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APPEARANCE OF THE LONG-PERIOD GEOMAGNETIC OSCILLATIONS IN THE MAGNETOSPHERE

V.B. Belakhovsky, V.C. Roldugin *(Polar Geophysical Institute, Apatity, Russia, E-mail: belakhov@mail.ru)*

Abstract. On the basis of ground-based and satellite data during the magnetic storm of May 15, 2005, geomagnetic oscillations in the range from *Pc5* (150-600 s) to an hour are considered. The problem of the influence of reconnection and compression of the magnetosphere on the development of long period pulsations is examined. On the GOES-12 satellite and the ground stations located near the GOES-12 footprint the modulation of Pc5 pulsations with a period of approximately 80 minutes is detected. We suppose that this modulation is associated with the magnetotail oscillations.

Introduction

It is known that arrival of high speed solar wind stream causes the compression of the magnetosphere and the *SC* event. It is also known that an *SC* event is accompanied by the appearance of long-period *Pc5* pulsations (150-600 c) [Tverskaya L.V., 1982; Kleimenova N.G., 1999; Roldugin V.C., 2006]. In paper by Saito et al. [1967] *Pc5* pulsations associated with the SC were extracted into a special class *Psc5*.

The disturbances in the magnetosphere occur not only during the compression, but during the reconnection when a magnetic cloud passes through the Earth. *Gillis* et al. [1987] discussed the possibility of generation of *Pc5* pulsations due to FTE (flux transfer events). In paper by *Baker* et al. [2003] it was demonstrated that the radial component of the solar wind velocity, proton density, and *Bz*-component of IMF influence the occurrence of the *Pc5* pulsations. On the basis of more than 10 years of magnetic data from CANOPUS chain it was shown that the northward *Bz*–component has the main effect on the appearance of *Pc5* in comparison with the southward *Bz*–component. The observation on GOES satellite in paper by *Sanny* [2006] gives a different result: the intensity of *Pc5* is higher during the southward *Bz*.

The solution of the problem about the relation of pressure and IMF is important for understanding the reasons of *Pc5* pulsations generation. The dominant mechanism of *Pc5* pulsations generation is the excitation of surface waves at the flanks of the magnetopause due to Kelvin-Helmholtz instability [Engerbretson, 1999]. According to FLR (field line resonance) theory [Southwood, 1974] the compression mode transforms into toroidal mode on the closed magnetic field lines.

The question about the role of IMF and pressure as well as on the role of the sign of *Bz*-component in the development of *Pc5* pulsations is still open. The importance of the question consists in the fact that the development of Kelvin-Helmholtz instability is more probable due to the compression of the magnetosphere.

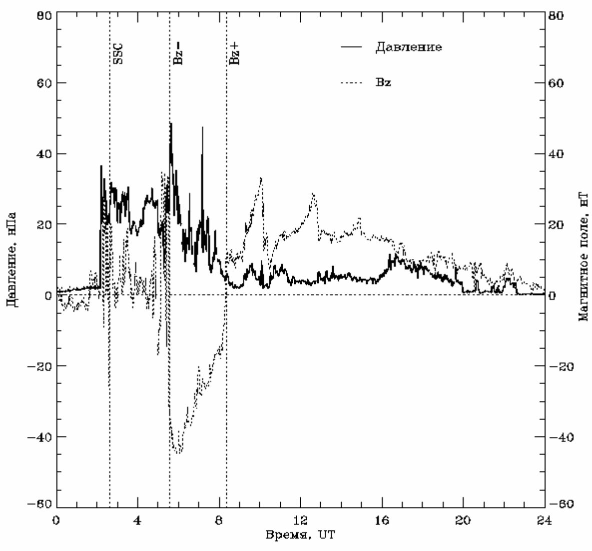

Fig.1. Solar wind dynamic pressure and Bz-component on WIND satellite on 15 May 2005.

