Proc. NIPR Symp. Upper Atmos. Phys., 5, 31–34, 1992

ELECTRIC FIELD OSCILLATION ASSOCIATED WITH CHARGED PARTICLE PRECIPITATION IN THE DAYSIDE POLAR REGION; EXOS-D OBSERVATION (EXTENDED ABSTRACT)

Ayako MATSUOKA[1], Toshifumi MUKAI[1], Hajime HAYAKAWA[1], Koichiro TSURUDA[1], Atsuhiro NISHIDA[1], Nobuyuki KAYA[2], Toshimi OKADA[3] and Hiroshi FUKUNISHI[4]

[1] *Institute of Space and Astronautical Science, 3-1-1, Yoshinodai, Sagamihara 229*
[2] *Faculty of Engineering, Kobe University, 1-1, Roko-daimachi, Nada-ku, Kobe 657*
[3] *Faculty of Engineering, Toyama Prefectural University, Kurokawa, Kosugi, Toyama 939-03*
[4] *Upper Atmosphere and Space Research Laboratory, Tohoku University, Aramaki Aoba, Aoba-ku, Sendai 980*

Satellite and rocket observations have frequently shown that intense and spiky electric fields appear associated with the auroral particle precipitations (*e.g.*, SUGIURA *et al.*, 1982; GURNETT *et al.*, 1984; WEIMER *et al.*, 1985). Therefore electric fields are considered to have a close relation with the mechanism which precipitates the plasma in the magnetosphere.

There are two models to explain the electric field fluctuations; one is quasi-static field-aligned current structures and the other is Alfvén waves. The electric to magnetic field ratio is important for understanding the nature of these oscillations. In the static model the electric field is related to the magnetic field by the Pedersen conductivity. On the other hand, in the Alfvén wave model the electric to magnetic field ratio is equal to the Alfvén velocity.

We have studied the low-frequency electric fields of 0.3 to several Hz and the relation with the associated charged-particle precipitations. In the present paper the data obtained in dayside polar region are investigated. We used the data of electric field detector (EFD), magnetic field detector (MGF) and low-energy particle detector (LEP) on board Japanese EXOS–D satellite.

Figure 1 shows LEP and EFD data obtained during a nearly noon-midnight path of 0420–0450 UT, October 23, 1989. The top and middle three panels are *E-t* diagrams for electrons and positive ions, respectively. Three panels are for three pitch angle ranges of 0°–60°, 60°–120°, and 120°–180°, respectively. The bottom three panels show electric fields in the solar ecliptic coordinate system. Intense fluxes of ions and electrons were observed from 0427 UT. Since the electron flux had its peak in the 100 eV range and the ion flux showed a characteristic energy dispersion, this can be interpreted as an entry of magnetosheath plasma into the cusp. Upward flows of low-energy ions also started around this time. While the ion flux weakened rapidly after 0432 UT, considerable electron fluxes still continued to precipitate until 0444 UT. In association with these particle signatures of the cusp, the electric field showed intense and irregular oscillations. On the low latitude

