"Physics of Auroral Phenomena", Proc. XXXII Annual Seminar, Apatity, pp. 55 - 58, 2009

Polar Geophysical Institute

CONNECTION OF TIME-SPATIAL VARIATIONS OF GEOMAGNETIC FIELD HORIZONTAL COMPONENTS WITH THE PLASMAPAUSE FORM ON RECOVERY PHASE

O.M. Barkhatova [1, 2], P.A. Bespalov [3], A.E. Levitin [4]

[1]*Research Radiophysical Institutes (NIRFI), 603950 Nizhny Novgorod, Russia*
[2]*Nizhniy Novgorod State Pedagogical University, 603950 Nizhny Novgorod, Russia*
[3]*Institute of Applied Physics, Russian Academy of Sciences, 603950 Nizhny Novgorod, Russia*
[4]*Pushkov Institute of Terrestrial Magnetism, Ionosphere and Propagation of Radio Waves (IZMIRAN), Russian Academy of Sciences, 142190, Troitsk, Russia*

Abstract. Influence of day time and afternoon sector plasmosphere plume on a level of ground geomagnetic field horizontal component disturbance at stage of a ring current decay is considered. It is shown, that geomagnetic field horizontal component varies synchronously on magnetic stations located on field lines meeting a day time plasmosphere plume. The spectral analysis of geomagnetic field horizontal component disturbances in geomagnetic pulsation range has shown, that on stations meeting day time and afternoon sectors plasmosphere plume increase of intensity in pulsation Pc-4 range is observed. The pulsations found out in a dynamic spectrum probably reflect resonant oscillations of magnetic field lines in the region of longitudinal currents in rather small altitudes. In our opinion, it is caused by instability of the longitudinal currents arising because of interaction of ring current energetic ions with electromagnetic waves in region of day time plume background plasma dense.

1. Introduction

Studying of a ring current dynamics during a magnetic storm assumes consideration of the most important part of this problem namely a ring current asymmetric part closing. As the main loss mechanism of ring current energetic ions to ionosphere usually mean their collisions with neutral atoms and dispersion in a loss cone because of wave-particle interactions [Fok et. al., 1991; Jordanova et. al., 1996; Cornwall et. al., 1970]. According to present-day representations [Bespalov and Trachtengertz, 1986], cyclotron instability of ring current energetic ions is the important mechanism of ions dispersion in a loss cone and their further intensive precipitation in evening sector. Presence of cold dense background plasma regions like a plasmosphere afternoon plume or cold detached plasma regions can stimulate development of cyclotron instability in afternoon sector [Trakhtengerts and Demekhov, 2005]. Experimental confirmation of cyclotron instability development because of energetic ions interaction with clouds of detached plasma is received [Yahnin, et. al., 2006]. The plasmospheric plume form during geomagnetic disturbances can change essentially. Formation of day time plasmospheric plume which arise on recovery phase of a geomagnetic storm is founded [Spasojević at. al., 2003]. Therefore it is possible to assume a presence of cyclotron instability not only in afternoon, but also in day time sector of a magnetosphere.

In the present work a consequence of longitudinal currents occurrence caused by intensive precipitations of ring current energetic ions is founded out. It is caused by their interaction with electromagnetic waves in region of cold background plasma dense corresponding to afternoon and day time plumes. Research is carried out on two week disturbed (-40 nT <Dst <-20 nT) days data (on June 2001, 10 and 27) for magnetic storm recovery phase. Within the days selected for research according to results [Spasojević et. al., 2003] there was a day time plasmospheric plumes which crossed magnetic shell L = 4 (Fig. 1).

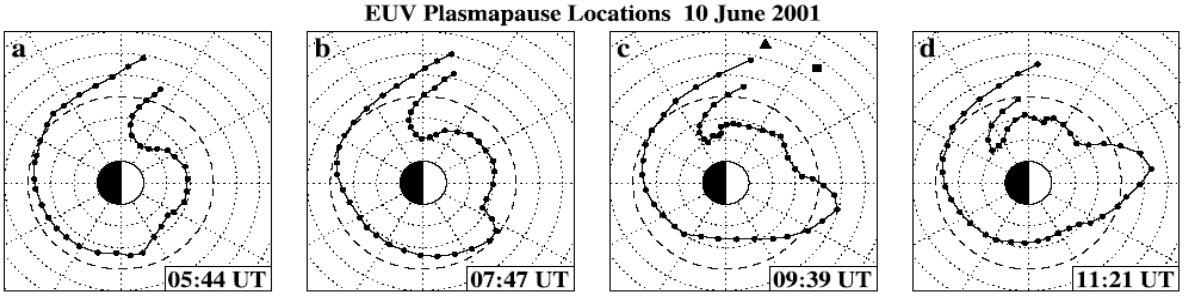

Fig. 1. Position of plasmapause boundary on June 2001, 10. The day time plasmospheric plume crosses magnetic shell L = 4 [Spasojević et.al., 2003]

