EPSC Abstracts
Vol. 7 EPSC2012-205 2012
European Planetary Science Congress 2012

The time-frequency structure of Jovian narrowband decametric radio emission as a probe of the ionosphere of Jupiter

V. Shaposhnikov (1), S. Korobkov (1), M. Gushchin (1), A. Kostrov (1), H. Rucker (2), and G. Litvinenko (3)
(1) Institute of Applied Physics, Nizhny Novgorod, Russia (sh130@appl.sci-nnov.ru), (2) Space Research Institute, Graz, Austria (rucker@oeaw.ac.at), (3) Institute of Radio Astronomy, Kharkov, Ukraine (gallitv@rian.kharkov.ua)

Abstract

We consider the origin of the time-frequency structure of Jovian narrowband decametric radio emission as a consequence of propagation of radiation in the Jovian ionosphere with time varied parameters. Our laboratory and numerical experiments show that the time-frequency structure of dynamic spectra of an initially continuous signal can drastically vary as functions of the form of the magnetic field disturbance in the media where the radiation propagates. Structures similar to those observed in the real experiments, ranging from NB emission and quasiperiodic trains of S bursts to more complex structures, arise in the dynamic spectrum. Assuming the formation of the time-frequency structure of the Jovian narrowband decametric radio emission as a result of propagation of the radiation in the ionosphere and lower magnetosphere of the planet we can get the information about the conditions in the Jovian ionosphere and low magnetosphere.

1. Introduction

The time-frequency structure of the dynamic spectra of the Jovian decametric radio emission is very diversified. Riihimaa discovered a type of radiation, which he named narrowband L emission [1]. Similar emission type was observed by Flagg et al. which they named a narrowband (NB) emission [2]. These emissions are quasi-continuous and have a narrow frequency spectrum. A characteristic feature of the mentioned narrowband emissions is that its dynamic spectrum is time varied. Namely, fluctuations with the frequency of the emission band appear with the time and sometimes the narrowband emission transforms to a train of S bursts, and vice versa, as the noise storm develops (Figure 1). It is important to mention that the transformation of the continuous emission into a train of S bursts can be accompanied by a significant increase in the frequency range occupied by the emission (up to about 3 MHz) and the appearance of a frequency drift characteristic of S bursts.

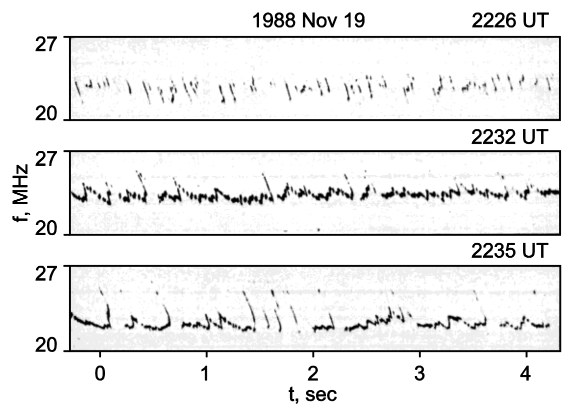

Figure 1. Example of dynamic spectrum of the narrowband emission recorded on 19 November 1988 (adapted from [3]).

2. Transformation of the radiation frequency in a nonstationary magnetized plasma

The propagation of waves in a medium with nonstationary variation in parameters can be accompanied by the amplitude-frequency modulation of a signal and the broadening of its frequency spectrum. In Figure 2 the dynamic spectra of radiation, obtained by a laboratory experiment analyzing the propagation of a quasi-monochromatic wave in a magnetized plasma with strong frequency dispersion and periodic disturbance of the magnetic field are presented. In this experiment the electron plasma frequency is f_{pe}=2.8 GHz, gyrofrequency is

f_{Be}= 225 MHz, magnetic field is modulated with the frequency W=1 MHz and amplitude dB=0.02 B, the radiation is a quasi-monochromatic wave with frequency $f < f_{Be}$. It is seen in Figure 2 that the initially continuous quasi-monochromatic signal propagating in the nonstationary region is modulated both in frequency (Figures 2a–2c) and in amplitude (Figures 2c).

