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# EVOLUTION OF GEOMAGNETIC PERTURBATIONS AND AURORA DYNAMICS DURING THE STRONG MAGNETIC STORMS EVENTS

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## 1. Introduction

In the given work auroral and low-latitude variations of the geomagnetic field by data of a global magnetic station chain, and also registration data of auroral luminosity equatorial boundary location are analyzed on the basis of television observations of aurora during periods of strong magnetic storms of October 29-31, 2003, November 20-21, 2003, November 7-8, 2004 and November 9-10, 2004. These storms were distinguished in intensity (Dst ≤ -400 nT) by a high solar wind speed up to > 1000 km/s, a significant amplification of solar wind (Pd) dynamic pressure and high values of IMF Bz (Fig.1). A singularity of these strong magnetic storms attracts attention of the world scientific community [Panasyuk et al., 2004; Raspopov, 2005] and many works were devoted to their studying (see, for example, [Yermolayev et al., 2005 and references in it]). However, in these works data are limited by the representation of magnetograms of separate stations only or variations of the H-component of the field located at the same meridional chain of the stations.

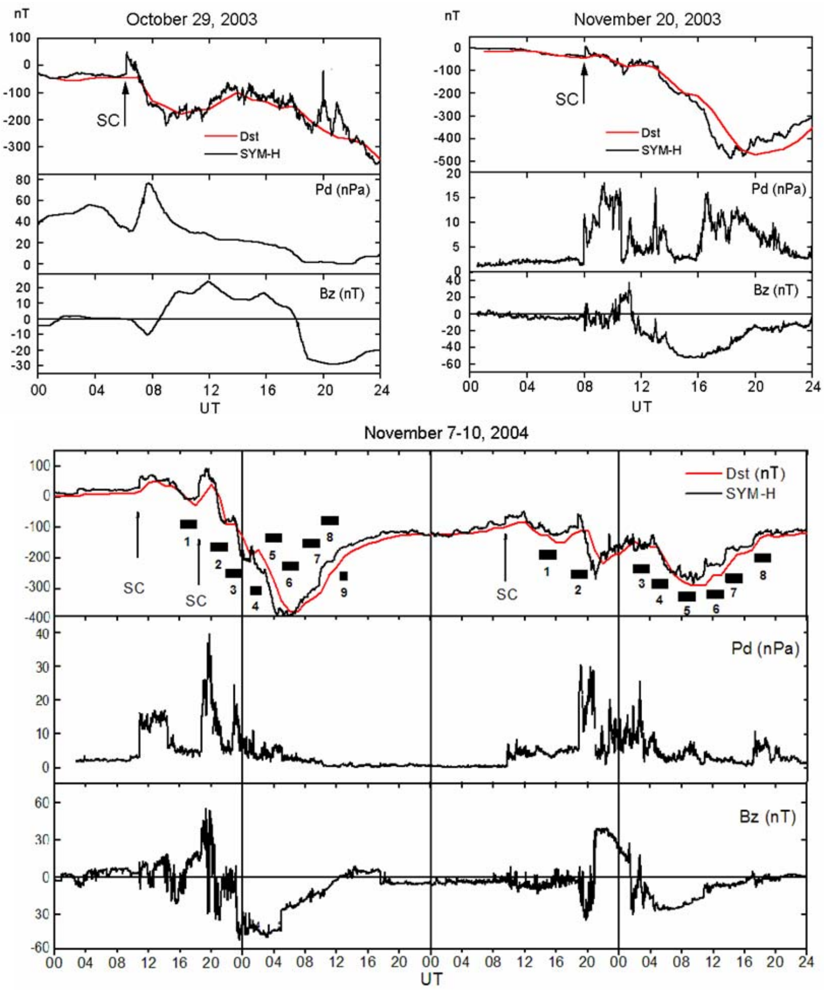


**Fig.1.** Variations of Dst, SYM-H indices and IMF Bz, Pd by ACE satellite data and intervals of impulse amplification of western electrojet intensity (Jw), during the magnetic storm in October- November 2003 and November 2004. Dark rectangles marked impulse amplification of the western electrojet intensity.