The characteristics of the near Earth environment

On the 15-th of May, 2005 ground based stations detected an *SC* event at 02.38 UT which was caused by the arrival of the bow shock. Besides SC there are two other important moments in the course of this storm: the change of the sign of *Bz*-component from positive to negative (*Bz-*) and the change of the sign of *Bz*-component from negative to positive (*Bz+*). This day was strongly disturbed: Dst-index is equal to -260 nT, Kp = 9, AE = -2000 nT. Fig.1 shows the solar wind dynamic pressure and Bz-component of IMF from WIND satellite data. The WIND satellite was located in the at the point with coordinates X=210 Re, Y= 84 Re, Z=28 Re in GSM system. Approximately at 02.10 UT the solar wind pressure reached the value of 35 nPa, *Bz*–component was some 30 nT.

At 05.30 UT a sharp jump from +30 to -40 nT was observed, and at 08.18 UT from -20 nT to +10 nT. These three significant changes (SC, Bz- and Bz+) marked in Fig. 1 with vertical lines affect on the ground and geosynchronous observations with delay of 30 min.

Influence of compression and reconnection on the development of Pc5 pulsations.

For investigation of the influence of dynamic pressure and *Bz*-component on the development of *Pc5* pulsations we use the analysis of the preliminary ground-based magnetic data, filtered magnetic data and their spectra. In Fig.2 there are shown the *H*-component magnetic data cut off by high frequency filter for periods greater than 17 minute for the three specific moments. It is seen from Fig.2 that *SC* and *Bz-* contribute to the development of long-period pulsations. *Bz+* has no effect on the development of the pulsations.

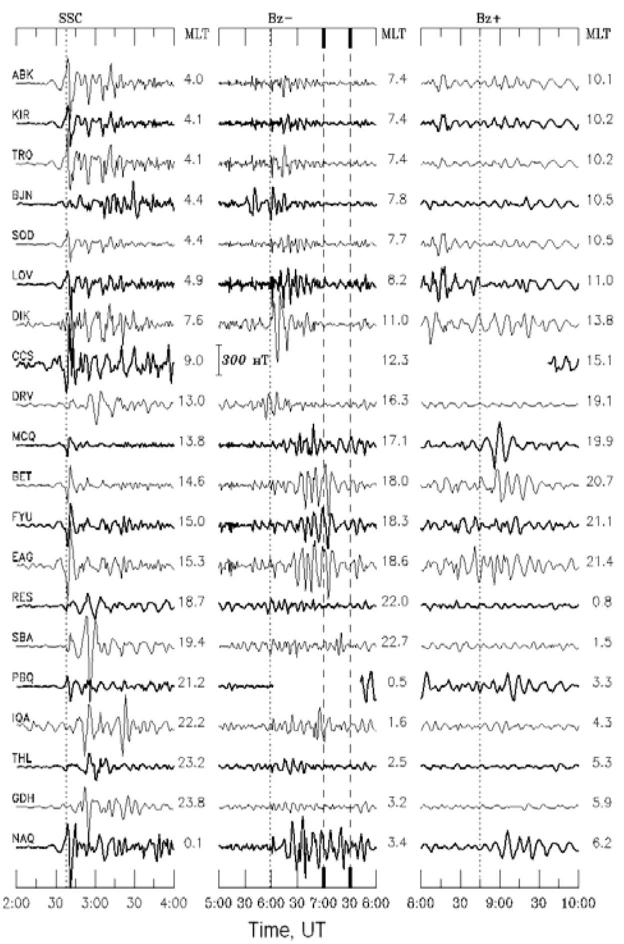

Fig.2. The filtered *H*-component of the magnetic field on ground-based stations for *SC*, *Bz-*, *Bz+*.

We also analyzed spectra obtained by means of Fast Fourier Transform for the 100-minute intervals after the three above-mentioned moments. After *SC* polyharmonic pulsations at all MLT sectors are appeared.

After *Bz-* large amplitude pulsations appear in the morning and evening MLT sectors. As compared with the spectrum of pulsations initiated by *SC,* the spectra after Bz- have a more monochromatic structure with the frequency of approximately 1.5 mHz.

