"Physics of Auroral Phenomena", Proc. XXXIII Annual Seminar, Apatity, pp. 137 - 139, 2011

Polar Geophysical Institute

STUDY OF GENERATION OF ARTIFICIAL MAGNETIC PULSATIONS IN Pc1 RANGE AT SPITSBERGEN

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Abstract. Excitation of artificial magnetic pulsations in Pc1 frequency range occurs rather rare. Moreover observation of the ionosphere response to ionosphere heating is not clear in the frame of a conventional model of their generation. Frequently for two events with very similar ionospheric condition artificial emissions may to be observed or not observed. This peculiarity was named as a sporadic nature of the artificial pulsations. Possible explanation of the sporadic nature is disturbances of neutral particle densities in the ionosphere. This parameter included in the numerical model is not controlled during experiments on ionosphere heating. Series of the heating experiments on the pulsation excitation at Spitsbergen give more features to the sporadic nature. Probability of their excitation is independent from local magnetic activity, although the artificial pulsation amplitude depends strictly on ionospheric magnetic field magnitude. The event study of the convection velocity also shows its insignificant correlation with the emission intensity. New ideas are needed to fit the experimental findings with the numerical model.

Introduction

Heating experiments at Spitsbergen on the artificial magnetic pulsations excitation in Pc1 frequency range carried out in 2006 through different seasons, local time, geophysical conditions, etc. Numerical calculations of the effects of the modulated heating with ground based HF powerful transmitter predict simple dependence of the pulsation amplitude on the ionospheric electric field (Pashin et al., 1995). Probability of the pulsation excitation is expected to be statistically increased with the magnetic activity growth; however it does not show clear dependence from magnetic activity (Mochalov and Pashin, 2010). In cases of the artificial pulsation observations a relationship of the emission parameters with ionospheric convection also is not observed (Mochalov and Pashin, 2010). Such behavior of the emissions contradicts to the conventional model of their generation and more extensive analysis of the intervals of the ionosphere response observations is needed.

Observations of ionospheric drift velocity by radar systems such as SuperDARN (Greenwald et al., 1995; Chisham et al., 2007) provide one frame of the convection map in 10 minutes. Intensity of the artificial emissions may vary faster so its comparison with the convection is not reliable. In simple case of one dimensional current system one may to estimate its location from ratio of horizontal component to vertical one. Magnetometer site at LYR is close to the SPEAR Heating Facility and magnetic variations recorded there are used to deduce ionospheric currents for comparison with artificial emission parameters. For this purpose it is very significant to determine a quite level corresponding to the zero density of ionospheric current. Also it should be noted that at high latitudes ionospheric currents frequently are arbitrary directed so we used variations of horizontal component calculated its direction as well. For our study we choose the heating intervals when a clear ionospheric response is observed, namely:

July 12, interval 05.30-06.30 UT;
July 15, interval 05.30-06.30 UT;
July 11, interval 15.50-16.50 UT.

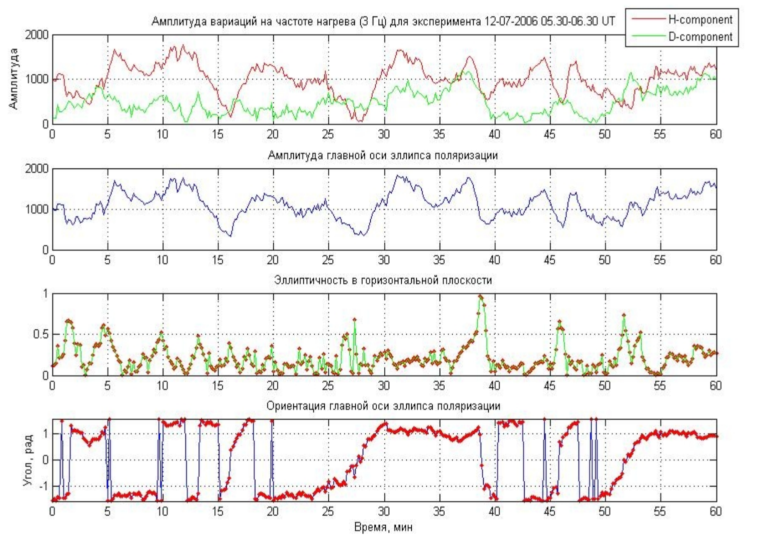

Figure 1. Artificial pulsation parameters deduced from spectral density for July 12, 2006 experiment.

