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VARIATIONS OF THE 557.7 NM EMISSION BRIGHTNESS EQUATORWARD OF LOW-LATITUDE BOUNDARY OF THE AURORAL BACKGROUND LUMINOSITY BEFORE THE BREAK-UP ONSET

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By data of photometric observations of 1991 and 1996 at st. Tixie the distinctive pecularities of the variations of the 557.7 nm emission brightness before the substorm expansion phase onset have been determined and the drift velocities of subauroral inhomogeneities equatorward of the low-latitude boundary of the background luminosity have been measured. A few tens minutes before the substorm expansion phase onset the variations of the 557.7 nm emission brightness changes syncronously in a zone of aurora discrete forms and equatorward of the low-latitude boundary of the background at first the increase of luminosity then the quasi-monotone decrease are observed. Another behaviour of the brightness - a smooth growth -takes place in the region of the auroral diffuse luminosity boundary that reflects the pecularities of the change of the electric field in the transient layer. The values of the electric field penetrating into the inner magnetosphere during different substorm phases have been estimated by the drift velocities of optical inhomogeneities. The value of the electric field at the meridian of formation of the substorm center before the expansion phase onset is ~ 9÷11 mV/m and during the recovery phase if the epicenter of the substorm center is in another longitudinal sector relative to the observation point then the field changes within the range of ~ 1-4 mV/m.

Introduction

The basis of the experimental material are the scannograms obtained at st. Stolb (Φ~66.6°; λ~193.1°) in October - November 1991 and at st. Tixie (Φ~65.6°; λ~196.9°) in January-March 1996. The geomagnetic conditions during the periods of optical observations have been defined more exactly by data of auroral magnetovariation stations separated along the longitude. The scanning photometer data have been treated by the methods presented in [1]. Fig. 1 presents the diagram of the surface brightness isolines of March 15, 1996 in latitude - time coordinates for the 557.7 nm emission plotted by the scanning photometer data from the st. Tixie from 12.00 to 13.40 UT. The values of the surface brightness of the 557.7 nm emission in relative units are shown by digits on the isolines of the diagram.

Fig. 1b displays the changes of the surface brightness integral values for three sectors of the dome of the sky. The width of every sector is 10, the first two ones refer to the north hemisphere, the upper plot shows the brightness variations occuring at a zenith angle Z-60°, the middle plot shows Z≈30°. The lower plot illustrates the brightness variations occuring in the southern sector at Z≈40°. One can identify the considered three sectors with three different precipitation regions: 1- the region of the auroral diffuse luminosity in the area of the auroral discrete forms (upper pot); 2- the region of the equatorial background boundary (the middle plot); 3- the region equatorward of the low-latitude boundary of the diffuse background by ~ 100-150 nm.

It has been possible to reveal such a distribution due to the selection of isolated events which occured in the evening sector during the transition from the magneto-quiet conditions to the disturbed ones at k_p≤1. The substorm expansion phase is determined by the geomagnetic field Pi 2 pulsation trains at st. Yakutsk(Φ~56°; λ~200°). From the above-considered example and additionally treated 5 events it follows that during the substorm increase phase the changes of the auroral diffuse luminosity brightness in the 557.7 nm emission both in the zone of aurora discrete forms and in the region of low-latitude boundary of the back-ground confirm the results obtained earlier [2-4]. Besides, it has been found, that a few minutes before the substorm expansion phase onset the variations of the 557.7 nm emission brightness had a similar change in the zone of aurora discrete forms and also equtorward of the low-latitude background boundary.

Further, let's consider dynamic changes of optical inhomogeneities in the 557.7 nm emission appearing at different substorm phases equatorward of the low-latitude boundary of the auroral diffuse luminosity. The upper part of Fig. 2 presents the magnetograms of three auroral stations separated by the longitude: Tixie (1); Barrow (Φ~69.6°; λ~250°)(2) and College (Φ~65°; λ~262°)(3) of October 16, 1991. Below there is a diagram of the surface brightness of the 557.7 nm and 630.0 nm emissions plotted using the scannograms of st. Stolb from 10.35 to 13.00 UT. The substorm expansion phase onset (T_0) has been determined by the moment of appearance of the Pi2 pulsation registered at st. Yakutsk in the considered case T_0=10.17 UT.