There is some problem in the determination of causes of *Pc5* for moment *Bz-* because almost simultaneously a jump of solar wind pressure was observed (Fig.1). In that case the reconnection and compression may cause the *Pc5* pulsations. The raise of solar wind pressure was also observed in 07.00 and 07.30 UT. The raise of pressure at 07.00 UT was greater than for the moment of *Bz-*. As one can see from Fig.3 these two raises do not contribute to the wave response on the Earth. Thus, it may be assumed that after *SC* the main contribution to the development of *Pc5* pulsations was due to *Bz-*.

Therefore, the first two events, *SC* and *Bz-*, stimulate

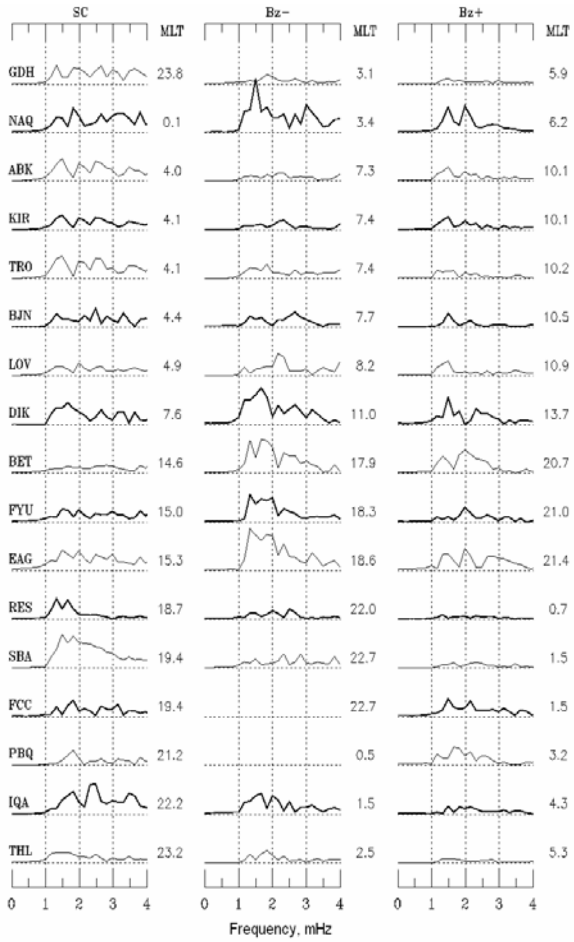

Fig.3. Spectrum of *H*-component for intervals *SC*, *Bz-*, *Bz+*.

the generation of *Pc5* pulsations, *Bz+* have not any effect on its development.

Pc5 pulsations on GOES-12

During the development of the magnetic storm **"**beautiful**"** *Pc5* pulsations in *hn*-component with amplitude 15 nT are identified on GOES-12 satellite. All three components of the magnetic field on GOES-12 were filtered with high frequency filter with cut off on periods greater than 17 minutes. The filtered data are shown in the upper panel of fig.4. The lower panel shows Z-components of magnetic field at the stations located near GOES-12 footprint: Godhavn (Φ=75.4°), Iqaluit (72.4°), PBQ (65.3°), Narsarsuaq (65.9°) и Fort Churchill (68.6°). As seen from the Figure pulsations were initiated, when *Bz*-component became negative. PBQ is located nearer to the GOES-12 footprint and the amplitude at this station has a greater value; the location of Godhavn is more distant and the amplitude has a smaller value. The periods at all stations coincide with the periods on GOES-12 in *hn*-component. At the same time, there