Data analysis

Artificial magnetic pulsations were observed at the Barentsburg observatory of the Polar Geophysical Institute by a three component magnetometer with a 40 seconds sampling rate. The

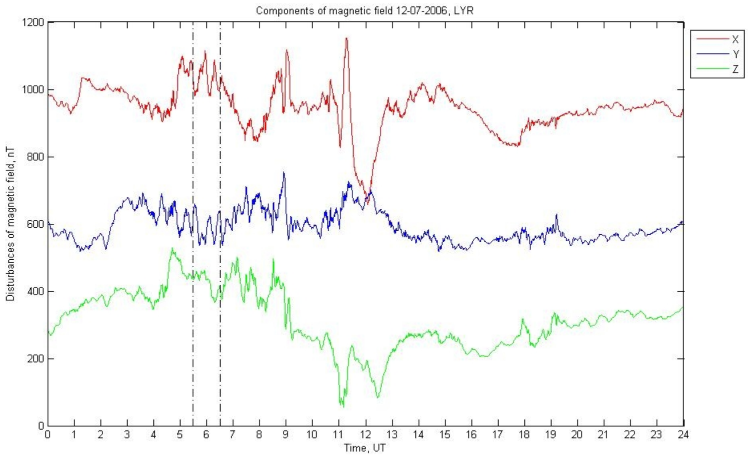

Figure 2. Magnetic variations recorded in LYR on July 12, 2006

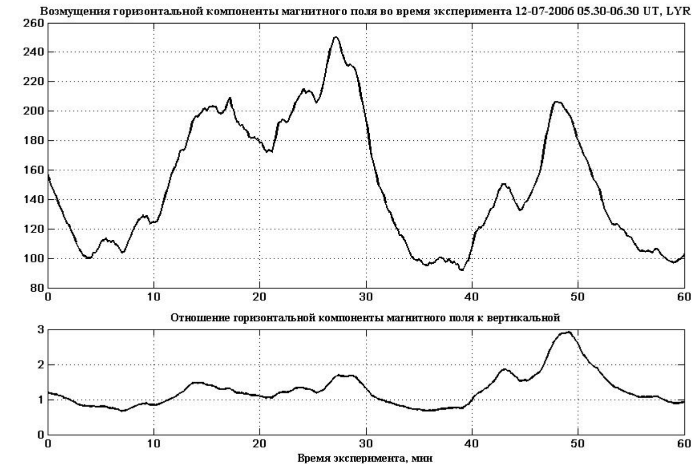

Figure 3. Variations of the horizontal vector (top diagram) and its ratio to the vertical component for one hour of the heating on July 12.

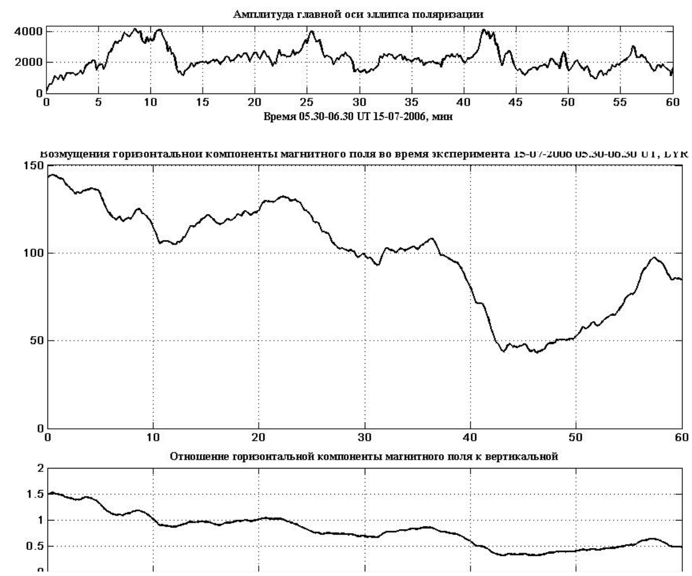

Figure 4. Amplitude of artificial emission in horisontal plane (top); variations of the horizontal vector (middle) and its ratio to the vertical component (bottom) for one hour of the heating on July 15, interval 05.30 – 06.30 UT.

frequency response of the magnetometer system is constant in the range 0.2 to 20 Hz. Data analysis is based on standard Fast Fourier Transform (FFT) for 4000 data samples. Dynamic spectra of the components are used for distinguishing the artificial signal from the background variations. From spectral parameters of the components the amplitude and polarization of the emissions in horizontal plane were determined. Figure 1 shows the pulsation characteristics from top to the bottom: first diagram presents variations of the amplitude of H- and D-components; second one gives calculated main axis of the polarization ellipse; next plot shows the minor axis to main one ratio; and the angle of the main axis in horizontal plane is shown at fourth diagram.

