

PEM027-01

Room:103

Time:May 25 16:30-16:45

## Initial results of auroral observations using an EMCCD camera in 2010/2011 winter campaign at Poker Flat Research Range

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Pulsating aurora is a phenomenon which shows periodic changes of emission intensity in the diffuse aurora. The emission is characterized by not sinusoidal change but pulsation, and its typical period is from a few seconds to a few tens of seconds [e.g., *Oguti et al.*, 1981; *Yamamoto*, 1988]. Precipitating electrons which generate pulsating aurora were observed with 3 Hz modulations by rockets and low-altitude satellites, and the energy ranges from a few keV to a few tens keV [e.g., *Sandahl et al.*, 1980]. Since pulsating aurora appears in diffuse aurora, electrons are thought to undergo cyclotron resonance with whistler mode waves in the equatorial region of the magnetosphere and to precipitate into the Earth's upper atmosphere by pitch angle scattering. Some simultaneous optical and VLF whistler mode wave observations have been carried out to demonstrate this idea [*Hansen and Scourfield*, 1990; *Tagirov et al.*, 1998]. These studies suggested that appearance of auroral pulsations were related to VLF emission activity, however, one-to-one correspondence of order of a few hundred ms between auroral fine-scale structures with high temporal fluctuations and each element of VLF emission were not shown yet. In addition, recent simultaneous ground-satellite observations of pulsating auroras suggests not only mechanism associated with whistler mode waves but also one associated with Electron Cyclotron Harmonics (ECH), especially in high latitude regions ( $L > 6$ ) [*Liang et al.*, 2010]. Therefore, continuous ground-based observations including optical and ELF-VLF measurements are still needed to reveal what drives pulsating auroras.

The purpose of this study is to investigate the characteristic of temporal variations in pulsating auroras using a high-speed camera equipped with an Electron Multiplying CCD (EMCCD). We are planning a new observation that addresses especially pulsating auroras. The plan is to carry out simultaneous observations with three cameras (two EMCCD cameras and another camera for guiding), a photometer, a VLF receive system (100 kHz sampling) for short term campaign and an ELF magnetometer (1 kHz sampling). EMCCD camera takes an image at mainly 670.0 nm ( $N_2$  1st Positive Band) wavelength at intervals of 10 ms. The field of view is 48.9 x 48.9 degrees and the spatial resolutions equals to 1.6 km at an altitude of 110 km (8 x 8 binning). The photometer consists of a Schmidt-Cassegrain telescope (F10.0, f2000mm), an interference filter at 670.0 nm, a photo counting head and a photo counting unit. Its field of view is 0.22 x 0.22 degrees and corresponding to 840 x 840 m at an altitude of 110 km. It is designed to detect 10% fluctuations of intensity of pulsating auroras with a few kR by 1 kHz sampling.

The observation began to be operated at Poker Flat Research Range (MLAT 66.77 deg. MLON 262.97 deg.) in Alaska on November, 2010. Our instruments are working without fatal errors and many data of pulsating auroras have been acquired. Initial results of our observations will be reported in this presentation.

Keywords: aurora, pulsating aurora, optical observations, wave-particle interaction, substorm

PEM027-02

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## Structure of field lines associated with ionosphere-driven interchange instability from the magnetosphere to atmosphere

