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S-bursts of Jovian decametric emission vs. hypotheses

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Abstract

Our new morphological and correlation analysis of broadband records of S-bursts of Jovian decametric emission reveals clear "fingerprints" of the low-altitude acceleration of the radio-sources in the standing dispersive Alfvén wave. This implies that S-burst emission, like AKR near the Earth, is generated inside depleted cavities. In addition, the considerable dispersion (−17.3±1.4 MHz/s at 25 MHz) of S-burst emission is found.

1. Introduction

The highly complicated phenomenology of Short (S-) bursts (Fig. 1) decametric emissions of Jupiter (DAM) is still a mystery. The dominant theory of S-bursts (e.g., [2,3]) is based on the assumptions on the *negligible dispersion delay* of the radio emission and on the acceleration of the emitting electrons in parallel electric fields of Alfvén waves *above the regions of DAM generation*. We test these hypotheses applying the morphological and the two-dimensional correlation analysis to the broadband S-burst storms recorded with the Nançay decametric array.

2. Acceleration effects

It is believed that the trajectories of radio-sources in DAM dynamic spectrum (time-frequency plot) reflects the motions of electron clumps, which radiate approximately at the local electron cyclotron frequency [2]. Analyzing these trajectories (i.e., S-bursts), we find the clear manifestations of wave acceleration of S-burst-sources in the regions of DAM generation:

a) there are sinuous S-bursts in the dynamic spectrum of DAM (Fig. 1);

b) the bands of S-bursts at certain frequencies were reproduced as captures of the radiating electron bunches in the parallel electric field of a standing Alfvén wave (Fig. 2);

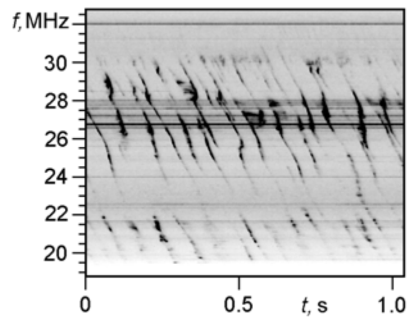

Figure 1: S-bursts (1996 June 11, 23:43 UT, Nançay decametric array).

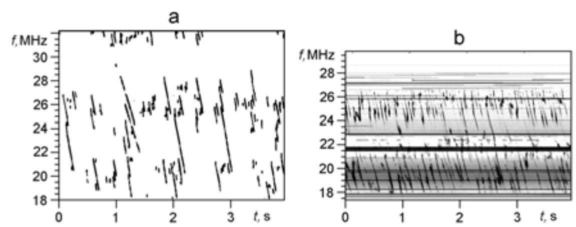

Figure 2: S-burst bands: a) the synthetic spectrum, which is calculated like in [1] but with the revised model; b) the real spectrum of S-bursts in two bands (2002 August 2, 9:00 UT, UTR-2).

c) the standing wave influence generate the specific correlation zebra-pattern in synthetic radio storms which corresponds to the observed pattern (Fig. 3).

Using 2D-correlation pattern, we estimate the wave phase velocity $V_{ph}=\lambda/P$ (Fig. 4). The typical velocity (~60,000 km/s) far exceeds the sound speed (5-17 km/s) in the region of S-burst sources. Hence, the wave disturbances can be identified only with Alfvén waves. Although the experimental estimates are systematically below the theoretical curves of current models (Fig. 5), they are in accordance with the solid curve, which is calculated for a low electron density (N_e=1 cm^{-3}) in the region of S-burst sources. Such low density permits the wave acceleration of emitting electrons even in the region of S-burst-generation.

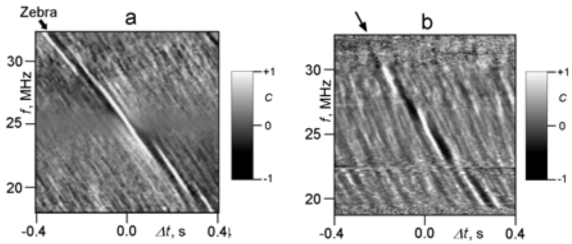

Figure 3: The correlation between S-bursts in the selected and reference channels is visualized with C parameter (description in [1]): a) the synthetic spectrum (Fig. 2a); b) the real spectrum (1996 June 11, 23:42:40; Nançay).