The purpose of this work-is the detailed study of spatial-temporary development of the auroral electrojets and geomagnetic variations at low latitudes characterizing the magnetic field depression at these latitudes during periods of strong magnetic field by data of global geomagnetic observations.

Such study with the use of auroral luminosity dynamics allows to find out the influence on the depression of the magnetic field characterized by the Dst-index, convectional auroral electrojets and phase of magnetospheric substorm expansion.

## 2. Experimental data

To study the development of auroral electrojets and low-latitude geomagnetic disturbancese digital geomagnetic data with a resolution of authority 1-20 sec of the CPMN, IMAGE, MACCS, CANOPUS, Greenland Coast chain, NRCAN projects and 1 - min data of H-component field variations in various longitudinal sectors at the latitudes $\Phi' \approx 10\text{-}30^0$ have been used.

For the analysis of spatial-temporary changes of the intensity of auroral electrojets at different meridians and their location in meridian the program of geomagnetic data processing stated in the work [Popov et. al., 2001 ] has been used.

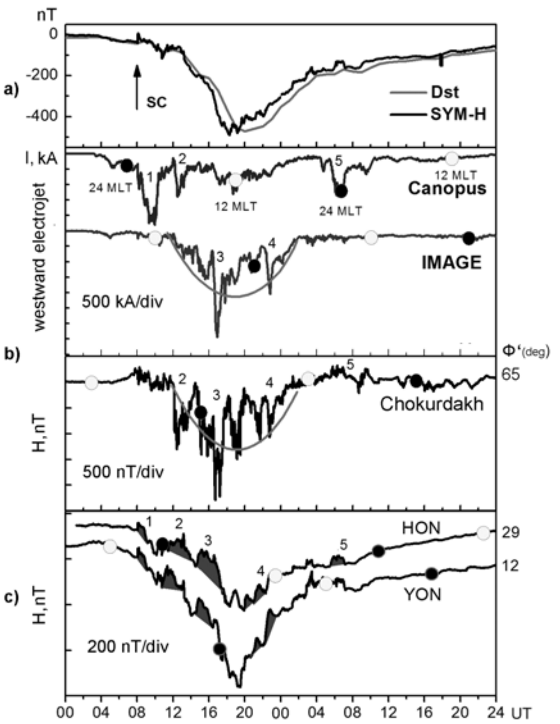


**Fig.2**

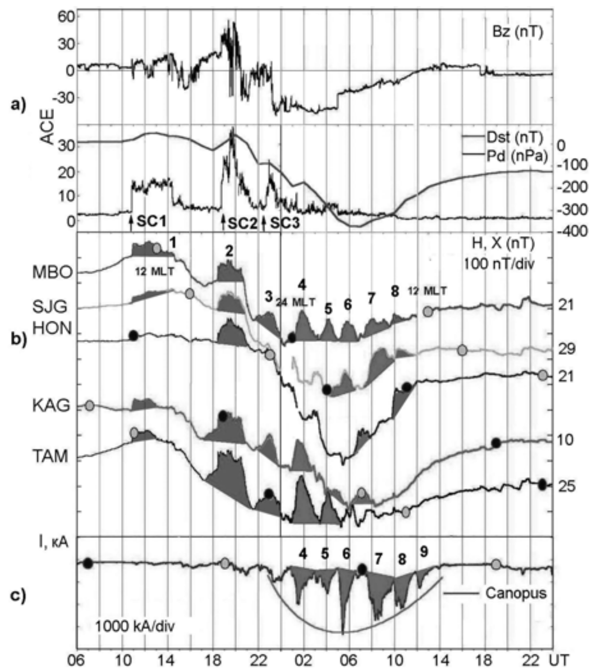


**Fig.3.** IMF Bz, solar wind dynamic pressure (Pd), Dst index variations (a), geomagnetic field intensity at low latitudes in different MLT (b) and westward electrojet intensity along meridian of Canopus station chain (c) during magnetic storm of November 7-8 2004.

Besides geomagnetic data also the spatial-temporal variations of intensity of auroral luminosity along the magnetic meridian $190^0$ by data of television observations of aurora at st. Zhigansk ($\Phi' \approx 61^0$) and st. Tixie ($\Phi' \approx 66^0$) along Yakutsk meridian ($\lambda \approx 190^0$) have been used.