The pulsation amplitude is rather variable during one hour of the heating although polarization is very stable. Magnetic field variations recorded at LYR observatory on July 12, 2006 are presented in figure 2, heating interval is denoted by vertical dashed lines. Magnitude of the variations is up to 100 nT in each component. July 6, 2006 was taken as a quiet day for our study. Variations counted off quiet day level were used for calculations of horizontal vector length and its ratio to vertical component

Figure 3 shows at the bottom diagram variations of length of the horizontal vector related with the ionospheric current intensity and its distribution in the ionosphere. Ratio of the horizontal vector to the vertical component is presented in bottom diagram. Approach of the current system center corresponds significant increasing of the component ratio. These dependencies are in a good correlation, it argues that magnetic variation is accounted for current system dynamics not time dependent intensity. Extreme values of the ratio correspond to the closest location of the current system center to a magnetometer. Note, that variations of the artificial pulsation amplitude near these moments have minimal values. In contrary minimum of the ratio producing by moving off currents associated with the artificial signal increasing.

Top panel of figure 4 demonstrates

amplitude of artificial emission in horisontal plane for July 15, 2006. Middle diagram shows variation of the horizontal vector produced by ionospheric current system. In the bottom part the ratio of the horizontal vector variations to the vertical component ones is presented. Three short lasting maxima is observed in the pulsation amplitude. Again one can see local minimums in the ratio of horizontal component of the disturbances to the vertical one corresponded to the pulsation amplitude maxima. Spatial variations of the current center position influences on the artificial emission amplitude: approach of the current center decreases the pulsation intensity, and vise versa.

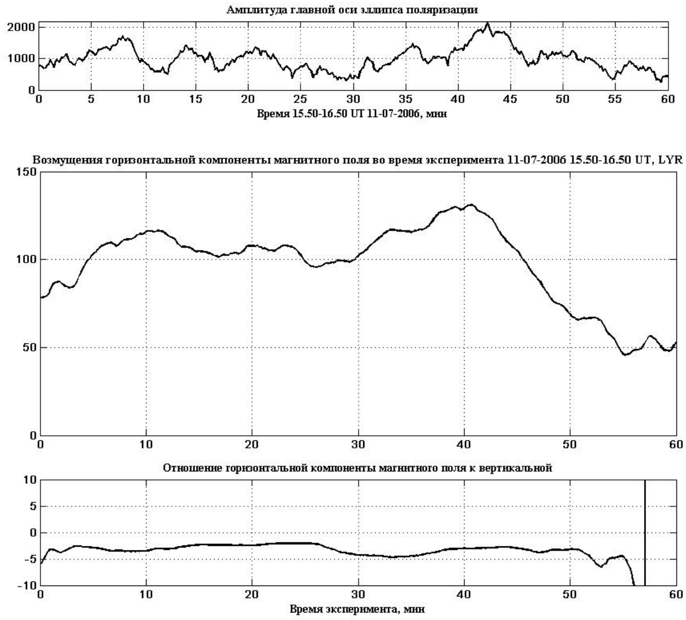

Figure 5. The same as fig. 4, but for July 11, 2006 experiment.

The same format of data presentation is used for July 11, 2006 experiment, time interval 15.50-16.50 UT (figure 5). This event is characterized by great value of the ratio of the horizontal vector to the vertical component. It means that current system center is located near magnetometer. Moreover at the end of the heating run sign of the ratio is changed, i.e. current crosses the zenith over the magnetometer. For this moment pulsation amplitude has a minimum. Clear maximum in the course of the experiment is observed again at the time of minimum of the component ratio.

The experimental findings of this study may summarize as follows:

- Artificial magnetic pulsations during heating interval vary rather significant.
- These variations are in relation with ionospheric current system dynamics
- Approach of the current system leads to decreasing of the emission amplitude and vise versa.

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