"Physics of Auroral Phenomena", Proc. XXII Annual Seminar, Apatity, pp.94-96, 1999

Polar
Geophysical
Institute

DYNAMICS OF AURORAL DIFFUSE LUMINOSITY FROM DATA OF FINLAND CUTLASS RADAR

G. Starkov *(Polar Geophysical Institute ASR. Apatity, Russia)*
P. Iglites, H. Opgenoorth *(Institute of Space Physics. Uppsala University, Uppsala, Sweden)*
M. Uspensky *(Murmansk State Technical University. Murmamsk, Russia)*
T. Pulkkinen, R. Pellinen (*Finnish Meteorological Institute. Htlsinki, Finland)*

The auroral substorm is the cleartst manifestation of magnetospheric disturbances. The beginning of substorm is a result of electric fields appearance in magnetospheric plasma sheet. The distribution and time variations of these electric fields has been investigated in [Pudovkin et al., 1991; Êornilova et al., 1997]. But this investigations are related to situation in auroral oval only and we don't know the distribution of magnetospheric electric field in the belt of equatorial diffuse luminosity. This belt was discovered by satellites [Anger and Lui, 1973; Lui et al., 1973] and later this phenomena was investigated many times. The poleward boundary of this belt joins the auroral oval and its equatorial boundary joins the plasmapause. The diffuse luminosity has not obvious structure, and its intensity is nearly ten times less than intensity in auroral oval. Sometimes a structured luminosity appeared in the diffuse belt, that moved to equator. The velocity of these structures are nearly equal to the equatorial velocity in auroral oval and electric field in the diffuse luminosity is mostly just the same [Pudovkin et al., 1995].

