ANALYSIS OF THE S-COMPONENTS FEATURES OF THE JOVIAN DAM EMISSION OBTAINED FOR THE IO-DEPENDENT SOURCES

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Extended Abstract

S-component of the sporadic radio emission of Jupiter decameter emission (DAM) is an extraordinary astrophysical phenomenon which is formed as the result of a unique interaction between the Jupiter and its Io satellite and this phenomenon is characterized by an unusual complexity of the frequency-temporal structure on the dynamic spectra. The Jovian S-burst emission appears during the decameter radio storms which can be predicted on the basis of the analysis of the geometric configuration between the Earth, the Jupiter and Io. Monitoring of the Io-dependent DAM emission revealed the characteristic Jupiter emission zones known as Io-A, Io-B, Io-C, and Io-D. It should be noted that despite of more than 50 years of extensive exploration of the Jovian DAM radiation the physical nature of this phenomenon remains insufficiently clear. On the other hand, many problems in the theory of the Jovian decameter emission have been successfully investigated and solved [Litvinenko et al., 2004; Zaitsev et al., 2006; Ladreiter et al., 1995; Shaposhnikov et al., 1997, 2011]. Nevertheless, there is reason to believe that not all issues concerning the physical nature of this unique phenomenon have been definitively resolved. One of the perspective approaches for finding new results is experimental investigation at a higher quality and quantity level followed by a detailed data analysis using both well known and modern mathematical methods. Development of the receiving equipment (improvement of the following characteristics: the temporal-frequency resolution, sensitivity, signal-to-noise ratio, etc.) allows to analyze the specific S-burst features from the microscopic to macroscopic scale [Litvinenko et al., 2009]. With this aim several observational campaigns were performed in November 2009 using the UTR-2 radio telescope (Kharkov, Ukraine) and effective registration systems possessing high frequency and temporal resolutions (antenna effective area is close to 100,000 m^2, the frequency resolution is 4 kHz, the temporal resolution is 0.25 ms, the dynamic range is 70 dB) [Konovalenko et al., 2001]. The main goal of

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these campaigns was an experimental investigation of the Jovian decameter radio emission with an attempt to find out and analyse the phenomena which can be detected using the above mentioned equipment.

A huge amount of wide-band data of the radiation from different Io-dependent sources taken for the present analysis has been obtained using the high frequency and temporal resolution digital receiver (DSP) [Kozhin et al., 2007] installed into the Ukrainian world's largest decameter band radio telescope UTR-2 [Konovalenko et al., 2001]. It is a fully digital baseband device which satisfies all modern requirements for the Jovian decameter emission investigations. The DSP provides an ultimate spectral analysis capability which allows performing digital signal processing in real time. The receiver has two input channels and it is able to operate in two main modes: as a spectral analyzer and as a waveform recorder. In the spectral analyzer mode it can perform a Fourier transformation of the real signal providing 8192 frequency channels in the continuous frequency band of up to 70 MHz in two independent data streams (two input channels: summing and subtracting channels, ON/OFF regimes). In the waveform mode the device is able to record the signal waveforms, i.e., "catching" the ADCs output signals (analog-to-digital converter). The data obtained are recorded in the high speed data storage system based on disk arrays arranged together for optimal performance (RAID-0). Raw data (or waveforms) storing gives a useful opportunity to implement an intelligent signal analyzing technique in post-processing.

An original software package consisting of two parts was developed to provide user interface controlling of the digital receiver operation and for the off-line data analysis at the post-processing stage.

The first part of the software package is the real-time software which is named WRSA (Waveform Receiver and Spectral Analyzer). This part controls the receiver parameters, the data acquisition process, the on-the-fly data displaying. The software is also used for calibration of the whole registration system consisting of an antenna, analog circuits, and a digital receiver. The WRSA use allows to perform an automatic adjustment of the digitally controlled analog filter bank and attenuators to the ADCs which contributes to an effective solution of the RFI mitigation task, which is the critical point for astronomical observation in decameter waveband.

