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SPLITTING OF AURORAL ELECTROJETS: GROUND-BASED AND SATELLITE DATA

D.G. Baishev and V.A. Velichko (*Yu. G. Shafer Institute of Cosmophysical Research and Aeronomy, Yakutsk, Russia, e-mail: baishev@ikfia.ysn.ru*)
E.E. Antonova (*Skobeltsyn Institute of Nuclear Physics Moscow State University, Moscow, Russia*)
L.I. Gromova (*Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation, Troitsk, Russia*)
M.V. Stepanova (*Departamento de Fisika, Universidad de Santiago de Chile, Santiago, Chile*)
R.A. Kovrazhkin (*Space Research Institute, Russian Academy of Science, Moscow, Russia*)
J.M. Bosqued (*Centre d'Etude Spatiale des Rayonnements, CNRS/UPC, Toulouse, France*)

Abstract

We present results of a comparison of simultaneous satellite and ground-based observations of multiple auroral structures for the event of December 30, 1982. Satellite measurements of electron fluxes, field-aligned currents along with synchronous geomagnetic field variations registered by the Scandinavian chain during magnetic disturbances are considered. It is shown that the magnetospheric plasma stratification leads to the eastward electrojet splitting.

Introduction

The problem of the ionospheric current fine structure during substorms has been of interest for the last three decades. *Potemra et al.* (1980) investigated striation of the field – aligned currents under disturbed conditions around the Harang discontinuity based on the Triad satellite observations. *Kuznetsov et al.* (1978) developed methods of analysis of the westward electrojet during substorm expansion phase. The stratified structure of the field–aligned currents at the substorm growth phase near the Harang discontinuity was discovered from magnetic variations aboard the satellite (*Iijima et al.*, 1993). Theoretical framework of the substorm current system formation has been developed for the recent decades. An increase of the region 1 and 2 field-aligned currents as well as of the eastward electrojet during a substorm growth phase was revealed (*Troshichev et al.*, 1974). *Kamide and Rostoker* (1977) observed the splitting of the electrojet into separate structures.

Antonova et al. (1991) developed a theoretical approach to the problem of the auroral plasma stratification being considered as a result of the magnetospheric plasma striation. This includes the theory of "cold-Alfven splitting" and concept of "hot splitting". According to the theory of "cold splitting", multiple plasma structures and corresponding structures in the auroral electrojet result from the Alfven resonator and quasi-stationary polarization currents in the magnetosphere. Within the framework of "hot splitting", magnetospheric plasma structures appear under the approximation of the magnetostatic equilibrium, i.e. when the plasma velocity is much smaller than the sound and Alfven velocities, so that the polarization currents are small. Stability of the Alfven resonator is one of the main problems of the "cold splitting" theory. *Galperin (2002)* noted that the passage of Alfven waves of large amplitude should lead to "destruction of the auroral interferometer". It is difficult to reconcile the existence of such an "interferometer" with the high level of turbulence observed on the auroral field lines (see *Antonova* (2002)). The "hot splitting" theory predicts the number of structures to be formed under the known values of the background upward field-aligned current, width of the band, typical energy of magnetospheric ions and ionosphere conductivity. Complex studies of particle fluxes, electric and magnetic fields, optical emissions onboard the polar Intercosmos-Bulgaria-1300 satellite (see *Antonova et al.* (1998)) and AUREOL-3 (*Luizar et al.*, 2000) enabled to determine the field-aligned current densities, ionospheric conductivity, temperature of the plasma sheet ions, etc. to calculate the major input parameters for the above model of magnetospheric plasma "hot stratification". The predictions of this theory are experimentally confirmed but many features still remain unclear.

The satellite crosses the auroral zone for a few minutes, i.e., in fact, observes a momentary profile of auroral particle fluxes. Such observations don't give an opportunity to distinct either fast (on the time scale of the Alfven wave passage from the ionosphere to the equatorial plane) or slow spatial and temporal variations of auroral fluxes. The reliable selection of quasi-stationary structures is possible using the ground–based observations simultaneous with the satellite passes. One kind of such data are ground magnetic data.