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On the basis of a magnetospheric energy principle the existence of an ionosphere-driven magnetospheric interchange instability has been suggested. The ionosphere-driven interchange instability is a new type of driving magnetospheric interchange instability. Therefore, a test of the existence of the ionosphere-driven interchange instability is very important in testing the validity and usefulness of the magnetospheric energy principle in discussing magnetospheric dynamics. The existence of the ionosphere-driven interchange instability is also important in discussing radiation belt dynamics and auroras in the inner magnetosphere, since in such a region the pressure gradient is so small that a conventional pressure-driven magnetospheric interchange instability cannot be destabilized. In the magnetospheric energy principle the existence of the neutral atmosphere under the ionosphere is completely neglected. Thus the magnetospheric energy principle cannot clarify the structure of perturbations from the magnetosphere to the neutral atmosphere. However, the magnetospheric energy principle has recently been extended to include the neutral atmosphere and it is now possible to discuss the structure of perturbations in the atmosphere associated with the ionosphere-driven interchange mode. Thus it is now possible to test the validity of the extended magnetospheric energy principle by examining the structure of perturbations not only in the magnetosphere but also in the atmosphere. In this paper the structure of magnetic field lines associated with the instability in the magnetosphere and in the atmosphere is clarified. Owing to the ideal MHD frozen-in law the concept of magnetic field lines is very useful in the magnetosphere and field lines are interpreted to comove with plasma. On the other hand there is no electric current in the neutral atmosphere and the magnetic field is represented by a potential field. Since there is no plasma in the atmosphere, the concept of field line motion comoving with plasma is not useful. Nevertheless, in the atmosphere there is also a magnetic field and it is possible to define magnetic field lines. In the ionosphere, which is a boundary region between the magnetospheric plasma and the neutral atmosphere, there is a magnetic field and field lines can be defined. Owing to the existence of dissipation in the ionosphere the frozen-in law is not valid and the concept of field line motion comoving with plasma is not valid. According to the magnetospheric energy principle, when the unperturbed field line is incident vertically on the spherical ionospheric surface, a horizontal magnetic perturbation is induced at the ionosphere due to the convective motion of field lines by an electric field perturbation. In the magnetosphere the magnetospheric interchange instability has no horizontal magnetic field perturbation. Thus it is expected that field lines are kinked at the ionosphere in an ionosphere-driven interchange instability. Owing to the continuity of a tangential electric field across the ionospheric surface, there also arises a horizontal magnetic field perturbation just below the ionosphere. Since the magnetic field in the atmosphere is a potential field, this horizontal component of the magnetic field must decrease toward the earth's surface. Therefore, in the ionosphere-driven magnetospheric interchange instability it is expected that the magnetic field has no horizontal component in the magnetosphere, has a kink in the ionosphere and decreases rapidly toward the earth's surface in the atmosphere. If such a field line structure is truly observed, the existence of the ionosphere-driven interchange instability predicted by the magnetospheric energy principle is confirmed and hence the validity and usefulness of the magnetospheric energy principle in discussing magnetospheric dynamics are verified.

Keywords: magnetosphere, ionosphere-driven interchange instability, MHD instability, neutral atmosphere, magnetic field lines, energy principle

PEM027-03

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## Spatiotemporal characteristics of Toroidal Pc 5 ULF during high-speed solar wind intervals

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ULF waves in frequency band between 1.67 and 6.67 mHz, especially Pc 5 magnetic pulsations, are believed to contribute to Relativistic Electron Enhancement (REE) in the outer radiation belt during magnetic storms. Many researchers suggested that high solar wind velocity and high long-duration Pc 5 power observed on the ground in the storm recovery phase are closely associated with the production of relativistic electrons (Baker et al., 1998; Rostoker et al., 1998; Mathie and Mann, 2000; O'Brien et al., 2001, 2003). Theoretically, the polarization (toroidal, poloidal or compressional modes) of the Pc 5 pulsations is discussed for the effectiveness of transporting radially energetic particles in terms of radial diffusion. Most of ground-based works focused on the activities of Pc 5 pulsations (e.g., amplitude or power), and they have rarely considered the polarization of Pc 5 pulsations because of difficulty to identify it by using only ground-based observations.

The purpose of this paper is to directly demonstrate the polarization characteristics and its spatiotemporal distribution of Pc 5 waves in the inner magnetosphere by the in-situ observations. We analyzed the magnetic and electric field data obtained by Time History of Events and Macroscale Interactions During Substorms (THEMIS) for the REE (14) / Non-REE (10) events under the high-speed solar wind conditions during 2008, and identified the polarization of these Pc 5 waves. It is clear that the Pc 5 polarization characteristics are strongly local time dependent. We found that the dayside toroidal Pc 5 wave at the outer radiation belt ( $L > 8$ ) is the important role of the radial diffusion mechanism.