The second part of the software package which is named AESA (Astronomical Enhanced Spectral Analyzer) is designed for the post-processing of the recorded data. The main goal of this software is the construction and optimal visualization of the Jovian radiation dynamic spectra. Dynamic spectra as a type of frequency-temporal signal representation can be constructed using either spectra or waveforms recorded by the help of the acquisition system. The software provides a flexible control for a number of dynamic spectra visualization parameters such as temporal-frequency samples decimation, averaging data, time and frequency resolutions, dynamic range of the received signal power, palette, etc. Due to the modular structure, AESA software can be easily adopted for various formats of the recorded observational data and successfully used for post-processing and analysis of the data recorded by different digital receiving facilities.

Figure 1 shows the dynamic spectra of the Jovian decameter emission, which were obtained for the Io-B source (27.11.2009) with the help of modern high performance equipment described above. In addition, to illustrate one of the possibilities of a detailed analysis of the radiation, above each spectrum the time dependence of signal intensity for any selected frequency is shown. Figure 1 presents a sequence of

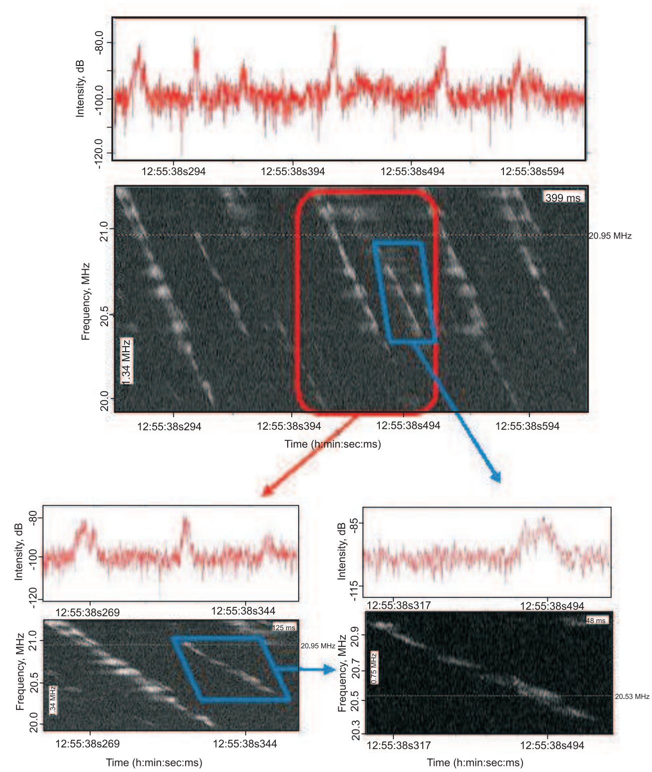

Figure 1: Sequence of S-bursts images in which every next image is constructed by decreasing time visualization scale of the spectrum (left bottom area) or decreasing time and frequency interval (right bottom area); the temporal dependence of the intensity at the chosen frequency along the spectrum time length (timeline above each spectrum)

S-bursts images in which every next image is constructed by decreasing time visualization scale of the spectrum (left bottom area) or decreasing time and frequency interval (right bottom area). The upper part of Figure 1 (time period is 399 ms) illustrates the structure of S-bursts having the following characteristics: the frequency drift is from 13 to 15 MHz/s, the duration at a fixed frequency is from 5 to 15 ms and the distance between adjacent bursts from is 10 to 50 ms. It should be noted that even with such a density of bursts on the spectrum there is an opportunity to examine the frequency-time of a single burst structure in details. At the bottom part of the figure the spectra with shorter time and frequency intervals are shown in consecutive order. It is evident that such procedure allows considering and analyzing the time-frequency characteristics of single bursts more comprehensively.

Undoubtedly, the theoretical and experimental investigations of the Jovian decameter emission phenomena are necessary to be continued. For the further stage of the DAM radiation investigation it is planned to process the recorded waveform data using the wavelet transform analysis. This procedure will allow a temporal resolution of the signal of nanosecond order.

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