## 3. Observation results

**3.1 Spatial-temporal intensity variations of auroral electrojets and H-component of geomagnetic low-latitude disturbance by data of global magnetic station chain– Figs. 2 and 3.**

In Fig.2 for the storm of November 20-21, 2003 variations of hourly average values of Dst, 1-minute values of SYM-H –indices (a), and intensity of western electrojet (I, kA) integrated in meridian for the IMAGE and CANOPUS station chains arranged in different longitudinal sectors, and also variations of H-component of the field at the high-latitude Chokurdakh (CHD) arranged at the Yakutsk magnetic meridian (b) and at low-latitude stations of HON and YON (c). The local midday and midnight are marked by light and dark circles, respectively.

It is seen from Fig.2 that in the temporal variations of western electrojet, and also in the variations of $\Delta H$ at CHD and low-latitude stations (Fig.2c) there present 2 components: the first one is the impulse variation of the current and $\Delta H$ with the duration $\Delta t \approx$ 1-2 hours registered at all longitudes but with the maximum intensity in the prenoon-morning sector (in Fig.2 they are designated by numbers1-5). Another component (the second one) is the regular (slow) sufficiently smooth variation with $\Delta t \approx$ 10-15 hours. These changes of a current and $\Delta H$ are designated on IMAGE and at CHD by a thin line and clearly visible in the $\Delta H$ depression at low-latitude stations (Fig.2c). These components have been defined as: the first component has all attributes of expansive substorm phase, the second component is characterized by the enchancement of eastern and western electrojets, i.e. convective disturbance. The comparison of variations of different components of current and $\Delta H$ by low-latitude ($\Delta H$) variations in Fig.2c shows, that substorm disturbances (the 1$^{st}$ component) cause impulse short-term enhancements of $\Delta H$ at low latitudes (dark color) that it can be manifested in SYM-H and Dst [Solovyev et al., 2008]. The second one is a convective component, on the contrary, leads to the enhancement of negative values of $\Delta H$, i.e. to the enhancement of Dst and ring current.

The conclusion which has been made by the reaction of low-latitude disturbances (Fig.3b) for two current components of auroral electrojets (Fig.3c) is also clearly observed for the storm of November 7-8, 2004. It is seen from Fig.3 that the decrease in $\Delta H$ intensity (dark positive impulses) at low latitudes, marked with numbers 1-8, are well correlated with the impulse variations of the Pd with Bz> 0 (№1-3, Fig3a,b) and currents (I, kA) at high latitudes along the meridian of CANOPUS (№4-8, Fig3c).

### 3.2 The dynamics of equatorial boundary position of auroral luminosity in meridian and its relation with variations of IMF Bz, Pd and H-component at low-latitude station – Figs. 4 and 5.