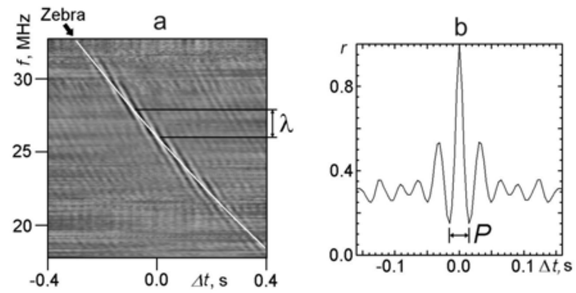

Figure 4: The extraction of parameters from the 2D-correlation pattern of the S-burst storm (1995 April 14, 5:43 UT; Nançay): a) the wavelength (λ) of wave modulation is the period of the zebra along the regression line (white curve); b) the period (*P*) of the modulating wave is the width of the main autocorrelation peak.

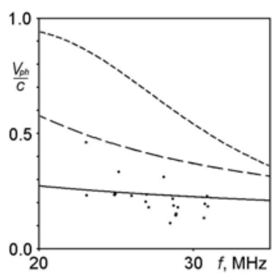

Figure 5: The phase velocity of dispersive Alfvén waves. Points are our estimates in comparison with theoretical curves, which are calculated as in [4] (dashed; $10^3<N_e<10^4$ cm^{-3}), with the doubled ionospheric scale height (long-dashed line; $N_e \sim 10^4$ cm^{-3}), and for $N_e = 1$ cm^{-3} (solid curve).

3. Dispersion effects

There are clear manifestations of frequency-related time-delay of DAM:

a) the hook-shaped figures in DAM dynamic spectrum (Fig. 6);

b) the inclination of zebra-pattern in 2D-correlation plots (−17.3±1.4 MHz/s at 25 MHz; Fig. 4).

The numerical modeling shows that the radiation delay in the compact (~0.1R_J) cold region around a small (< 0.03 R_J) depleted cavity with the radio source inside seems the appropriate explanation of the dispersion effects in dynamic spectra of S-bursts. The radiation frequency of the cyclotron maser in the cavity is below the cutoff frequency f_x of X-mode in the ambient dense plasma. In this case the radiation can leave the cavity if f_x is decreased to the radiation frequency *f*. Under this condition ($f_x \rightarrow f$), the group velocity tends to zero.

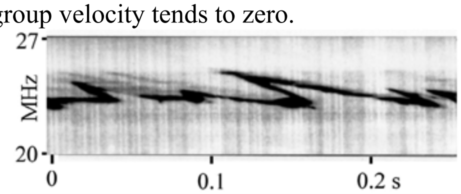

Figure 6: The hook -events in DAM dynamic spectrum [5] are a clear indication of a greater time delay of the radio emission at low frequencies.

4. Summary and Conclusions

Apparently, the phenomenon of S-bursts is much more complex than generally assumed. The local acceleration of electrons in regions of DAM sources and the dispersive delay of radio emission, which still being believed as insignificant, are important and should be taken into account.

Acknowledgements

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References

[1] Arkhypov, O. V., Rucker, H.O.: Dynamics of decametric radio-sources and standing Alfvén waves in jovian magnetosphere, Icarus, Vol. 212, pp. 714-718.

[2] Hess, S., Zarka, P., Mottez, F.: Io-Jupiter interaction, millisecond bursts and field-aligned potentials, Planet. Space Sci., Vol. 55, pp. 89-99, 2007.

[3] Hess, S., Delamere, P., Dols, V., Bonfond, B., Swift, D.: Power transmission and particle acceleration along the Io flux tube, J. Geophys. Res., Vol. 115, A06205, 2010.

[4] Jones, S. T., Su, Y.-J.: Role of dispersive Alfvén waves in generating parallel electric fields along the Io-Jupiter fluxtube. J. Geophys. Res., Vol. 113, A12205, 2008.

[5] Riihimaa, J.J.: Wide-range high-resolution S-burst spectra of Jupiter, Univ. of Oulu, 1992.