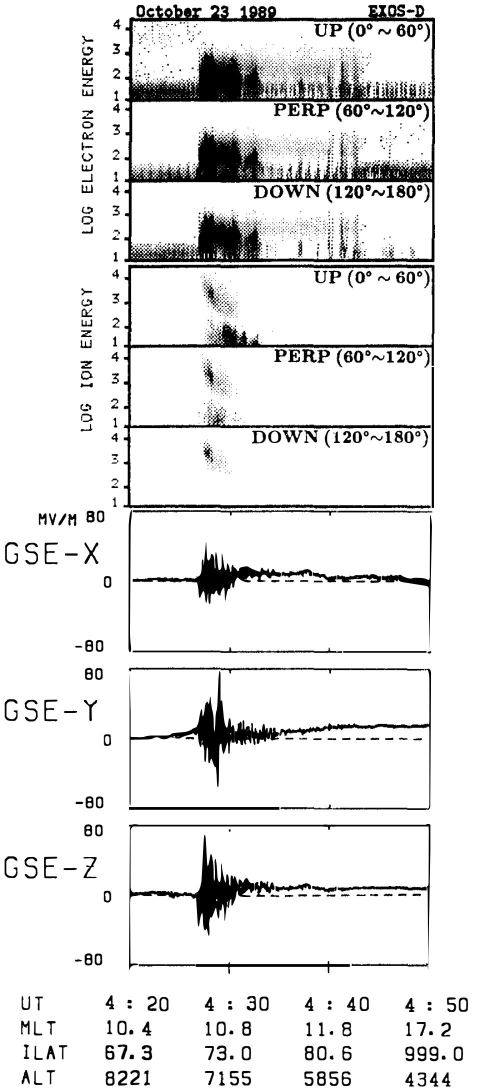


Fig. 1. The LEP (low-energy particle detector) and EFD (electric field detector) data obtained during 0420–0450 UT, October 23, 1989. The first and the second sets of three panels are E-t diagrams for electrons and positive ions, for three pitch angle ranges, i.e., 0°–60°, 60°–120° and 120°–180° (upward, perpendicular and downward with respect to the ambient magnetic field), respectively. The bottom three panels display the observed three components of the electric field in the geocentric solar ecliptic coordinates (GSE).

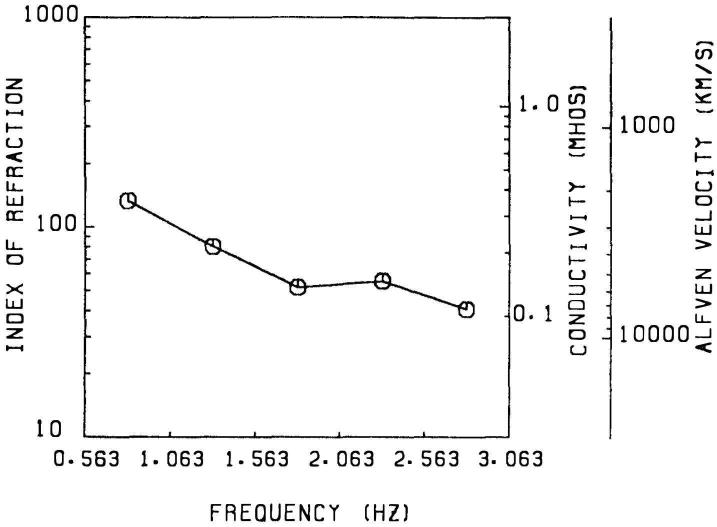
side of the cusp the GSE-Y component of the field gradually increased while GSE-X and Z components were almost zero. In the polar cap region, which was located poleward of the cusp, the amplitude of the oscillations in the electric field decreased with increasing latitude.

We carried out a power spectral analysis for this case. Figure 2 shows the electric to magnetic field ratio for the observed events of every 0.5 Hz frequency range in terms of refraction index, conductivity and Alfvén velocity at 042740 UT. The conductivity is below 0.4 mho while the expected Pedersen conductivity is an order higher than this value. On the other hand, the phase velocity deduced from the electric to magnetic field ratio is several thousands km/s. The Alfvén velocity is about 10000 km/s in this region at altitudes of 7000 km and greater than the observed value. However, it is reasonable to consider that the observed E/B ratio is reduced by the reflection at the ionosphere since the reflection reduces E but enhances B. Therefore the Alfvén wave model seems to be appropriate for the mechanism of the oscillations in this case.

We investigated the electric fluctuations seen in the 80 events selected out of 43 paths in the dayside region from March 1 to April 10, 1990. All of them were located at the polar-cap boundary and observed in association with discrete electron precipitations.

