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VLF EMISSIONS AND ELECTRON PRECIPITATION STIMULATED BY POWER LINES HARMONICS RADIATION (PLHR)

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Introduction

Among a large variety of different types of magnetospheric origin VLF emissions which can be seen in VLF dynamic spectra (sonogramms) e.g. hiss, chorus and their different combinations, very often present thin separate lines. Those emissions are the power line harmonics of 50 Hz (PLHR), occurring because of different nonlinear processes in power line systems [1] and it is really not easy to escape them when performing VLF observations nowadays. Usually a large part of the energy of these harmonics is circulating in the Earth - ionosphere wave guide though the waves of sufficient amplitude often can penetrate into the magnetosphere [2]. More over, sometimes there is also some positive feedback between substorm activity and PLHR [3,4]. Horizontal component of geomagnetic field fluctuations related to substorms can produce DC currents in power lines, resulting in a strong magnetic bias on a power transformer cores. The waveform of the current can be distored because of transformer nonlinearity. High frequency components of the distorted current will emit electromagnetic waves, penetrating into the magnetosphere as a power line harmonic radiation. The PLHR can trigger a large variety of VLF emissions through the wave-particle interaction [5,6]. This mechanism is well known, but its physical details are not explained yet.

Instrumentation and data analysis

Auroral pulsations have been investigated by low-light TV camera, VLF emissions - by receiver with a loop antenna. Information was synchronously recorded on videotape. TV and VLF data have been collected during the Russian-Finnish observational campaigns in 1993-1997. Two recording stations were located it the north of Finland: Porojarvi (69.17 N,21.47 E, L=5.88), Kalkoaivi (68.73 N, 22.11 E, L=5.86). The third station was Lovozero (67.97 N, 35.02 E, L=5.23). TV data were analysed by precise analog videointegrator, connected with a computer via 12-bit analog-digital converter (ADC) card, so very weak auroral pulsations, even through strong fog and clouds could be studied. Real-time analysis of VLF dynamic spectra with massive spectra integration was performed by spectranalyser, connected with a computer. Very weak amplitude variations of VLF emissions in different frequency bands were also studied using ADC computer card. In total, more than 50 hours of data with PLHR effects have been analysed.

Results

Analysis of the integrated dynamic spectra of VLF emissions revealed the emission intensifications at some frequencies looking like a stable frequency periodic structure in VLF spectrum with the main frequencies of about 250-400 Hz. Detailed investigation including in addition to the VLF recording the grid of calibrated frequencies and correlation analysis of that complex signal has shown that the periodic structure has a fundamental frequency very close to 50 Hz. The main difference of the effect observed from normal power line harmonics usually visible in VLF dynamic spectra is large (about 50%) spectrum broadening without significant spectral power decreasing with increasing of harmonic number. No periodic spectral structures have been found for geophysically active days with strong, full-scale breakups, the effect being observed only during quiet time intervals and pseudobreakups. Fig.1 (top panel) demonstrates an example of spectrum-broadened PLHR emissions. Though the effect is rather weak and there is a lot of noise on the sonogram (sonogram is an integral picture of 100000 individual spectra), the frequency periodic structure is quite noticeable. Some activations of spectral periodic emissions can be found for different intervals (for example, 19.35 and 20.00) in the frequency range of 1.5-2.3 kHz. It is interesting to note, that 20.00UT activation corresponds to pseudobreakup. The bottom panel of Fig.1 is a result of sonogram integration over time (1 hour interval) for one day of a moderate activity. For comparison, the middle panel demonstrates an example of spectrum integral for an active (or very quiet) day. Fig.2 demonstrates an example of active interaction of observed emissions with the magnetospheric electrons. On the top panel average amplitude of VLF emissions in the frequency range of 15% bandwidth around 2300 Hz is shown. The emissions appear in the form of shot pulses with the duration of 8-15 seconds and period about 20-40 seconds). Emission activation (19.05-19.35) clearly correlates with TV photometer signal. At that time aurora is observed as a weak diffuse luminosity with changes of brightness being less than one per cent. The central panel of Fig.2 shows the sonogram for the top picture fragment (19.20-19.30). It is clearly visible that VLF emission intensification appears at the frequencies of previously existed periodic structure. On the bottom panel of Fig.2 VLF-aurora integrated correlation function with the time scale of about 10 seconds is presented. Though the amplitude of VLF and of aurora pulsations with periods of 0.5-2 seconds is very small and totally masked by noise in the previous pictures (top and middle panels), the correlation function looks much like that for ordinary chorus and auroral pulsations with aurora lead chorus for about 1.5 second. So, it seems that VLF intensifications have some fine structure identified like chorus elements.