The preliminary investigations carried out by *Baishev et al.* (2002) show a possibility to use the magnetic data from Greenland chain for studying the eastward electrojet splitting before the substorm onset. The geomagnetic field variations for the event of March 24, 1997 have been treated. The equivalent current systems obtained by the methods developed by *Popov et al.* (2001) were used. It is shown that in the course of transition from magneto-quiet conditions to disturbed ones, an increase of the intensity of the discrete in latitude eastward electrojets is observed several tens of minutes before the substorm onset. It is suggested that ionospheric current jets whose longitudinal extent is limited constitute the footprints of the Birkeland current loops at the growth and expansion phases of substorm.

In the present paper the results of comparison of simultaneous ground-based and satellite observations of multiple auroral structures for the event of December 30, 1982 are presented.

Data

Complex measurements of electron fluxes and field-aligned currents onboard the AUREOL-3 satellite, and synchronous variations of geomagnetic field by the Scandinavian station chain at 30° eastern meridian during magnetic disturbances on December 30, 1982 are conducted. The non-uniform structure in the precipitating flux of electrons, field-aligned density and equivalent ionospheric currents has been found using satellite measurements and simultaneous ground based data.

Figure 1 presents the results of measurements onboard the satellite and distributions of equivalent ionospheric currents. The satellite was at 2139 MLT, and the Scandinavian station chain was at 2015 MLT (the difference MLT – UT equals 3 hours) located 1.0 hour to the east of the satellite passage. Vertical bars mark the time interval 1714-1716 UT in the bottom diagram corresponding to the passage of the satellite. The enhancement of the eastward electrojet is observed in the region of intense precipitations at the magnetic latitudes of 64.6°-66.5° (solid vertical bar). A weak precipitation at magnetic latitudes of 67.2°-68.8° (dashed vertical bar) is presumably associated with the enhancement of the westward electrojet. Splitting of the eastward electrojet was observed both before the passage of the satellite (near 16.30 UT) and in the period of the measurements. It follows from Figure 1 that the ground magnetic observations allow us to extract the same structures, which are fixed by the satellite in the fluxes of precipitating particles. The comparison of satellite and ground-based observations show that the satellite observations reproduce mainly the spatial structure that has been formed. Only the small-scale variations, which are impossible to see on the ground magnetogram can have temporal character.

Discussion

The present work testifies effectiveness of using simultaneous ground and satellite data in studying auroral electrojet splitting. A defect of the ground magnetic data is rather low spatial resolution as compared to the satellite observations. Their obvious advantage is a possibility to observe the temporal evolution at a fixed meridian. At the same time, a good spatial resolution as well as a possibility to determine the auroral particle fluxes directly are advantages of the satellite observations. On the other hand, they fail to reproduce the temporal evolution of the splitting process, because typical periodicity of satellite measurements ~2 hours determined by the time of satellite rotation around the Earth exceeds the characteristic time of electrojet splitting.

Interpretation of auroral electrojet splitting during the growth phase of substorm is directly related to clarifying the nature of the processes that lead to expansion onset. Numerous data (see references in *Lyons* (2000), *Stepanova et al.* (2000)) have shown that the processes responsible for expansion onset develop inside the magnetosphere on the quasi-dipole magnetic field lines. According to *Stepanova et al.* (2002), localization of the onset site is related to the asymmetry in splitting of the upward field-aligned current, with the most powerful inverted V structure being formed at its equatorial edge. The above asymmetry is really revealed in the case considered as indicated by the satellite data. On the contrary, the ground-based data suggest that the most powerful structure was located at the polar edge during the satellite passage. However, the ground observations outline the enhancement of the equatorial structure approximately 1 hour later, which is consistent with the satellite data, considering the difference in MLT.

Formation of the substorm-current wedge (Birkeland current loop) and its relation to the large-scale westward and eastward electrojets as well as to the region 1 / 2 field-aligned currents are not quite clear yet. The current system of the substorm expansion phase is apparently not a component of the large-scale auroral current structure. Correspondingly, the current splitting observed during the growth and expansion phases can be of different nature. Further clarification of this point requires complex ground-based and satellite observations with a good spatial resolution.

Conclusion

The results of coordinated satellite and ground-based measurements of geomagnetic field variations during magnetic disturbances suggest that the magnetosphere plasma stratification results in the eastward electrojet splitting.

