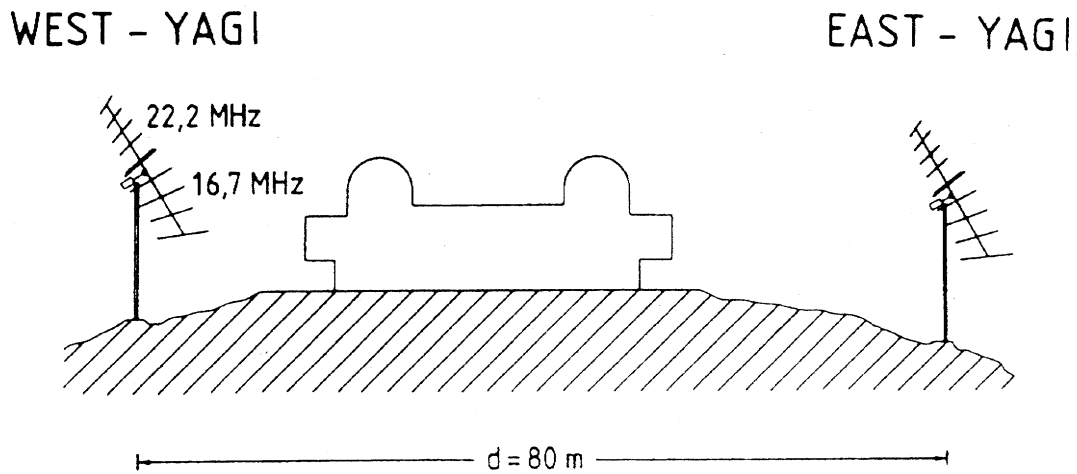


Fig. 1: The interferometer system at the Observatory Lustbühel.

From the theory of interferometric systems it is known that the beam width of one single antenna is split into a number of lobes if interferometrically connected with a second antenna (Wohlleben and Mattes, 1973). In the case of the Observatory Lustbühel radio station the width of one separate Yagi antenna is approx.  $60^\circ$ , which reduces within the twin interferometer system to about  $10^\circ$ , a poor beaming but sufficient for the dominating Jovian DAM emissions.

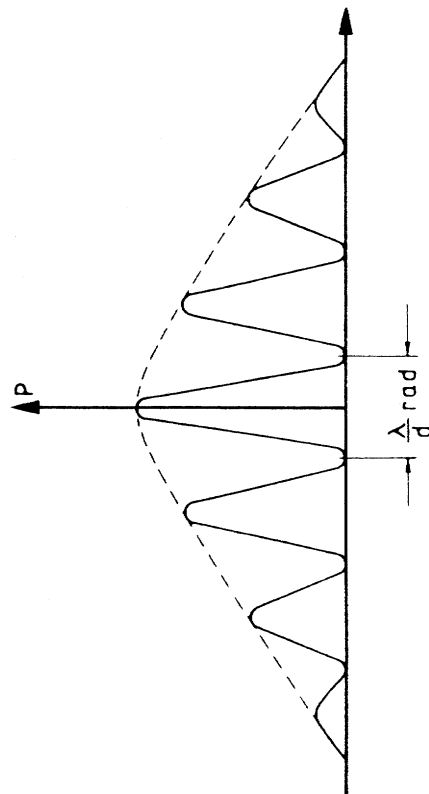
The Observatory Lustbühel interferometric system operates as a so-called “meridian–transit–interferometer” with antennas fixed and oriented in the noon meridian plane. The corresponding diagram of the receiving power is shown in Figure 2a.

With the angle  $\alpha$  between the radio burst wave front and the baseline direction, and with wavelength  $\lambda$  the relation

$$d \sin \alpha = n \lambda$$

defines the received power maxima at  $n = 1, 2, 3, \dots$  as well as the power minima at  $n = 1/2, 3/2, 5/2, \dots$ . The knowledge about the exact location of such power maxima/minima is an essential criterium in identifying DAM radio bursts. For one frequency ( $f=22.2 \text{ MHz}$ ) the temporal and angular distance, resp. location of the interference structures (minima and maxima) with respect to the noon meridian crossing are shown in Figure 2b.