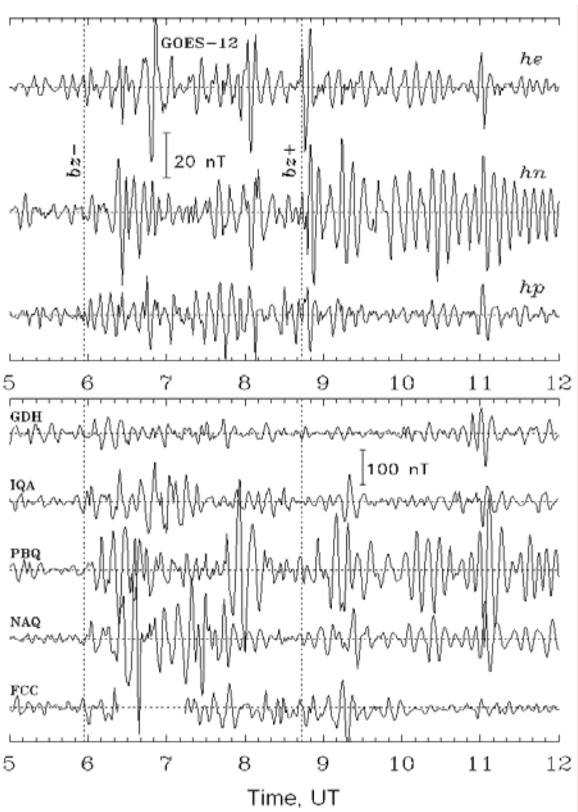

Fig. 4. Geomagnetic field oscillations on GOES-12 (the upper panel) and on ground-based stations in *Z*-component (the lower panel).

is no correlation between perturbations of the magnetic field on WIND satellite with pulsations on GOES-12. Hence, we consider that these magnetic pulsations on GOES-12 have inner magnetosphere origin during the time interval under consideration.

In Fig. 4 one can notice an interesting phenomenon: 8-minute *Pc5* superimpose on long 60-80 minute oscillations especially well seen at PBQ station. We suppose that these oscillations are connected with proper perturbations of geomagnetic tail, which were predicted by Ershkovich and Nusinov [Ershkovich, 1969; Nusinov, 1971] and had character times 1-2 hours. A beating may have appeared due to the combining of two wave processes. The double-peak spectrum at many stations for the interval of *Bz+* testifies in favor of this.

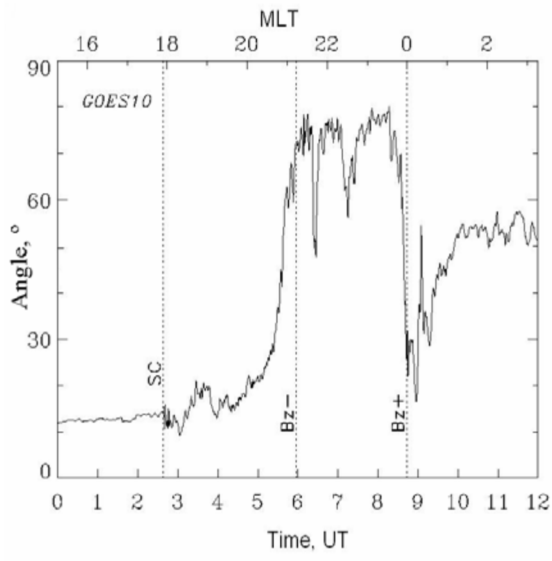

Fig.5. Magnetic tilt angle to the plane of geographic equator on GOES-10 satellite.

In order to detect the tail oscillations we use geosynchronous GOES magnetic data. The relation *he/hp* is determined, which describe the angle of inclination of the magnetic field line to the plane of geographic equator. Fig. 5 shows variations of this angle. In quiet conditions the angle is equal to 10-20^o, depending on the season. As seen from Fig. 5 the inclination on the night side of magnetosphere rises to the angle of 75^o when IMF *Bz* became negative and performs oscillatory motions between 60 and 75 ^{o} with periods of 60-80 minutes as the "beating" *Pc5*.

Conclusions

During the development of magnetic storm on May 15, 2005 the geomagnetic Pc5 pulsations were excited by compression and by changing of the sign of *Bz*-component from positive to negative. Changing of the sign of *Bz* from negative to positive have no effect on the development of *Pc5* pulsations.

Geomagnetic Pc5 pulsations have inner magnetosphere origin during the main phase of the magnetic storm May 15, 2005.

For this event geomagnetic beatings superimposed on the *Pc5* pulsations with periods of 60-80 minutes on GOES-12 satellite and at the stations located near GOES-12 footprint are identified. We assume that this beating was caused by geomagnetic tail oscillations.

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