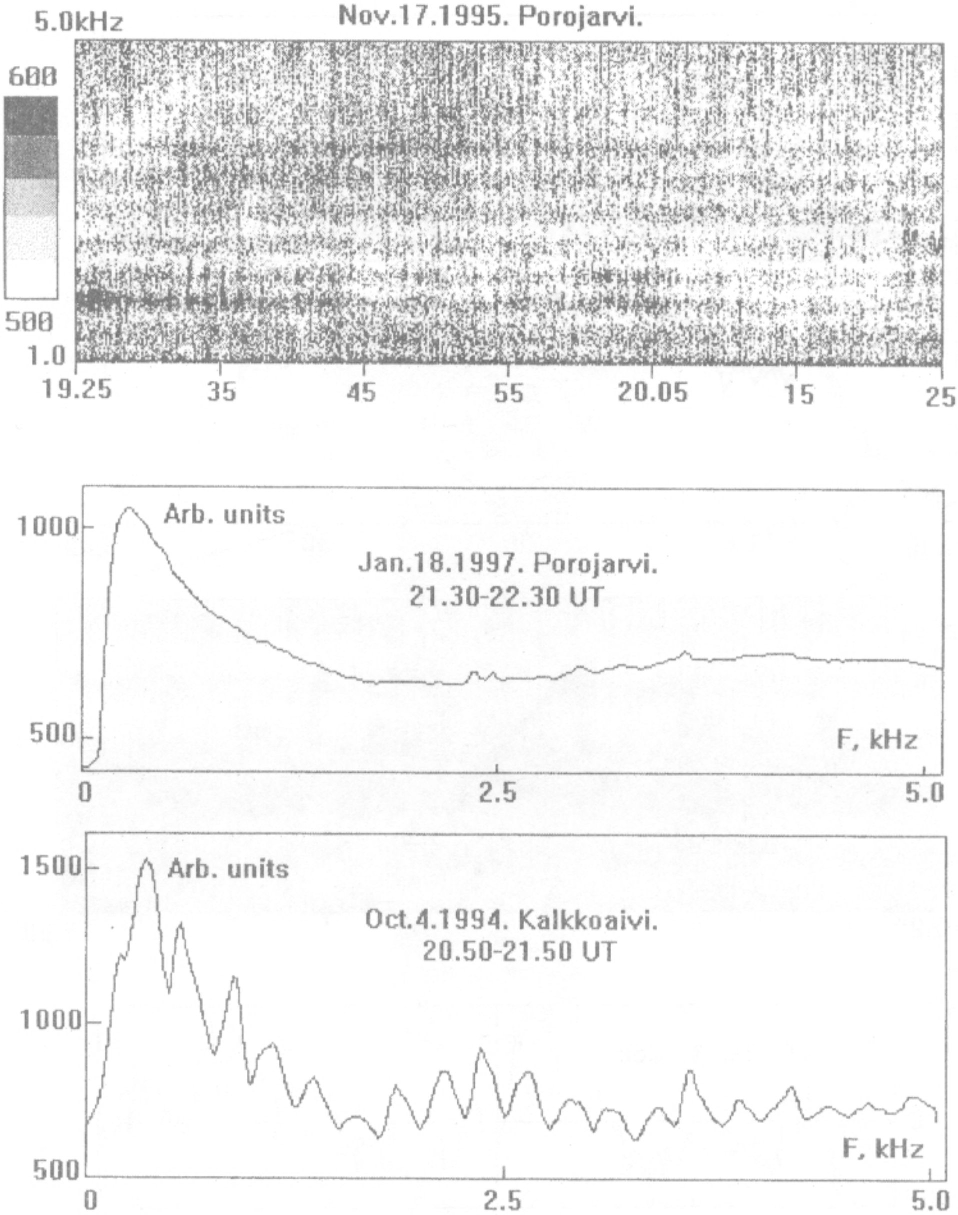

Fig.1. Examples of periodic spectral structure of VLF emissions.