The subvisual inhomogeneity in the 557.7 nm emission has been registered with the scanning photometer at 10.45 UT at latitude ~66.8°, i.e. equatorward of the low-latitude boundary of the auroral background luminosity by 1.2° in the 630.0 nm emission. The shift of the intensity maximum of the 557.7 nm emission towards low latitudes

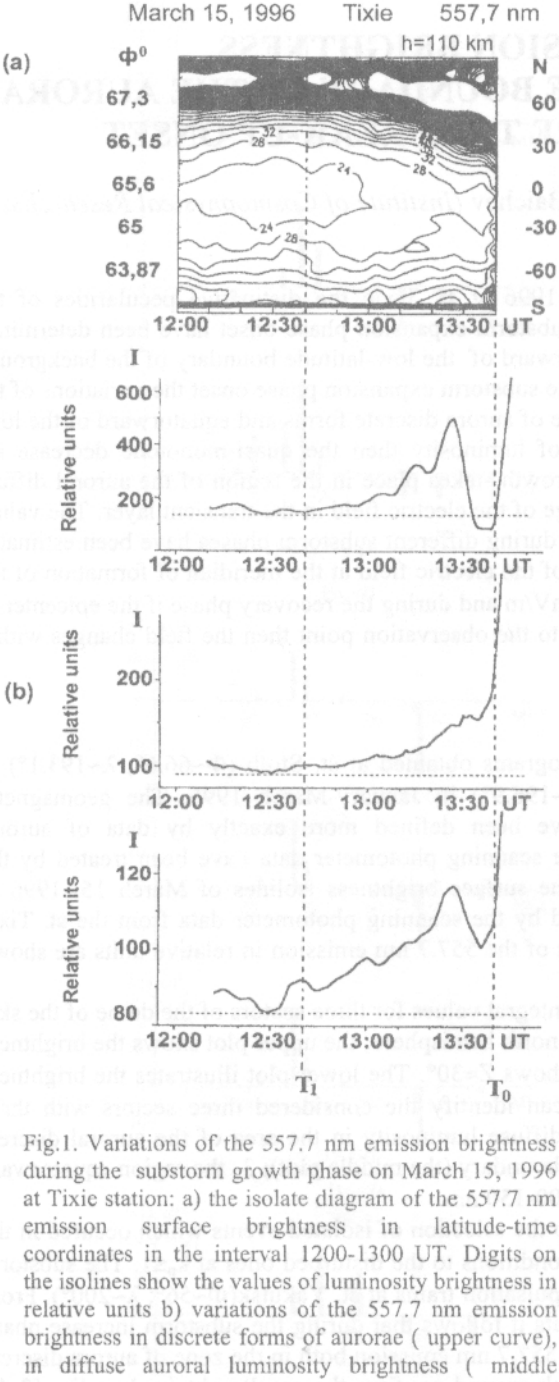

Fig.1. Variations of the 557.7 nm emission brightness during the substorm growth phase on March 15, 1996 at Tixie station: a) the isolate diagram of the 557.7 nm emission surface brightness in latitude-time coordinates in the interval 1200-1300 UT. Digits on the isolines show the values of luminosity brightness in relative units b) variations of the 557.7 nm emission brightness in discrete forms of aurorae (upper curve), in diffuse auroral luminosity brightness (middle curve) and changes of the 557.7 nm luminosity brightness equatorward of the auroral diffuse luminosity region (lower curve).

depending on the time, one can interpret as the equatorial drift of the subvisual structure. On the diagram it looks in

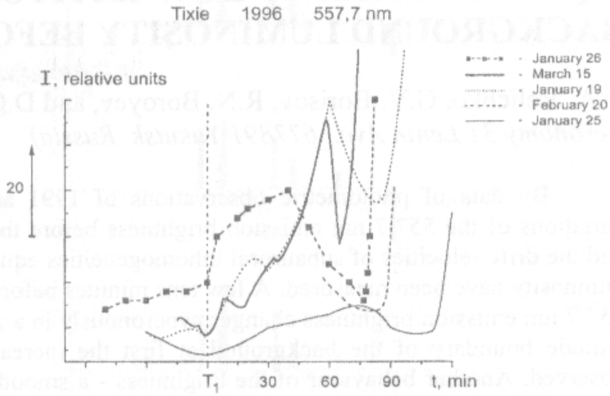

Fig.2. Variations of the 557.7 nm emission brighteness equatorward of the auroral diffuse luminosity region during substorm growth phase.

the form of the contour which is shifted to the low-latitudes. The width of the contour is ~0.3°, and in the linear scale at the height of 110 km it accounts for 33 km.

For the recovery phase of six substorms the epicenter of which is in another longitudinal sector relative to the meridian of the optical observations, the velocities of the drifting subvisual inhomogeneities depending on the time have been determined by the change of their location. The values of these velocities are given in Table 1a. T_1 is the onset by appearance of inhomogeneities, T_2 is the moment of their disappearance. Besides that, this Table presents the values of the drift velocities of southward optical inhomogeneities (V_D) and estimations of the electric field (E) obtained by the methods [5]. Two last columns present: the longitude of the substorm expansion phase center (Λ°) and the moment of the substorm expansion phase onset (T_0).