2. The spectral analysis of geomagnetic field horizontal components disturbances on stations meridional chains

Consequence of assuming interaction of ring current energetic ions with electromagnetic waves in background plasma dense region namely afternoon and day time plasmospheric plumes are the descending longitudinal currents closed through an ionosphere. For a significant heterogeneous longitudinal current on transversal coordinate the instability of Alfven waves with wave vectors almost perpendicular to a magnetic field [Kozlovsky and Lyatsky, 1997] it is typical. This is probably why the longitudinal currents are frequently accompanied to local geomagnetic Pc-4 pulsations. Therefore Pc-4 pulsation detection in a spectrum can be evidence of significant longitudinal currents existence [Olson, 1986]. We shall note, that the general question about localization of geomagnetic pulsation in one's time has been carefully investigated [Pudovkin et. al., 1976].
For check of this hypothesis the spectral analysis of geomagnetic field horizontal components on the magnetic stations meeting day time and afternoon plasmospheric plumes is executed. Location of these stations allows to investigate a horizontal component spectra for cases than meridional chain of stations was outside of plasmospheric plume region and under the plasmospheric plume. Data from a stations chain (BJN, TRO, LOV, MRB, BNG) along 19-th meridian have been chosen for research of H-component changes under a day time plasmospheric plume; data from a stations chain (CBB, YKS, MEA, NEW, FRN) along 240-th meridian – for research of changes under an afternoon plume. Data about H-components changes have the one minute resolution [http://www.intermagnet.org/Data_e.html] and previously are cleared of a Sq-variation. Comparison of the received magnetic record spectra shows, that on magnetic stations meeting field lines of a day time plasmospheric plume region with geomagnetic latitudes is lower 45÷57° (L=2.04÷3.30), increase of intensity for high-frequency parts of amplitude-frequency spectrum in the range of Pc-4 pulsations is observed. For more high-altitude stations general recession of spectra intensity is observed. Comparison of spectra on stations for afternoon plasmosphere plume shows increase of intensity of high-frequency spectra parts for all considered stations. Thus, results of magnetic record spectral analysis for two meridional chains of stations are evidence of amplitude increase for spectra parts corresponding to Pc-4 pulsations (with frequencies is higher than $6 \cdot 10^{-3}$ с$^{-1}$) on magnetic station meeting the field lines corresponding to plasmospheric plumes.

3. Display of longitudinal currents connected to a day time plasmospheric plume in horizontal components disturbances and the analysis of their dynamic spectra

The changes of horizontal component amplitude-frequency spectra on magnetic stations are evidence of significant longitudinal currents existence. It takes place at going through the day time and afternoon plasmospheric plumes. However estimating their contribution in H-components asymmetry within the region of afternoon plasmospheric plume is difficult enough. The fact of this plume existence is not caused by development of geomagnetic disturbances. In this case consideration of a day time plume is interesting because it is formed mainly on recovery phase of geomagnetic storm. Following to the assumption what additional current form along field lines near to a day time plume, for investigation four magnetic stations have been chosen: Abisko (68.36 N, 18.82 E), Lerwick (60.13 N, 358.82 E), Lovoe (59.34 N, 17.82 E), Sodankyla (67.37 N, 26.63 E). For June 2001, 10 and 27 stations Lerwick and Lovoe were under day time plasmospheric plume, and stations Abisko and Sodankyla – outside.
Existence of field aligned currents, connected with a day time plume, is possible to find out by comparison of H-component magnetic records on the specified stations. On Fig. 2 the example of simultaneous H-component data records for four stations on June 2001, 27 is shown. Comparison of H-components on stations located under a day time plume (LER, LOV) and stations outside it (ABK, SOD) shows, that at the moment of stations LER, LOV passage through the day time plume, the significant decrease in horizontal component is observed. On stations ABK, SOD similar changes it is not observed. It means that above stations LER, LOV the intensive current proceeds which is connected to a day time plasmospheric plume.