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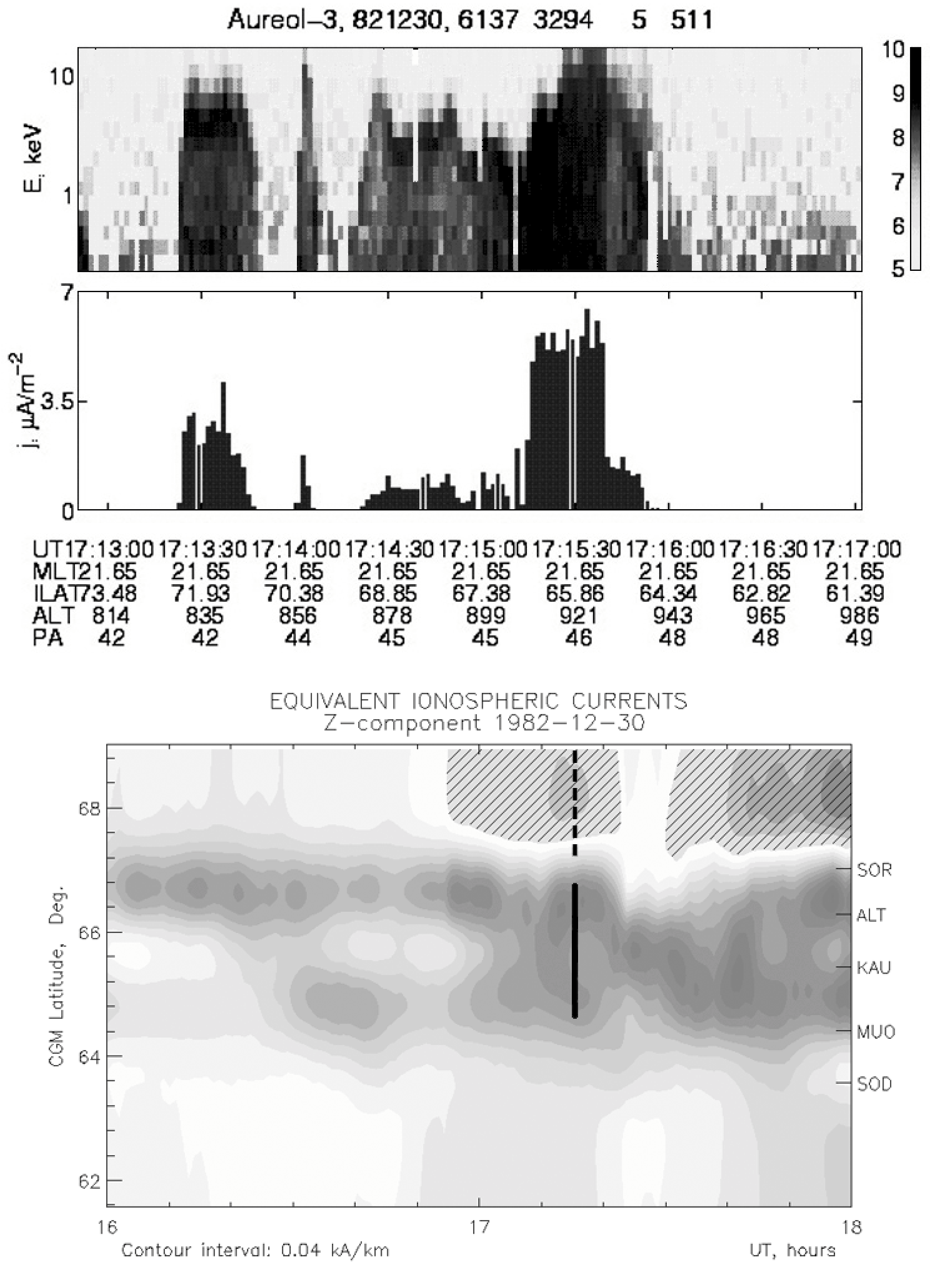

Fig.1. The data of synchronous observations from the AUREOL-3 satellite and Scandinavian magnetometer chain. Time interval of 1714-1716 UT corresponding to the passage of satellite is marked by vertical bars. Gray-scale areas and hatched areas are intensifications of eastward and westward electrojet, respectively.