(a)



(b)

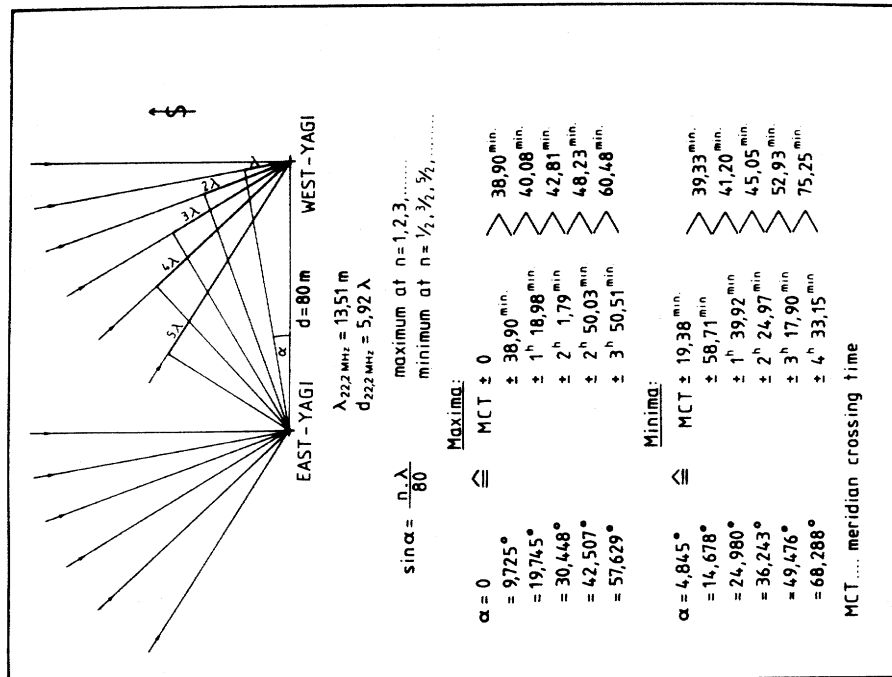


Fig. 2: a) Diagram of the received power at the twin-interferometer operating as a so-called meridian-transit-interferometer. The relation  $1/n = \lambda/d$  holds with wavelength  $\lambda$  and baseline distance  $d$ .  
 b) Positions of interference stripes for  $f = 22.2 \text{ MHz}$ .

### 3. DAM-observations and results

The Jupiter radio station at the Observatory Lustbühel was brought into test operation in October 1986 and started routine measurements in September 1987. For each observed frequency three channels are recording relevant parameters, as shown in Figure 3:  $E^2 \cos \varphi$  and  $E^2 \sin \varphi$  as the intensity of the received DAM radio wave multiplied by the cosine (sine) of the phase difference between the waves at the east-(west-)antennas. A third channel (riometer) records the antenna temperature.

As already pointed out the identification of DAM bursts follows some criteria, which are as follows:

- At the moment of noon meridian plane crossing the sine-phase must exhibit a zero crossing, whereas the cosine-phase has to be at positive maximum. These facts are necessary conditions caused by internal receiver techniques.
- Due to the celestial motion of the radio source the maxima, resp. minima of the cosine/sine channels must follow a defined sequence.
- The temporal position of these maxima/minima are exactly defined (as shown in Figure 2b) and are symmetrically located with respect to the noon meridian plane.
- In the very moment of a detected radio burst any rise in the riometer channel indicates a corresponding rise of the antenna temperature.

Due to these criteria the DAM events were selected and summarized in a catalog, which is also displayed in the well-known CML-Io phase diagram (Figure 4). Three categories were applied to the selected events:

1. Possible emission (Figure 4a, dotted line) with more than 50% probability of being DAM due to the above mentioned criteria.
2. Weak emission (Figure 4a, dashed line) with all criteria applicable.
3. Strong emission (Figure 4a, full line) with all criteria applicable and with a significant high intensity level.

For the period of September 3, 1987 through January 17, 1988, all selected DAM events of  $f = 16.7$  MHz and  $f = 22.2$  MHz are plotted in the CML-Io phase diagram (Figure 4a). During this period the time Jupiter crossed the meridian plane moved from UT = 2:03 hours (Sept 3, 1987) over midnight to UT = 16:34 hours (Jan 17, 1988). (After the latter date any further observation was increasingly disturbed or even obscured due to daytime man-made noise).

As can be seen in Figure 4a, the main DAM sources Io-A, Io-B and Io-C, which are made visible in dashed contours as given by Carr et al. (1983, Table 7.4) are well represented even during this relatively short period of 4 1/2 months. For reasons of comparison the