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PEM027-04

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## Activities of Pc5 pulsations in high-latitudes associated with energetic ion enhancement at geosynchronous altitudes

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There have been two aspects associated with high latitude Pc5 pulsations. The first one is propagation characteristics in east-west direction (Saka et al., JGR, 1983) and the other one is association of the local injection of particles (Saka et al., JGR, 1992). Those results suggest that Pc5 pulsations in high latitudes are not only related to the flow shear in the solar wind but also to substorm injections.

We show in this report that Pc5 events (17 Jan and 10 Aug, 1994) observed at the high latitude stations in the morning sector are accompanied by energetic ion enhancement related to the inflation of inner magnetosphere that began 10 min after the onset of substorm injection (e.g., Saka et al., JASTP, 2010).

The dipole field configurations invoked by the inflation might be a favorable condition for the flow shear to excite field line oscillations. The Pc5 activities are then related to both the solar wind flow and local injection of particles.

Keywords: Pc5 pulsation, energetic particles, inner magnetosphere, geosynchronous altitudes, auroral region

PEM027-05

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## Statistical analysis of the ion pitch angle distribution in the inner magnetosphere

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It is known that energetic particles are drifting around the Earth in the inner magnetosphere and many researchers have been studying their pitch angle distribution (PAD) and its cause in order to know some physical mechanisms occurred along their drift path. Various PADs, (e.g., normal, isotropic, head-and-shoulder, and butterfly types) have commonly identified by previous studies. In particular, for the butterfly PAD, there are several proposed generation mechanisms such as "particle injection and drift effect" [Konradi, 1973], "drift shell splitting + magnetopause shadowing" [West et al., 1973], "drift shell splitting + negative radial flux gradient" [Sibeck et al., 1987], "ring current effect" [Ebihara et al., 2008], and "multiple pitch angle scattering effect" [Shibahara et al., 2010].

In this study, we focus on the high-energy ions (10-200 keV) in the inner magnetosphere and conduct a statistical analysis of the PAD by classifying disturbance level and particle energy. We examine which of the generation mechanisms of the butterfly PAD mentioned above is the most plausible. We use the particle flux data measured by the CAMMICE/MICS instrument (1.0-200 keV/q) onboard the Polar satellite and select the event when the Polar satellite traversed the magnetic equatorial plane during 1996-2002.

For high energy ions ( $\geq 50$  keV), we find that normal, butterfly, and isotropic PAD can be seen respectively on the whole dayside, around midnight, and between the region where the normal and butterfly PADs were found. On the other hand, low-energy ( $\sim 10$  keV) ion PAD shows a quiet different characteristic. We classify the butterfly PAD into the "M-type" butterfly which looks like a smooth bowl and "U-type" butterfly which has a deep bite-out at 90 degree pitch angles, and find that most of the butterfly PAD is "M-type" but "U-type" butterfly can be seen on the night side in low-energy ( $\sim 10$  keV) ion. There are only a few butterfly PAD events in the pre-noon region, leading us to say that generation mechanisms except "magnetopause shadowing" theory should have a strong effect. In this presentation, we will show the statistical analysis results of the pitch angle distribution in the inner magnetosphere and discuss the generation mechanisms of the butterfly PAD.

Keywords: inner magnetosphere, pitch angle distribution

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PEM027-06

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## Magnetic Configurations around a Plasmoid in the Near-Earth Magnetotail

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Magnetic configurations around plasmoids propagating in the directions of earthward and tailward in the near-Earth plasma sheet were studied using MHD simulations and statistical analyses of Geotail observations. MHD simulations were done giving a single X-line. These results are appeared in the statistics of events. This fact making it possible to conclude that magnetic configurations around plasmoids in the near-Earth plasma sheet are the NFTE-like structure, not the flux rope-like structure.