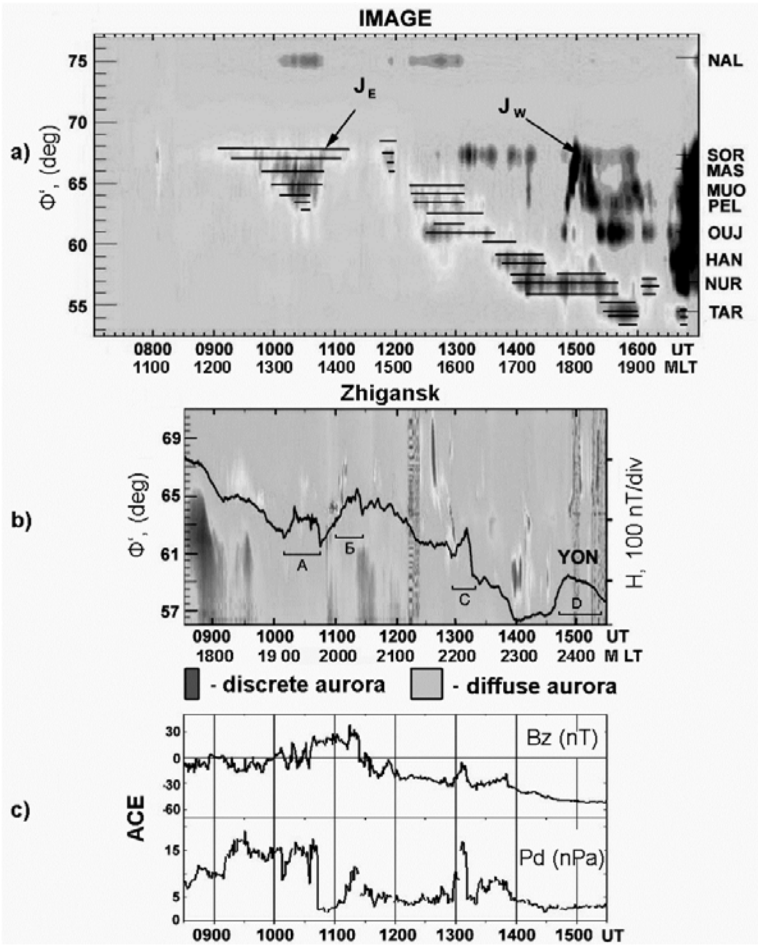


**Fig.4.** The spatial–temporal dynamics of the eastward ($J_E$) and westward (Jw) electrojets at 1000–2000 MLT according to the IMAGE data (a), the keogramm of the auroral luminosity based on the 4-s data from Zhigansk station (Φ' ≈ 61°) and the H component at YON (Φ' ≈12°) in the 1800–2400 MLT sector (b), the variations in the IMF and solar wind parameters (c) from 0800 to 1600 UT during the magnetic storm of November 20, 2003. Letters A, B, C, D marked a sharp decrease in the ΔH at YON.

It follows from the analysis of Fig.4 that the equatorial boundary of luminosity - EBL (Fig.4b) from 0830 UT to 1430 UT, on the average, moved to the south from $\Phi'\approx67^0$ up to $\Phi'\approx56^0$ . It is similar to the shift of the center of eastern electrojet approximately with the same velocity which was 80-90 m/s from ~1130 UT to 1400 UT .Variations of ΔH at the YON reached maximum negative values at ~ 1400-1430 UT when the boundary of luminosity was in the most southern position (Fig.4b) at the growth of negative values of IMF Bz from 1130 UT to ~ 1500 UT (Fig.4c).

The comparison of intervals A, B, C, D with the variations Pd and IMF Bz shows that they were caused by the growth of Pd at positive values of IMF Bz ( Bz > 0) or during the decrease of Bz up to ~ 0 (the interval C). The interval "D" was connected with the enhancement of impulse component of the western electrojet (Fig. 4a).

Comparing the data in Fig.2b and Fig.4a,b shows that the convective disturbances of I, kA and pΔH (thin lines at Fig.2b) accompanied by a shift of EBL and the position of the eastern electrojet center to the equator at latitudes $\sim55^0$ deg. (Fig.4a,b) when there the growth of IMF Bz negative values. (Fig.4c)

For the event of November 10, 2004 Figure 5, besides variations of IMF Bz , presents the keogramm of auroral luminosity at the st.Tixie (Φ′≈ 66°) illustrating the intensity variations at various latitudes and luminosity dynamics in meridian from 0800 UT to 2300 UT in connection with variations of IMF Bz (Fig.5a) and variations of H-component at the low-latitude station of Какioka (KAK) - Φ′≈ 30° (Fig.5b). It is seen from Fig.5 that at high negative values of IMF Bz the impulse auroral activization from ~ 0800 UT to ~ 1130 Ut occurred at the latitudes $\Phi'\leq 57^0$ and were accompanied with positive impulses Δ*H* at the Какioka. During the decrease of negative values of IMF Bz after ~ 1100 UT up to zero values of Bz at ~ 1700 UT (Fig.5a) a sharp shift of area of auroral luminosity to higher latitudes (Tixie, $\Phi'\approx66^0$) took place (see Fig.5b). Later on the equatorial boundary of area of luminosity was not displaced in latitude, it was over the Tixie station at values of IMF Bz being closed to ~ -5 nT and zero. The luminosity variations were defined as impulse enhancements of luminosity brightness (Fig.5b) accompanied by intensity impulses of ΔH at the Kakioka (Fig.5b).