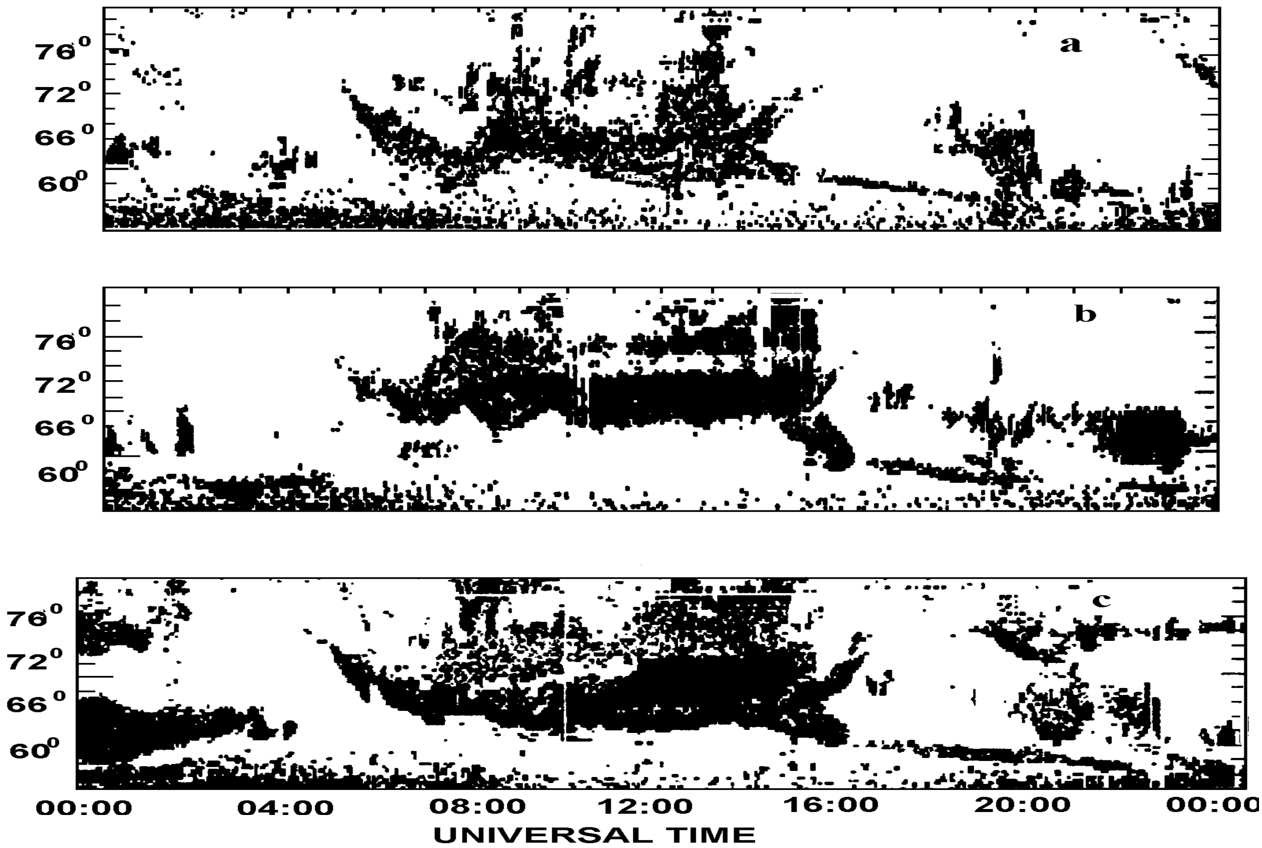

Fig.1. The three events of radioaurora location of Finnish radar.
a - November 17, 1996; b - February 25, 1997; c - February 10, 1998.

The Finnish CUTLASS radar may give us the information of diffuse luminosity structure. It is a system consisting of two radars in Iceland and Finland that work at the frequency of 10 MHz. The radar beam of Finnish radar is nearly meridional orientated and transverse to auroral electrojet, auroral arcs and equatorial boundary of diffuse luminosity band. At the moderate distances of 500 - 1000 km the radar beam is nearly exactly orthogonal to magnetic field lines and Finland radar has been in good conditions for observation of the reflection from equatorial boundary of diffuse luminosity during evening and night time [Uspensky et al., 1998].

Three examples of radar reflections are shown in Fig.1. The narrow radioaurora, that gradually moved to equator is observed during evening time for all events.

The comparison of radioauroral dynamics with the boundary of diffuse luminosity and auroral arcs is shown for November 17, 1996 in Fig.2 in detail. The boundaries of auroral oval and diffuse luminosity calculated from formulas [Starkov, 1994], that is mathematical approximation of big set of experimental data. This model gives us the position of all boundary of auroral luminosity regions for concrete AL-index.

During November 17, 1996 geomagnetic activity was moderate, Al-index was equal 100 nT. The radar reflection appeared at 16.30 UT and its position coincides well with the calculated boundary of diffuse luminosity. From 16.30 to 18.00 UT all-sky cameras in Finland were not working because of the sunlight. During 18.00 - 19.00 UT all-sky camera at Muonio station worked but did not register the diffuse luminosity because of the weak luminosity intensity and weak sensitivity of all-sky camera. But during all period from 16.30 to 19.00 UT Finnish radar registered narrow echoes that moved to equator with good coincidence to dynamics of calculated equatorial boundary of diffuse luminosity. The all-sky camera at Muonio began to register the equatorial boundary of diffuse luminosity after 19.01 UT and this boundary coincides with radar echoes and calculated boundary of diffuse luminosity.

The data of Finnish radar have given the important additional information about development of auroral substorm. At 18.00 UT radioaurora appeared near the poleward boundary of auroral oval and at 18.52 UT it began to move equatorward with velocity ~400 m/s. The Finnish radar echoes and start of their equatorward motion from poleward edge of auroral oval is the first indicator of the substorm preliminary phase beginning. These signatures appeared at last 20 minutes earlier than similar information derived from the ground-based geomagnetic and optic data The velocity corresponded to ionospheric electric field equal to 20 mV/m, that coincided well with the magnitude of electric field during the preliminary phase [Zverev et al., 1994]. The time of substorm beginning confirm the data of satellite IMP-8. November 17, 1996 there is turn to negative Bz-component of interplanetary magnetic field at 18.35 UT. One needs to pay attention to the fact that the altitude of this radioaurora has been near 300 km, it is altitude of ionospheric F-layer.

The all-sky camera in Muonio began to register the equatorial boundary of diffuse belt at 19.01 UT and the velocity of boundary motion had been increased during the development of preliminary phase. The ionospheric electric field, that was calculated by the auroral velocity, increased from 15 to 25 mV/m.