Keywords: Reconnection, Plasmoid, Magnetic Configuration, MHD simulation, Satellite observations

PEM027-07

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## Characteristics of fast plasma flows in the near-earth plasma sheet

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The Bubble model or the interchange motion of the plasma depleted flux tube, which is originally proposed to solve the so-called 'Pressure Balance Inconsistency', is one of the accepted candidates of the mechanism for high-speed flows observed in the near-earth plasma sheet. However it is not clear yet that it is quite so, and eventually how they are associated with (play a role in) the magnetospheric convection and substorm dynamics.

This study addresses the above problem by investigating the characteristics of fast flows in the central plasma sheet observed by Geotail. We use plasma moments and magnetic field data acquired respectively with LEP and MGF instruments during January 1993 to November 2005. We also include EPIC/STICS data for the derivation of plasma moments. By classifying the fast flow events according to the flow direction (earthward or tailward), flow speed, and distance from the earth, we examined the variations of physical quantities that will show the systematic change if the fast flow was a passage of 'Bubble.' The quantities include the ion pressure ( $P$ ), north-south component of the magnetic field ( $B_z$ ), and value equivalent to the specific entropy ( $PV^\gamma$ , where  $V$  is the volume of the flux tube, but here we use  $B_z$  as an alternative).

As for the earthward flows, summing up the analysis results, we can conclude that the earthward flows can be basically interpreted as the passage of Bubbles. In addition, it is found for the first time that the speed range in which the Bubble-like features prominently appear shifts to the relatively lower-speed ( $<400\text{km/s}$ ) range in the region closer to the earth ( $|x| < 15R_E$ ). This result not only indicates the flow breaking but also suggests that we should reconsider the categorical criteria for the selection of fast flows used in statistical studies. As for the tailward flows, we will discuss their characteristics in association with possibilities, such as bounces of bubbles, vortex-like flows, and the ballooning instability.

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## Magnetospheric Dynamics on Southward/Northward Turning of IMF

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One of important problems in space plasma physics is to understand relationships among magnetic reconnection and initiation of substorm processes and magnetospheric dynamics when the IMF turns from northward to southward or vice versa. When the IMF is northward, a dipole-like magnetic field configuration is formed in a steady state and magnetic reconnection occurs in high latitude tail region. On the other hand, when it is southward, a tail-like configuration is formed and reconnection occurs at the dayside magnetopause and plasma sheet. The reconnection site shifts to subsolar region in the dayside magnetosphere when the IMF turns southward from northward. Then, reconnected magnetic flux transfers from the subsolar region to lobes through polar regions and is accumulated in lobe regions of magnetotail. As the result, plasma sheet thinning is happened and successively tail reconnection as formation of near-earth neutral line (NENL) begins and fast jet flows appear in both directions in the plasma sheet.

How do the processes of magnetic reconnection proceed at the dayside magnetopause and in the magnetotail? What are causal relationships satisfied in processes such as the initiation reconnection, formation of NENL, full spread of neutral line up to flank magnetopause, start of lobe reconnection? What do the plasma, momentum and energy carry toward the earth and how do the plasma sheet configuration change? We have studied the detail processes on magnetic reconnection in the plasma sheet and successive magnetospheric dynamics from a high-resolution and 3-dimensional global MHD simulation of interaction between the solar wind and earth's magnetosphere when the IMF turns from northward to southward and vice versa. As the results, the first reconnection occurs in closed field lines in the magnetotail and proceeds to full spread of reconnection line up to flank magnetopause and lobe reconnection in a few minutes, and then fast plasma flows appear in the plasma sheet. We will discuss what are important to carry the plasma, momentum and energy in the plasma sheet and to change the configuration of near-earth plasma pressure and magnetospheric convection.