Discussion

Magnetospheric processes are very sensitive to various external disturbances [7,8]. VLF emissions and electron precipitations can be triggered by power line harmonics, lightnings, powerful radiotransmitters and so on [9,10]. New type of PLHR is found wich is a spectra broadened PLHR with a periodic frequency structure. The fact that spectrum broadened PLHRs are not observed during quiet and active time intervals, but mostly during intermediate moderate activity with small auroral activisations and pseudobreakups gives evidence that the effect is noticeable when the magnetosphere comes close to the limit of stability. So, the effect discussed can give useful information for magnetosphere diagnostic because of a large number of measurable parameters i.e. the frequencies of spectrum intensifications, level of harmonics spectral broadening, interaction with the electron population and stimulated precipitations and so on.

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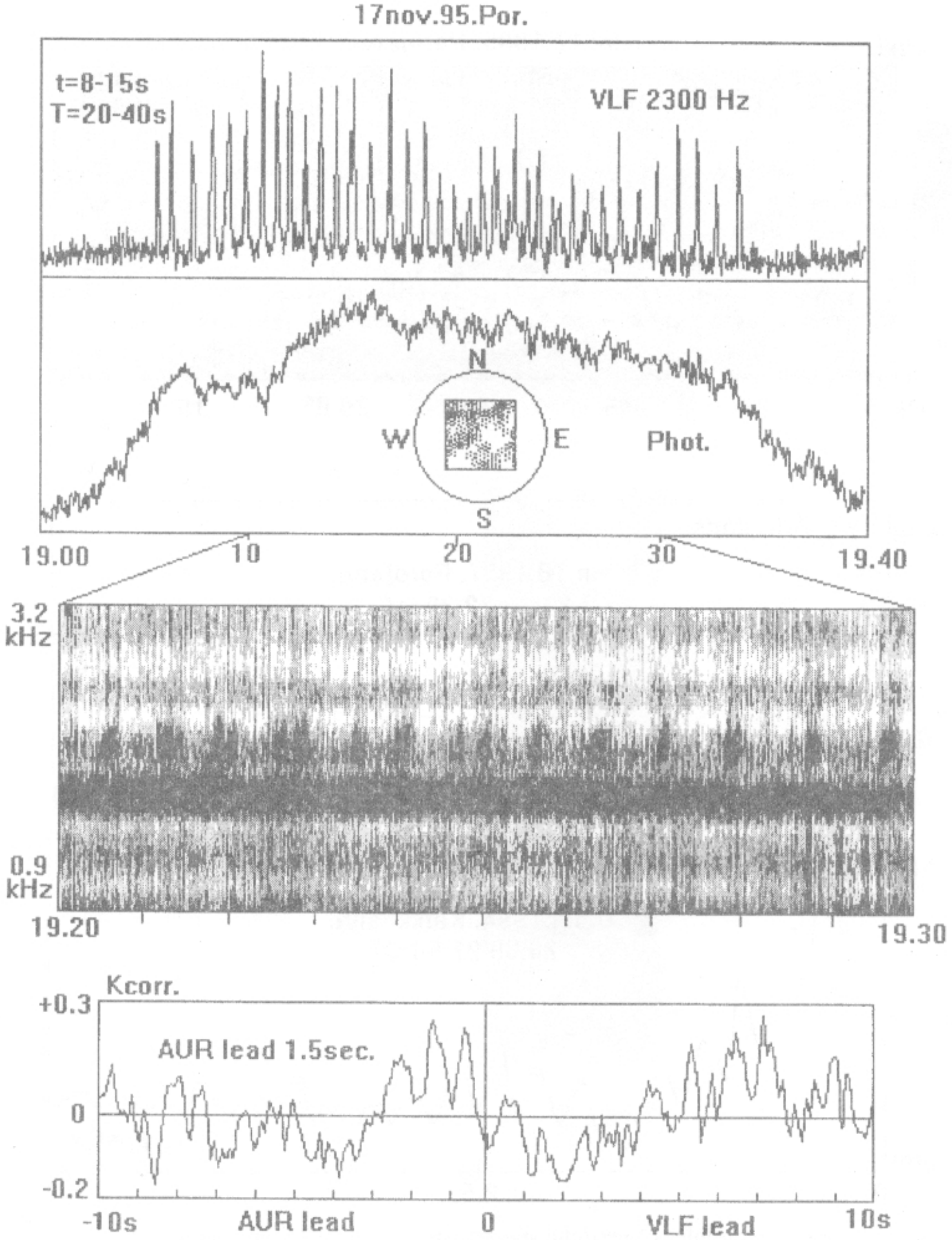

Fig.2. Chorus and electron precipitation stimulated by PLHR

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