We carried out a power spectral analysis of the observed oscillations in the 0.3–0.8 Hz frequency range and obtained the following result. The electric to magnetic field ratios are plotted in Fig. 3, for the events of the electric powers exceeding 100 $(mV/m)^2$. The Alfvén velocities obtained from the observed ratios are concentrated between 1000 km/s and 10000 km/s. This result seems to be inconsistent with the work of Weimer *et al.* (1985) or others that suggested a static model. However, the frequency range dealt with in their work was much lower than ours. At lower frequency, the same signature as theirs may be observed.

Fig. 2. The electric to magnetic field ratio for the observed oscillations of 0.5 Hz and 3.0 Hz at 042740 UT shown in Fig. 1. The ratios are scaled in terms of the index of refraction (cB/E), the conductivity ($B/(\mu_p E)$) and the Alfvén velocity (E/B).



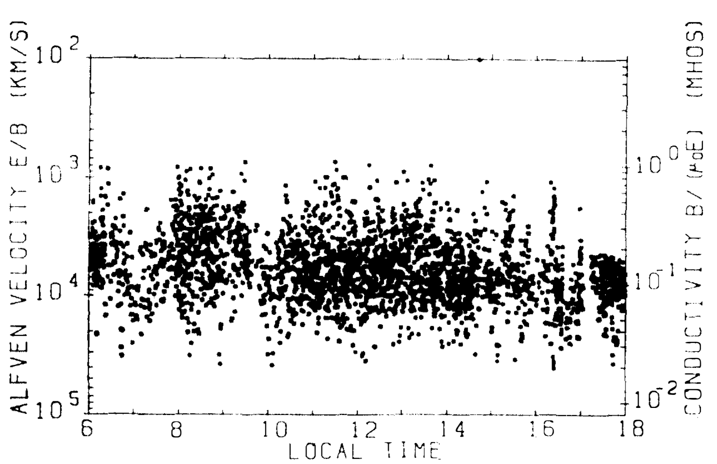


Fig. 3. The electric to magnetic field ratios in the frequency range of 0.3125–0.8125 Hz for 80 dayside events when the electric powers exceeded 100 $(mV/m)^2$. The ordinates are scaled as the Alfvén velocity (E/B) or as the conductivity ($B/(\mu_0 E)$).

A possible mechanism is that the Alfvén wave is generated at the magnetopause where ions and electrons are injected to the magnetosphere from the sheath. As to the cusp region, broadband waves at several Hz were observed by LABELLE *et al.* (1987) at the dayside magnetopause in association with FTE.

The summary is that, electric oscillations often appear at the polar-cap boundary in association with discrete electron precipitation. The Alfvén wave model is more appropriate than a static model for the oscillations of the frequency above 0.3 Hz.

References

GURNETT, D. A., HUFF, R. L., MENIETTI, J. D., BURCH, J. L., WINNINGHAM, J. D. and SHAWHAN, S. D. (1984): Correlated low-frequency electric and magnetic noise along the auroral field lines. J. Geophys. Res., **89**, 8971–8985.

LABELLE, J., TREUMANN, R. A., HAERENDEL, G., BAUER, O. H., PASCHMANN, G., BAUMJOHANN, W., LÜHR, H., ANDERSON, R. R., KOONS, H. C. and HOLZWORTH, R. H. (1987): AMPTE IRM observations of waves associated with flux transfer events in the magnetosphere. J. Geophys. Res., **92**, 5827–5843.

SUGIURA, M., MAYNARD, N. C., FARTHING, W. H., HEPPNER, J. P. and LEDLEY, B. G. (1982): Initial results on the correlation between the magnetic and electric fields observed from the ED-2 satellite. Geophys. Res. Lett., **9**, 985–988.

WEIMER, D. R., GOERTZ, C. K., GURNETT, D. A., MAYNARD, N. C. and BURCH, J. L. (1985): Auroral zone electric fields from DE1 and 2 at magnetic conjunctions. J. Geophys. Res., **90**, 7479–7494.

(*Received May 24, 1991; Revised manuscript received August 5, 1991*)