Keywords: MHD Simulation, Interplanetary Magnetic Field, Magnetic Reconnection, Magnetospheric Dynamics, Substorms, Energy Transport



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## Roles of magnetic reconnection induced by the Kelvin-Helmholtz vortex in the solar wind entry into the magnetosphere

Takuma Nakamura<sup>1\*</sup>, Hiroshi Hasegawa<sup>1</sup>, Iku Shinohara<sup>1</sup>, Masaki Fujimoto<sup>1</sup>

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We have performed two and half dimensional full particle simulations of the MHD-scale Kelvin-Helmholtz vortex (KHV). The KHV has been believed to cause direct entry of the solar wind plasma into the magnetosphere across the low-latitude magnetopause under northward IMF conditions. Indeed, KHVs have been frequently observed around the low-latitude magnetopause when the IMF is northward. In order to understand the precise solar wind entry mechanism related with the KHV, a number of numerical simulations have been performed. Nevertheless, there is still no comprehensive understanding of the actual entry mechanism. Since the size of the observed KHVs is of MHD-scale, it may be expected that the behavior of the KHV can be described by the ideal-MHD equations. In the ideal-MHD, however, the frozen-in condition does not allow plasmas to be transported across the magnetic boundary. This indicates that non-ideal MHD effects should be considered to truly understand the actual entry mechanism. Fortunately, recent developments of computer resources allow non-ideal MHD simulations of the MHD-scale KHV to be performed. Such simulations have revealed that magnetic reconnection induced by the KHV can cause the effective solar-wind entry along reconnected field lines. Furthermore, our particle simulations are quantitatively confirming the actual entry rate of the solar-wind plasma via the vortex-induced reconnection. In this presentation, we will present the particle simulation results and discuss how important the KHV is in the solar wind entry into the magnetosphere.

Keywords: Kelvin-Helmholtz, solar wind entry, magnetic reconnection, particle simulation, plasma mixing, magnetic island

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## Statistical analysis of LH plasma waves observed by Geotail spacecraft

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In this study, we make analysis on generation conditions of LH plasma waves observed by Electric Field Detector (EFD) onboard Geotail spacecraft. We detected LH plasma waves automatically from EFD data, and made an occurrence frequency distribution of LH plasma waves.

LH plasma waves are observed in Lobe region and PSBL region in the magnetosphere. We studied several plasma parameters at the time when LH waves were observed. We found that LH waves were observed with the large perpendicular velocity of ion and the earthward ion flow. In addition, the LH plasma waves observed with the earthward ion flow have low frequencies, and the strengths of those LH plasma waves are relatively large. Figure 1 shows the spatial distribution of the point where LH plasma waves were observed by Geotail spacecraft. Red, blue and light blue points show LH plasma waves observed in Lobe, PSBL and other regions, respectively. These results suggest that strong LH plasma waves are observed in the boundary region where ion flow usually exist, such as Lobe region close to PSBL. In addition, LH plasma waves are observed when ion velocity perpendicular to the ambient magnetic field is enhanced and earthward ion flows are observed. We will farther investigate the occurrence conditions of LH plasma waves to clarify the generation mechanism of these waves and their effects on local plasma environment in the magnetosphere.

Keywords: Lower Hybrid plasma wave, magnetosphere, statistical analysis, ion flow, wave-particle interaction

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PEM027-P03

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## Contribution of kinetic Alfvén waves to the formation of the low-latitude boundary layer

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One of the biggest problems in magnetospheric physics is to understand how the solar wind plasma enters the magnetosphere and forms the low-latitude boundary layer (LLBL) during northward interplanetary magnetic field periods. Several processes have been suggested including: (1) magnetic reconnection at the poleward-of-the-cusp in both hemispheres, (2) reconnection or turbulence within well-developed Kelvin Helmholtz vortices on the flank magnetopause, and (3) diffusive transport induced by wave-particle interactions.