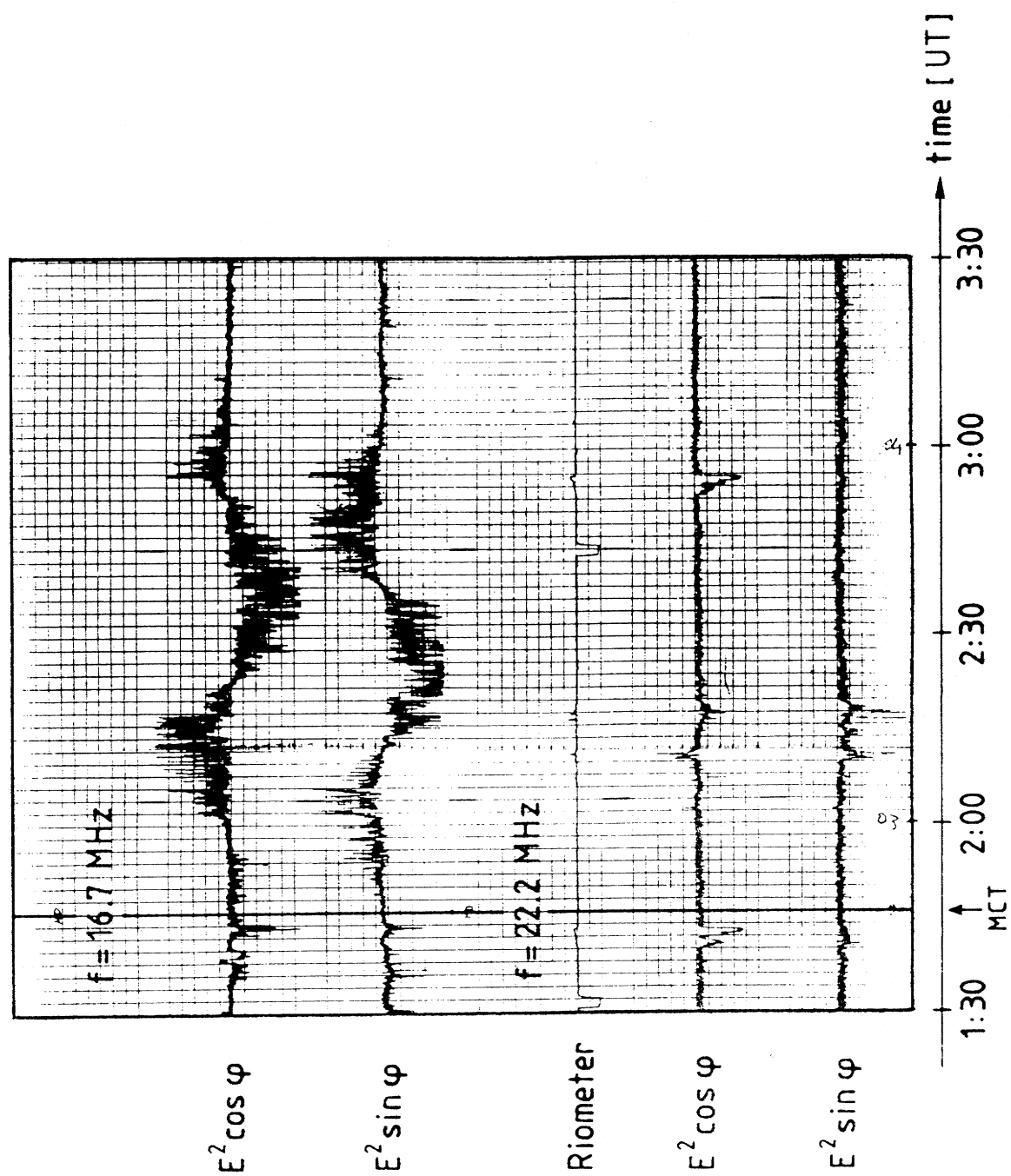


Fig. 3: Observations of an Io-C radio burst at Sept 7, 1987 (MCT denotes meridian crossing time).