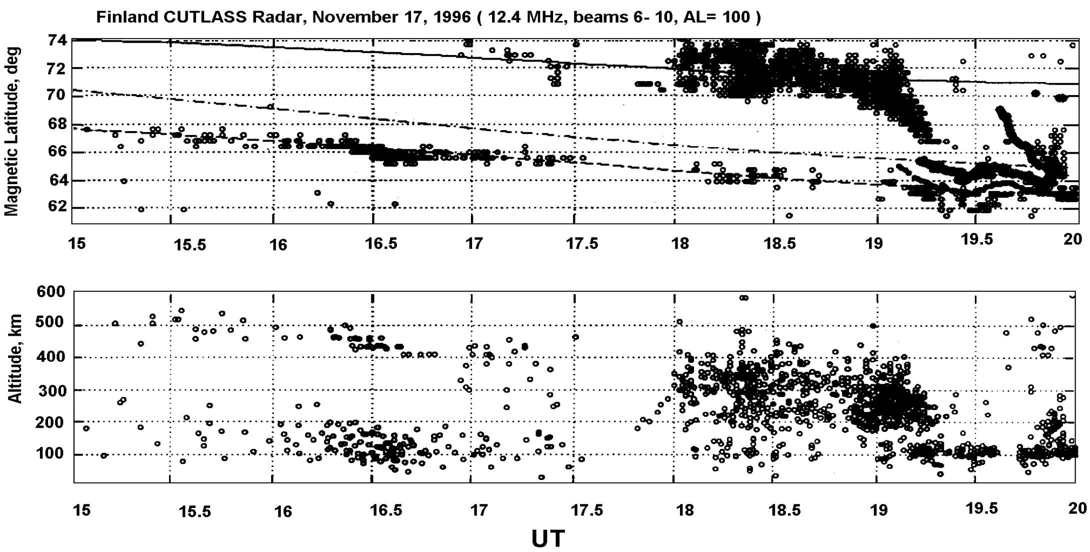

Fig.2. The development of auroral disturbance on 17 November 1996

The top panel shows the position of radioaurora (circles), poleward boundary of auroral oval (solid thin line), equatorward boundary of oval (touch-dotted thin line), equatorward boundary of diffuse belt (touch thin line) and location of auroral arcs (thick line). The bottom panel shows the altitude distribution of radar echoes.

The beginning of the substorm active phase after 19.30 UT connected with the appearence of bright auroral arcs in the oval, that moved fast to equatorward. The maximal auroral velocity is observed during first part of active phase and after decrease gradually. The maximal magnitude of ionospheric lectric field equals to 40 mV/m.

The results of this work allow to hope that Finish radar of CUTLASS system is an effective instrument for investigation of the diffuse luminosity band dynamics and space-time distribution of ionospheric electric field into this band. Finish radar observed the equatorial boundary of diffuse luminosity while optical registration were not possible because of the sunlight or clouds.

The authors would like to express their heartly thanks to Dr. Mark Lester and the team at the Space Plasma Physics Group, Leicester University for the operation of the CUTLASS radars and for providing the data for interval discussed in the paper.

References

Anger C.D., Lui A.T.Y. A global view of the polar region on 18 Lecember 1971 // Planet. and Space Sci. 1973. V.21. P.873-878.

Kornilova T.A., Kornilov I.A., Pudovkin M.I., Starkov G.V. The velosity of aurora and distribution of electric fields during the active phase of substorm // Geomagnetism and aeronomy. 1997. V.37. ¹6. P.47-55.

Lui A.T.Y., Perreault P., Akasofu S.-I., Anger C.D. The diffuse aurora // Planet. and Space Sci. 1973. V.21. P.857-861.

Pudovkin M.I., Semenov V.S., Starkov G.V., Kornilova T.A. On the separation of the potential and vortex parts of the magnetotail electric field // Plan. Space Sci. 1991. V.39. P.563-568.

Pudovkin M.I., Zaitseva S.A., Kornilova T.A., Pellinen R.J. The auroral dynamics near the equatorial edge of auroral zone // Geomagnetism and Aeronomy. 1995. V.35. ¹3. P.47-54.

Starkov G.V. Mathematial discribution of the boundary of auroral luminosity // Geomagnetism and Aeronomy. 1994. V.34. ¹3. P.80-86.

Uspensky M.V., Huuskonen A., Kustov A.V. et al. On stereoscopic features of HF short-range auroral backscatter // Proceedings of the 3d International Arctic Seminar. Murmansk State Technical University. 1998. P.153-180.

Zverev V.L., Pudovkin M.I., Starkov G.V. The auroral motion and the electric fields during the preliminary phase of substorm // Geomagnetism and Aeronomy. 1994. V.34. ¹2. P.49-55.