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Short-periodic VLF emissions observed simultaneously by Van Allen Probes and on the ground

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Extended Abstract

We present simultaneous observations of VLF emissions with periodic bursts by Van Allen Probe A (VAP-A) near geomagnetic equator and Kannuslehto and Lovozero ground-based sites [1]. The repetition period and ground–spacecraft delay are consistent with guided whistler wave propagation between conjugate ionospheres. In contrast to lightning whistlers, the group velocity dispersion is not accumulated from one burst to another, thus implying a nonlinear mechanism of its compensation.

Two regimes were observed. In one regime, Poynting flux direction alternates in the magnetosphere, and the burst period (2 s) is half of that detected on the ground (4 s), corresponding to single wave packet bouncing along the field line. The calculated one-hop propagation time of whistler mode waves (2 s) is in good agreement with the power repetition period at VAP-A and exceeds twice the measured time delay of 1 s between KAN and VAP-A, which is consistent with the fact that VAP-A was very close to the equator.

This regime is switched to the other one, with the burst period unchanged in the magnetosphere but halved on the ground. Thus, the period is equal to T_g both at KAN and VAP-A. In this second regime, no alternating Poynting flux direction is observed. This can naturally be explained by the existence of two whistler-mode wave packets propagating almost symmetrically between the hemispheres. These wave packets meet at the equator, and the period there remains equal to T_g. If the powers of these wave packets were equal, then the Poynting flux would not have had a predominant direction. In the opposite case, the direction of the wave packet with higher amplitude prevails. Thus, the second regime corresponds to two symmetrically propagating wave packets synchronously meeting at the equator.

The angular distribution maps of Poynting flux at LOZ reveal a preferential south-west direction of wave propagation, that is close to the magnetic projection of the VAP-A trajectory to the ground, which allows us to assume that VAP-A could have passed the source region at the time of event.

A sharp halving of the repetition period on the ground can be related to a change in the generation regime in the magnetospheric cyclotron maser. We did not notice any strong changes in the energetic particle population detected by VAP-A. Therefore, if the spacecraft crossed the source region during PE observations, the change in the generation regime was probably related to the ionospheric reflection change. Indeed, the local time of the event approximately corresponded to the solar terminator passing.

Both observed regimes are consistent with a model of passive mode locking in the magnetosphere whistler-mode cyclotron maser [2], and a sharp transition from one regime to the other could occur to the change in the ionospheric reflection of VLF waves related to the terminator crossing.

References

[1] A. G. Demekhov, E. E. Titova, J. Manninen, A. S. Nikitenko, and S. V. Pilgaev, "Short-periodic VLF emissions observed simultaneously by Van Allen Probes and on the ground," *Geophysical Research Letters*, **48**, No.20, e2021GL095476, https://doi.org/10.1029/2021GL095476.

[2] P. A. Bespalov "Passive mode locking in masers with unequally spaced spectra," *Sov. Phys. JETP*, **60**, No.6, pp.1090-1095.