EPSC Abstracts
Vol. 7 EPSC2012-879 2012
European Planetary Science Congress 2012

On the influence of the burst structure of the Jovian radio emissions and group delay effects in Earth ionosphere on spectra recorded by ground-based receivers

A. Kostrov, S. Korobkov, M. Gushchin
Institute of Applied Physics, Nizhny Novgorod, Russia (mguschin@appl.sci-nnov.ru)

Abstract

The additional effects for the formation of the lane structure in dynamic spectra of Jovian radio emission are considered, which are due to "group" Faraday effect in Earth ionosphere. If the emission represents a sequence of time-separated bursts, these bursts are doubled in Earth ionosphere due to the difference between group velocities of two normal modes, i.e. ordinary and extraordinary. As a result, if the time constant of the receiver is larger than both the burst's duration and group delay in a "doublet", than the spectrum of the emission would be complicated by the lanes separated by the inverse group delay time in ionosphere.

Model and discussion

It is well known that Jovian radio emission passes the Earth ionosphere before its detection by ground-based receiver. Due to static magnetic field of the Earth, two modes with elliptic polarization can propagate in ionosphere with different phase and group velocities. Due to phase velocity difference, Faraday rotation occurs in Earth ionosphere, which gives rise to conventional lane modulation effect [1]. Indeed, if we consider a linear-polarized receiver of a broad-band radiation, than we see the signal maxima when the polarization is parallel to dipole antenna orientation and signal minima when the polarization is orthogonal. The frequency separation between Faraday lanes is calculated based on so-called rotation measure *RM*, which is

$$RM = 2.36\times10^4 \int N_e B \cos\theta ds ,$$

where N_e is electron density, B is magnetic field strength, θ is an angle between the ray path and magnetic field direction. Faraday nulls occur at frequencies satisfying the equation

$$\frac{RM}{f^2} + \varphi = \left(n + \frac{1}{2}\right)\pi ,$$

where f is a radiation frequency and φ is an angle between initial polarization and dipole antenna orientation.

Despite the simplicity of this conventional "phase" Faraday effect, the frequency separation between the lanes observed is often smaller than the predicted one based on realistic ionospheric plasma densities. As a result it was proposed to take the Jovian ionosphere into calculations, or consider the longer propagation paths in Earth ionosphere. Here we propose an model, which can possibly explain the smaller separations between the lanes in Jovian emission spectra.

Our approach is based on an effect, occurring during the passage of burst-like radiation through the ionosphere, when the burst "doublet" is formed due to signal propagation in two normal modes, right and left polarized, respectively. In this case, if we analyze the sequence of bursts within the time constant of the receiver, we will see the lanes separated by the frequency $\Delta f = \Delta t_{gr}^{-1}$, where Δt_{gr} is a group delay between two normal modes in the ionosphere. Both analytics and numeric calculations performed for realistic ionosphere and radiation parameters show that the group delay is several times higher than equivalent "phase delay", which is attributed to Faraday rotation, and the lanes with smaller separations occur in radiation dynamic spectra due to this specific "group" Faraday effect (see figure 1).

To support the proposed model the simulations are performed, both for pulsed (burst-like) radiation and continuous noise-like signals. These results are presented and discussed in detail. The lanes separated by the inverse group delay, are mainly not due to the specifics of Jovian radiation, but represent a general property of the Fourier transformation of the signal containing the repeating (or coherent) elements with the given time delay.

It should be stressed that the model proposed is valid both for overlapping signals with group delay smaller than the burst duration and the separated signals with group delay larger than burst duration. In any case, the interference effects leading to lane structure formation occur directly in a receiver – as a response of each of its channels on repetitive burst excitation with given group delays and phase shifts.

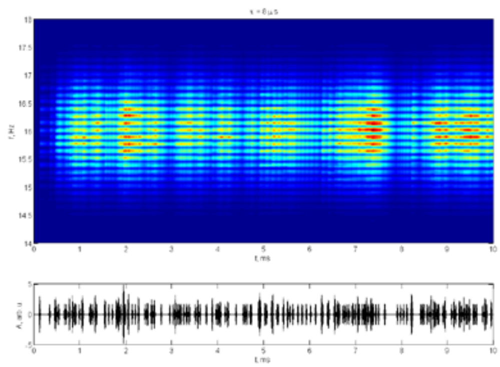

Figure 1. Simulated dynamic spectrum of a burst-like emission (upper panel) and the emission waveform (lower panel) for the parameters typical for Earth ionosphere with group delay 8 μs between the pulses in two normal modes.

Acknowledgements

The work was supported by the Russian Foundation for Basic Research (projects 10-02-01417- a, 11-02-97086-r_povolj'e_a).

References

[1] Phillips, J.A., T.C. Ferree, J. Wang, Earth-based observations of Faraday rotation in radio bursts from Jupiter. J. Geophys. Res., V.A94, pp.5457-5466 (1989)