Let us now turn to the analysis of the event when the substorm center was formed at the meridian of the optical observations. Fig. 3 (upper) presents the magnetograms of the auroral zone stations: Tixie, Kotelny (Φ~69.6°; λ~201°) and Makkyart island (Φ~64.5°; λ~247.8°) of January 19, 1996. The presented magnetograms allow us to make a conclusion that intensification of eastern and western auroral electrojets, typical for the region of the substorm expansion phase center, takes place in the longitude interval Λ~147÷197° i.e. near the meridian of optical observations. The onset of the expansion phase is marked by the dashed line. The width of the equatorial boundary of the back-ground luminosity in the 630.0 nm emission during ~ 3 houts (from 0800 to 1100 UT) does not change substantially and is registered at Φ~66.7°. During the first 20 minutes after the onset of the equatorward drift the appearing inhomogeneities (1120÷1140 UT) shifted by ~ 180° km, and the drift velocity has accounted for ~ 150 m/s. For all events of this group the drift velocity values of equatorward subvisual inhomogeneities are of the same order (Table 1b). The conventional symbols in Table 1b is analogous to ones in Table 1. The comparison of estimations of the electric field leads to the conclusion that before the onset of the substorm the value of electric field center at the meridian of formation of the disturbance, penetratorg from the plasma layer region onto the inner magnetosphere, is greater than during the recovery phase when the optical observation station is in another longitudinal sector relative to the phase of the substorm center location.

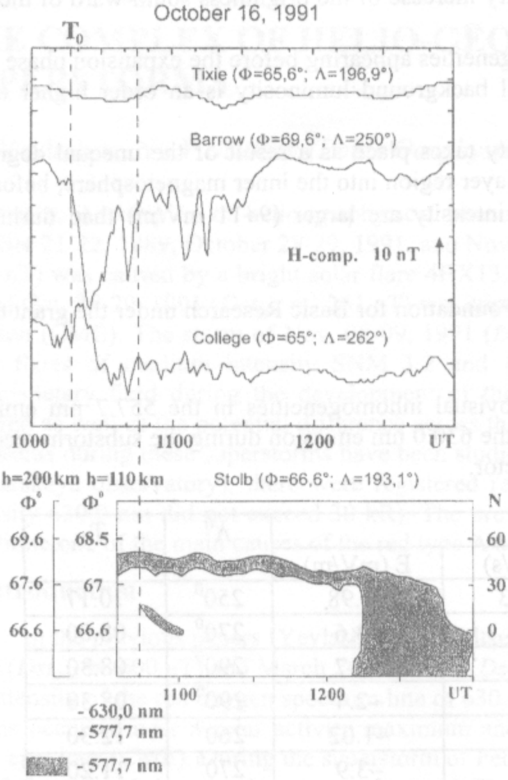

Fig.3. Variations of the geomagnetic field H-component at auroral stations separated in longitude (1 – Tixie Bay, 2 – Barrow, 3 – College) and a diagram of change of the low-latitude boundary location of auroral diffuse luminosity in 557.7 nm and 630.0 nm emissions by data of the scanning photometer at Tixie station on October 16, 1991 from 1035 UT till 1300 UT. The first dashed line marks the substorm expansion phase onset (1017 UT), the second dashed line is the onset of equatorward drift of the 557.7 nm inhomogeneity arising equatorward of auroral background luminosity in 630.0 nm emission.