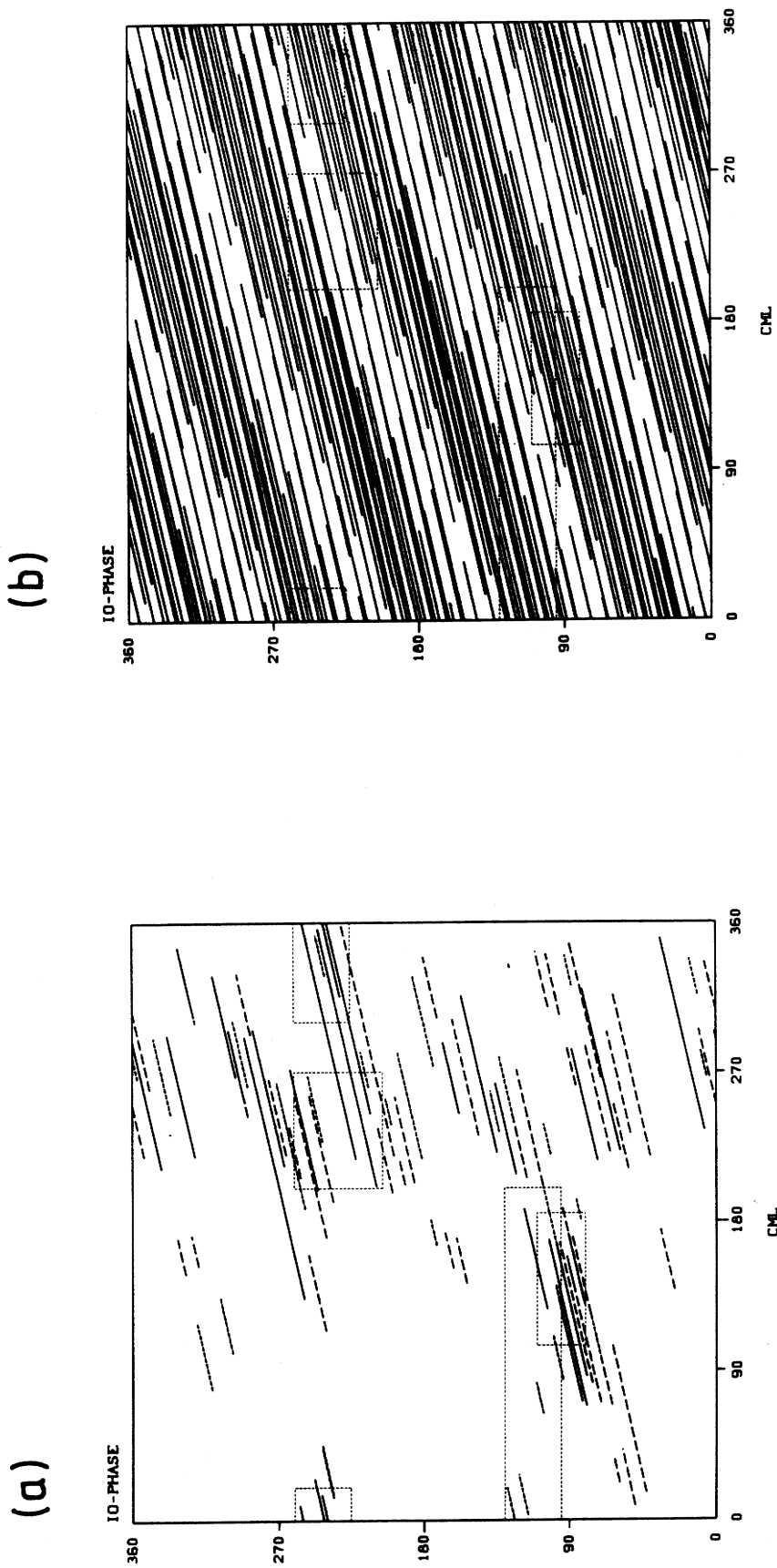


Fig. 4: Jupiter DAM-events organized in the CML - Io phase - diagram. The respective DAM sources Io-A, -B, -C, and -D are indicated by dashed rectangles (after Carr et al., 1983, Table 7.4).  
a) The observed radio bursts at frequencies  $f = 16.7$  MHz and  $f = 22.2$  MHz for the period Sept 3, 1987 through Jan 17, 1988 are plotted as follows: strong (weak) emission by full (dashed) lines and possible emission by dotted lines.  
b) For the same period of time the observation tracks are assembled  $\pm 4$  hours regarding the meridian crossing time of the respective day.

observation tracks and possible duration of observation ( $\pm 4$  hours around meridian plane crossing) are displayed in a separate CML–Io phase diagram (Figure 4b).

It is known that in the range  $180^\circ \leq \text{CML} \leq 360^\circ$  Jupiter exhibits a higher DAM emission activity than in the range  $0^\circ \leq \text{CML} \leq 180^\circ$ . This fact is visible in Figure 4a. If measurements at  $f=16.7$  MHz and 22.2 MHz are separately analyzed, a significant higher number of events could be recorded at the lower observing frequency. As an additional check of quality of the present measurements it was found from the data set that only  $f=16.7$  MHz–events exist within the Io–D area. This is consistent with previous observations (Carr et al., 1983) that Io–D has an upper limit in frequency of approx. 18 MHz.

These results confirm that the Jupiter radio station at the Observatory Lustbühel is able to detect and to identify DAM radio bursts, as a first step towards more sophisticated investigations.

#### 4. Future aspects

Due to daytime ephemeris transit times of Jupiter no observations will be performed between February and probably August 1988. On Sept 1, 1988, the meridian plane crossing time of UT = 4:30 hours will again allow a continuous recording.

At this time (fall 1988), the radio station of the Observatory Lustbühel will have been converted from a two–channel interferometry system to a multi–channel spectrometry system capable of observing DAM by 50 receiver channels with high frequency and temporal resolution. This receiver, kindly provided by the Observatoire de Paris–Meudon, will be used to investigate Jovian L– and S–bursts.

Groundbased observations of the Jovian emission in the decametric wavelength regime still are a matter of high scientific interest: They will be brought into context with the present “Jupiter–Watch” program and will also give important and additional information to corresponding measurements on upcoming missions like “Galileo” and “Ulysses”.

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