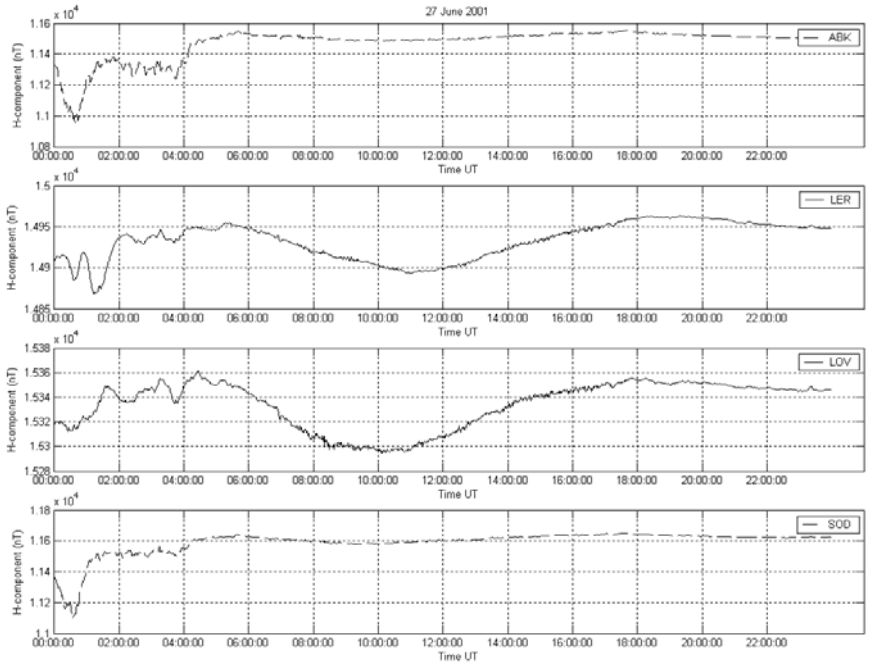

Fig. 2. Magnetic records on stations Abisko (68.36 N, 18.82 E), Lerwick (60.13 N, 358.82 E), Lovoe (59.34 N, 17.82 E), Sodankyla (67.37 N, 26.63 E) on June 2001, 27. The dashed line marks the stations located outside of day time plasmospheric plume (ABK, SOD), solid line – stations inside a day time plasmospheric plume (LER, LOV)

As marked above, one of longitudinal current existence signs are Pc-4 pulsations. Detection of such pulsations and time of their occurrence is possible by the dynamic spectra analysis. On Fig. 3 dynamic amplitude-frequency spectrum of geomagnetic field horizontal component for three of considered stations on June 2001, 10 and 27 are shown. For calculation of dynamic spectra data with 10 s time resolution are used.

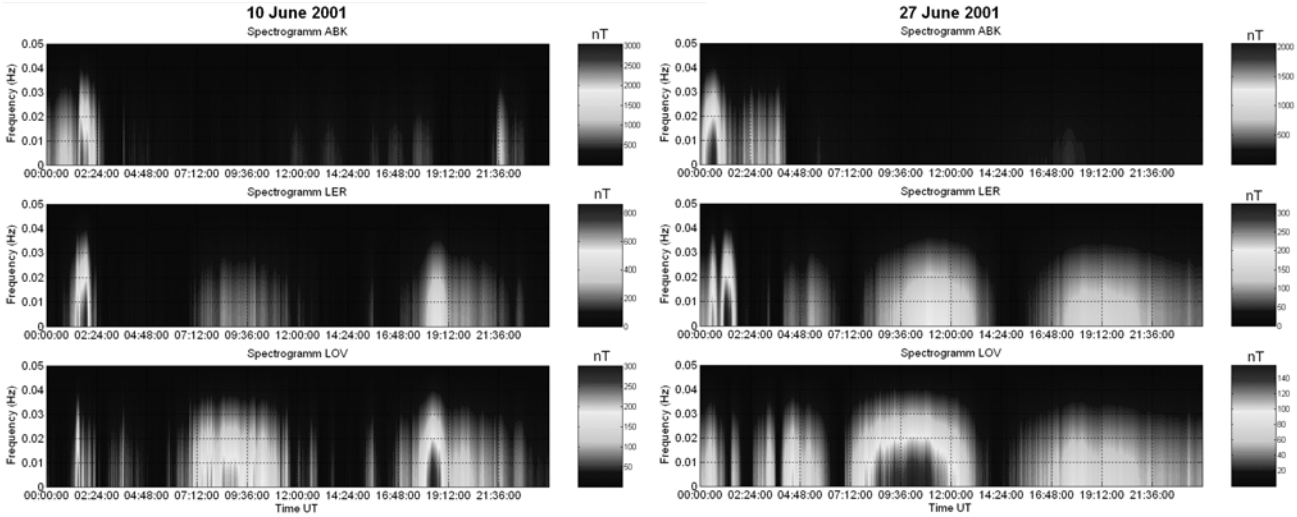

Fig. 3. Amplitude-frequency dynamic spectra of H-components for stations Abisko (68.36 N, 18.82 E), Lerwick (60.13 N, 358.82 E), Lovoe (59.34 N, 17.82 E) on June 2001, 10 and 27

Comparison of the received results shows significant changes in H-components on stations LER and LOV in comparison with stations ABK, SOD, located outside of a day time plume. In spectrum of a horizontal component there is a frequency set among which the frequencies corresponding to Pc-4 pulsations are marked. It indirectly confirms the assumption of intensive field-aligned currents formation due to interaction of ion-cyclotron waves with energetic ions in day time plasmospheric plume region. The field-aligned current can then spread over ionosphere. According to [Grafe et. al., 1997; Sun and Akasofu, 2000; Бархатов, et. al., 2008] such ionospheric current can be eastward electrojet for interaction in day time plume region, and westward electrojet for interaction in afternoon plume.