## 4. Discussion and conclusion

Thus, by data of observations (Figs.4 and 5) there exists a sufficiently close relationship between the position of equatorial boundary of oval, variations of IMF Bz and low-latitude disturbances of ΔH that characterize the Dst index .In such a manner the movement of equatorial luminosity boundary to the south corresponds to the negative values of Bz and growth of these values ,and also to the intensity enhancement of negative values of ΔH at low-latitude stations. It indicates to the presence of general reason of these variations, that, most probably, is the growth

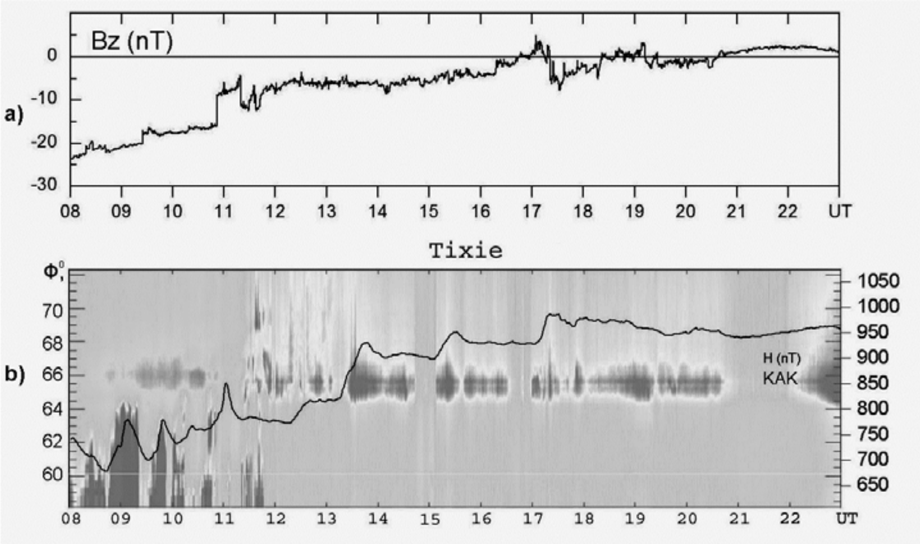


**Fig.5.** Variations of IMF Bz (a), keogramm of auroral luminosity at Tixie station (b) and the H component at Kakioka station during the magnetic storm of November 10, 2004.

of the western electric field intensity and level of the magnetospheric convection. The deceleration of growth of negative values of ΔH is connected with the growth of Pd at positive values of IMF Bz or with a sharp decrease of negative values of Bz, i.e. during periods of the weakening of magnetospheric convection level and of the enhancement of eastern currents on the magnetopause in connection with the growth of Pd.

On based the analysis the data of global geophysical observations the influence of auroral electrojets on variations of low-latitude geomagnetic disturbances and Dst during periods of strong magnetic storms were studied. The following results were obtained:

1. It is shown that: (a) the impulsive (substorm) component of the electrojet current with $\Delta t \approx 1$–2 h, or the substorm expansive phase, results in positive low-latitude disturbances of ΔH with an amplitude of ~30–100 nT in the premidnight–night sector. The obtained ΔH values are comparable with the positive ΔDst disturbances caused by the substorm current wedge, which has longitudinal dimensions of $\Delta\Lambda \approx 90°$ and is located at a latitude of ~55° [Friedrich et al., 1999]; (b) an increase in the negative ΔH values at low latitudes and in Dst is mainly caused by the regular current component or convection electrojets with $\Delta t \geq$ 10 h, the centers of which shift to latitudes of ~ – 55° during the storm development .
2. It is established that maximum negative values of H-component of the field at low latitudes at 18-24 MLT are observed during periods of the most southern position of equatorial boundary of the auroral luminosity at a growth of negative values of IMF Bz.
3. It is shown that the shift in meridian of the position of centre of the electrojets and equatorial boundary of the oval of aurora to the south (north) is determined by the increase (decrease) of negative values of IMF Bz.

It is assumed that in given storms the main reason of depression of the magnetic field at low latitudes was the enchancement of magnetospheric partial-ring current closing on the ionosphere with the help of longitudinal currents on equatorial boundary of auroral oval.

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