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Electron Scattering and VLF Noise Suppression by Whistler Echo Trains

David R. Shklyar*(1), Jyrki Manninen(2), Elena E. Titova(3)(1), Ondrej Santolík(4)(5), Ivana Kolmašová(4)(5), and Tauno Turunen(2)

(1) Space Research Institute, Russian Academy of Sciences, Moscow, Russia
(2) Sodankylä Geophysical Observatory, Sodankylä, Finland
(3) Polar Geophysical Institute, Apatity, Russia
(4) Department of Space Physics, Institute of Atmospheric Physics, Czech Academy of Sciences, Prague, Czechia
(5) Faculty of Mathematics and Physics, Charles University, Prague, Czechia

Whistler echo trains are one of the remarkable wave phenomena in VLF band registered on the ground [1]. It is generally associated with quasi-parallel whistler wave propagation in a duct. VLF noise, sometimes also called VLF hiss, is another wave phenomenon observed in the lower-frequency part of VLF band. It was discovered long ago that intense whistler echo trains can suppress VLF noise by removing a part of free energy of energetic electrons responsible for VLF noise generation [2].

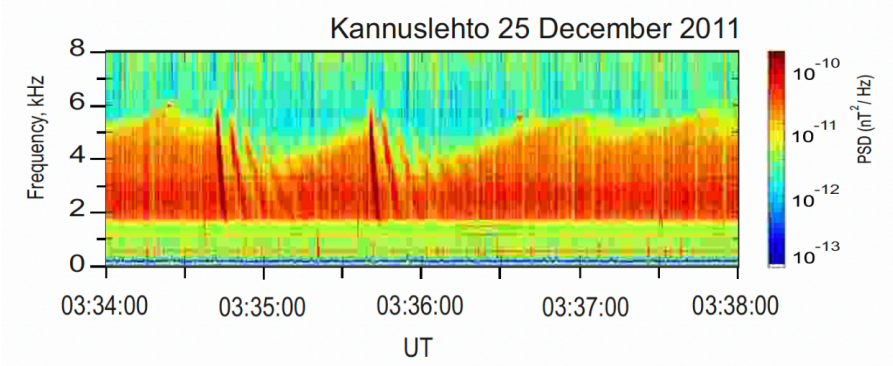

Figure 1: Spectrogram in the frequency band up to 8 kHz registered at Kannuslehto ground station in North Finland ($L = 5.5$) illustrating the phenomenon of VLF noise suppression by intense whistler echo train.

To develop this idea into qualitative model, we set forth a theory of electron resonant interaction with parallel propagating multihop whistlers (whistler echo train). We derive and solve numerically the set of equations that describe electron interaction with multihop whistlers in the ambient inhomogeneous geomagnetic field. These equations take into account space-time variations of frequencies and wave vectors, as well as space-time boundedness of the wave packets representing an echo train. We show that resonant interaction with such wave packets leads to electron diffusion in the phase space, which reduces the free energy of unstable electron distribution.

While VLF noise suppression by whistlers has first been discovered on the ground station, we have found similar effect in the VLF data from Van Allen Probe B taken in the equatorial region on L-shell ~ 3. Detailed analysis of the data shows that the whistler echo train as well as the VLF noise have small wave normal angles. Based on this observation, we limit our analysis to parallel (ducted) whistler wave propagation. The persistence of whistler echo train as well as the VLF noise suggests that in the events under discussion, plasma is unstable in the frequency range corresponding to the observed VLF noise band. Thus, the indicated observations made on the Van Allen Probe B satellite serve both as the basis of the developed theory and as an object of its application.

References

[1] R. A. Helliwell, *Whistlers and Related Ionospheric Phenomena*, Stanford University Press, Stanford, California, 1965.

[2] W. B. Gail, and D. L. Carpenter, "Whistler induced suppression of VLF noise," *J. Geophys. Res.*, **89**, 2, 1984, pp. 1015–1022.