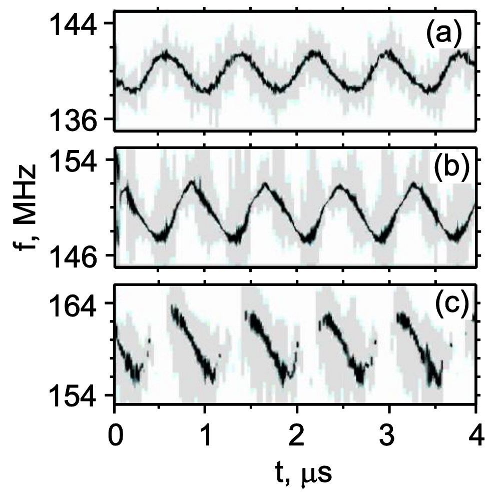

Figure 2. Dynamic spectra of the initially continuous quasi-monochromatic wave after the passage across the region with periodic disturbance of the magnetic field for (a) f = 140 MHz, (b) f = 150 MHz, and (c) f = 160 MHz.

Considering the formation of time-frequency structure of the Jovian narrowband decametric radio emission as a result of propagation of the mentioned radiation in the ionosphere and lower magnetosphere of the planet we numerically solve the problem of propagation of the initially continuous emission corresponding to the fast extraordinary wave with frequency close to the cutoff frequency in a plasma with parameters typical of the Jovian ionosphere and with nonstationary disturbance of the planetary magnetic field. Calculations show that the form of the structure of dynamic spectra depends on many reasons, such as the magnitude and form of the magnetic field disturbance, sizes of the disturbed region, dispersion and length of the ionospheric path. Figure 3 shows an example of calculated dynamic spectra of decametric emission at the output of the Jovian ionosphere.

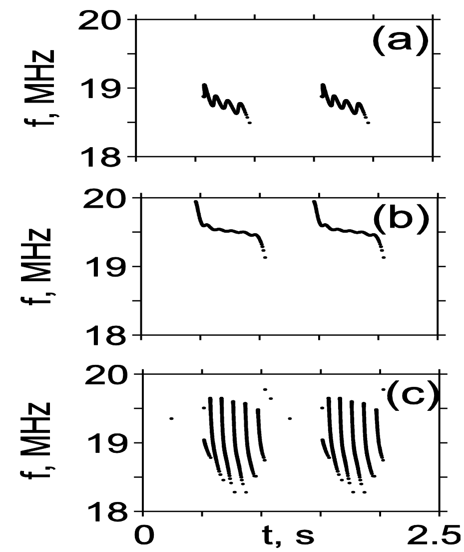

Figure 3. Examples of calculated dynamic spectra at the output of the Jovian ionosphere.

6. Conclusions

The form of the fine structure of the dynamic spectrum and its variation with time are determined by conditions in the source and in its close vicinity as well as by their time variations. This allows the dynamic spectra containing narrow-band emissions to be used for radioastronomical diagnostics of the Jovian ionosphere.

Acknowledgements

The work was supported by the Russian Foundation for Basic Research (projects 12-02- 90424-Ukr_a, 10-02-00265-a, 11-02-97086-r_povolj'e_a) and the National Academy of Sciences of Ukraine.

References

[1] Riihimaa, J. J.: Drift patterns in the dynamic spectra of Jupiter decametric radiation, Astrophys. Lett., Vol. 2, pp. 185, 1968.

[2] Krausche, D. S., R. S. Flagg, G. R. Lebo, and A. C. Smith, High resolution spectral analysis of the Jovian decametric radiation. I. Burst morphology and drift rates, Icarus, Vol. 29, pp. 463–475, 1976.

[3] Riihimaa, J. J. (1992), Wide-range high-resolution S-bursts spectra of Jupiter, Technical report, Dep. of Electr. Eng., Univ. of Oulu, Oulu, Finland.