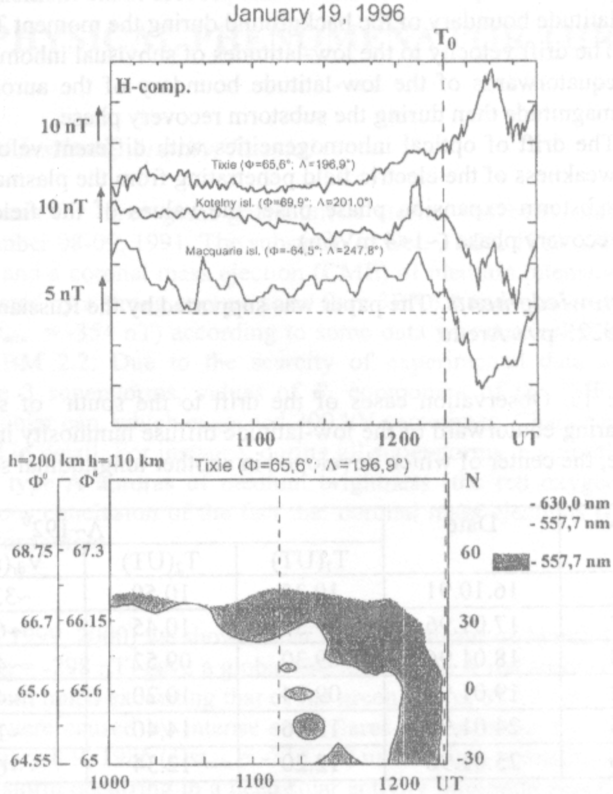

Fig.4. Variations of the geomagnetic field H-component at auroral stations (1 – Tixie Bay, 2 – Kotelny, 3 – College) and a diagram of location change of the low-latitude boundary of the auroral diffuse luminosity in 557.7 nm emission by data of the scanning photometer at Tixie station on January 19, 1996 from 1000 UT till 1200 UT. The first dashed line is the onset of equatorward drift of 557.7 nm emisson inhomogeneity, the second dashed line is the substorm expansion phase onset (T_0)

It is known, that low-latitude boundary of the auroral diffuse luminosity in the 630.0 nm emission and the equatorial boundary of the zone of diffuse intrusion of low-energy electrons coinscde. This region corresponds to the plasmapause projection latitude or the external boundary of the plasma layer [6]. Equatorward of this boundary the action of the magnetospheric convection electric fields is essentially attempted, probably, because of the effect of braiding.

Geomagnetic disturbances lead to the structural changes of the subauroral ionosphere and formation of energetic particle local diffuse precipitations. These diffuse precipitations of average scales, extending to tens of kilometers along the longitudinal, serve as an origin of subauroral spots and surfaces appearing during the substorm recovery phase [7-10]. The drift of equatorward inhomogeneties is the indicator of plasma drift in the magnetospheric under the electric and magnetic fields. A few tens of minutes before the breakup the electric field intensity in the inner magnetosphere (in the region of the plasmosphere external boundary) increases noticeably.

Conclusion

1. A few tens of minutes before the break-up onset the variations of the night sky brightness in the 557.7 nm emission change synchronously in the zone of aurora discrete forms and equatorwards of the low-latitude boundary of the background: at first the rise of brightness, then the quasimonotonous decrease are observed. Another change of the behaviors of the brightness i.e. a smooth rise occurs in the region of the auroral diffuse luminosity boundary that reflects peculiarities of the electric field change in the transient layer. During the preliminary substorm phase the preparation of the plasma layer inner edge region or of the external plasmasphere to the sudden extension of the substorm expansion phase center into the magnetosphere takes

place. The optical indicator of this process is the momentary increase of the brightness south-ward of the low-latitude boundary of the background during the moment T_0.

2. The drift velocity to the low-latitudes of subvisual inhomogeneities appearing before the expansion phase onset equatorwards of the low-latitude boundary of the auroral background luminosity is an order higher of the magnitude than during the substorm recovery phase.
3. The drift of optical inhomogeneities with different velocity takes place as a result of the unequal degree of weakness of the electric field penetrating from the plasma layer region into the inner magnetosphere; before the substorm expansion phase onset the values of the field intensity are larger (9÷11 mV/m) than during the recovery phase (~1÷4 mV/m).

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Table 1a. Observation cases of the drift to the south of subvisual inhomogeneities in the 557.7 nm emission appearing equtorward of the low-latitude diffuse luminosity in the 630.0 nm emission during the substorm recovery phase, the center of which developed in another longitudinal sector.

N	Date	Λ~192^0				Λ^0	T_0
		T_1(UT)	T_2(UT)	V_{dr}(m/s)	E (mV/m)		
1	16.10.91	10.35	10.50	~33.3	~1.98	250^0	10.17
2	17.01.96	09.55	10.45	~60	~3.6	270^0	08.00
3	18.01.96	09.30	09.52	~45	~2.7	290^0	08.30
4	19.01.96	09.04	10.20	~40	~2.4	290^0	08.30
5	24.01.96	13.46	14.40	~17	~1.02	260^0	12.30
6	25.01.96	12.20	12.34	~65	~3.9	270^0	11.20

Table 1b. Observation cases of the drift to the equator of subvisual inhomogeneities in the 557.7 nm emission appearing southward of the low-latitude boundary of the auroral diffuse luminosity in the 630.0 nm emission before the substorm center formation onset at the observation meridian.

Λ~192^0						
N	Date	T_1(UT)	T_2(UT)	T_0(UT)	$V_{dr.}$(m/s)	E(mV/m)
1	16.01.96	14.20	14.30	14.35	~150	~9
2	19.01.96	11.20	11.50	12.20	~150	~9
3	25.01.96	16.40	16.46	16.55	~180	~10.8

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