4. Conclusions

In present paper the influence of day time and afternoon plasmospheric plumes on asymmetry and amplitude-frequency characteristics of ground geomagnetic field disturbances is considered. Following results are received:

- Development of plasmospheric plumes during increased magnetic activity is shown on the Earth surface as local increase of some spectral components intensity in range of geomagnetic pulsations.
- The decrease of geomagnetic field horizontal component at input of magnetic stations in day time plume region is observed. It can be connected to formation of an additional current system on plume boundary.
- According to comparative results of H-component dynamic amplitude-frequency spectrum analysis, at input of magnetic stations in day time plasmospheric plume region significant increase of frequencies intensity on range of geomagnetic pulsations are found out. Presence of Pc-4 pulsations as indirect attribute of intensive longitudinal current in this region is revealed.

Development of the cyclotron instability can ensure effective interaction of ring current energetic ions with ion-cyclotron waves in plasmospheric plumes region. It can lead to formation of longitudinal currents in neighbourhood of east boundary both afternoon and day time plasmospheric plumes. Such processes can ensure an asymmetric ring current closing.

Acknowledgments. We thank Sarah Reay (The British Geological Survey) and Patrik Johansson (Geological Survey of Sweden) for granting of geomagnetic field component magnetic records with high resolution.
This work is supported by RFBR grants 08-05-12051, 08-02-00979 and 09-05-00495.

References

Barkhatov N.A., Levitin A.E., Tserkovnyuk O.M. Relation of the indices characterizing the symmetric (SYM) and asymmetric (ASY) ring currents to the AE (AU, AL) indices of auroral electrojet activity // *Geomagnetism and Aeronomy, 48*(4), P. 520-525, 2008.

Bespalov P.A., Trahtengertz V.Y. Alfven masers. Gorky: IAP AS USSR, 1986, 190 p.

Pudovkin M.I., Raspopov O.M., Kleymenova N.G. Earth magnetic field disturbances. Part 2. Short-time period oscillations of geomagnetic field. L.: LGU. 1976. 271 p.

Cornwall, J. M., F. V. Coroniti, and R. M. Thorne. Turbulent loss of ring current protons // *J. Geoph. Res., 75*(25). P. 4699. 1970.

Fok, M.-C., J. U. Kozyra, A. F. Nagy, and T. E. Cravens. Lifetime of ring current particles due to coulomb collisions in the plasmasphere // *J. Geoph. Res., 96*(A5). P. 7861. 1991.

Grafe A., Bespalov P.A., Trakhtengerts V.Y., Demekhov A.G. Afternoon mid-latitude current system and low-latitude geomagnetic field asymmetry during geomagnetic storms // *Ann. Geophysicae, 15*. P.1537-1547. 1997.

Jordanova, V. K., L. M. Kistler, J. U. Kozyra, G. V. Khazanov, and A. F. Nagy. Collisional losses of ring current ions // *J. Geoph. Res., 101*(A1). P.111. 1996.

Kozlovsky A.E., Lyatsky W.B. Alfven wave generation by disturbance of ionospheric conductivity in the field-alignend current region // *J. Geoph. Res., 102*(A8). P.17297-17303. 1997.

Olson J. V. ULF signatures of the polar cusp // *J. Geoph. Res., 95*(A9). P.10055-10062. 1986.

Spasojević M., Goldstein J., Carpenter D.L., Inan U.S., Sandel B.R., Moldwin M.B., Reinisch B. W. Global response of the plasmasphere to a geomagnetic Disturbance // *J. Geoph. Res., 108*(A9). 1340. doi:10.1029/2003JA009987. 2003.

Sun W., Akasofu S. – I. On the formation of the storm – time ring current belt // *J.Geoph. Res., 105*(A3). P.5411–5418. 1999.

Trakhtengerts V.Y., Demekhov A.G. Discussion paper: Partial ring current and polarization jet // *International Journal of Geomagnetism and Aeronomy, V.5*. GI3007. doi:10.1029/2004GI000091. 2005.

Yahnin A.G., Yahnina T.A., Demekhov A.G. Interrelation between localized energetic particle precipitation and cold plasma inhomogeneities in the magnetosphere // *Geomagnetism and Aeronomy, 46*(3), P. 349–356, 2006.