Regarding the third process, we revealed from test particle simulations that transverse and compressional fluctuations via kinetic Alfvén waves (KAWs) can cause selective transport associated with their perpendicular wavelengths. Applying the results to a magnetopause crossing event in which the existence of the KAWs had been identified, we successfully found that KAWs can actually transport solar wind plasma across the magnetopause. In this presentation, we will show applications to various magnetopause-crossing events and discuss whether the KAWs can contribute to the formation of the LLBL.

Keywords: low latitude boundary layer, plasma wave, kinetic Alfvén wave, reconnection, plasma transport

PEM027-P04

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## Statistical visualization of the Earth's magnetosphere with THEMIS probe data

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In this study, we have visualized the averaged structure of Earth's magnetosphere using the magnetic field and plasma data obtained by THEMIS probes during the interval from August 2007 to October 2010. An advantage of using the THEMIS data is that they give us a clear picture of the Earth's magnetosphere including various boundaries.

This is due to the following characteristics:

(1) Five THEMIS probes cover large areas around the Earth up to  $30 R_E$  ( $R_E$ : one Earth radius), and they offer large amount of data.

(2) The interval of the observations (2007-2010) is relatively short and the solar activity is low during its time period, so that we can expect that the data were obtained under uniform conditions.

First, we distributed THEMIS data on the X-Y plane with the GSM coordinate system. Then we separated the plane into the bins with  $1R_E \times 1R_E$  ( $R_E$ : Earth radius) size. Finally, we calculated averaged values of the parameters such as density, temperature, three-components of velocity for ions and electrons, as well as three-components of magnetic field in each bin, and we displayed them with color code. Employing this method, we could visualize the Earth's magnetosphere which composed of the bow shock, magnetosheath, magnetopause etc.

We further discuss the following two points based on the obtained results.

(1) Comparison between our results and the results of previous models of the magnetosphere (such as Shue et al.'s model [1997], and Peredo et al.'s model [1995])

(2) Variations in the magnetospheric structures and the plasma transport to the change of the solar wind dynamic pressure change or to the occurrence of magnetic storms

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## Reconstruction of quasi-static plasma structures in spacetime from in-situ measurements

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Even after the advent of multi-spacecraft missions such as Cluster and THEMIS, it has been difficult to distinguish between spatial and temporal variations from in situ measurements. This is partly because most data analysis methods do not accommodate both features. For example, the original version of Grad-Shafranov (GS) reconstruction (Sonnerup and Guo, 1996; Hau and Sonnerup, 1999), the method for recovering two-dimensional magnetohydrostatic structures from in situ measurements, assumes that the structures are time independent (as seen in a proper frame of reference) over the interval to which the method is applied. However, actual structures may be evolving, even if slowly, during that interval. We present a novel method for reconstructing such slow evolution of quasi-static structures (Hasegawa et al., 2010), which is an extension of the original GS method. The method is tested by use of synthetic data from numerical simulations of time-dependent magnetic reconnection, and the results from application to Cluster observations of a flux transfer event at the dayside magnetopause are presented. We also show that multipoint information allows for the size of the reconstruction domain to be increased, and for proper estimation of the orientation of the invariant axis, along which gradients are assumed to be negligible.

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Sonnerup, B. U. O., and M. Guo (1996), *Geophys. Res. Lett.*, 23, 3679-3682.

Keywords: Grad-Shafranov equation, magnetopause, magnetohydrostatic equilibrium, magnetic reconnection, data analysis method

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## Response of the Earth's magnetosphere to change of IMF Bz component

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It is known that plasma energy is transported from the solar wind to the Earth's magnetosphere, and IMF Bz component plays the most important role in the transportation through magnetic reconnection. Thus, it became clear that large magnetic storms in the magnetosphere are caused by CME with a southward IMF.

In contrast, high-energy electrons in the Earth's outer radiation belt are due to CIR (Co-rotating Interaction Region) which doesn't cause strong magnetic storms in contrast with CME. The characteristics of CIR are long duration of high-speed solar wind and fluctuations of IMF.

Thus we have executed a 3-dimensional global MHD simulation between the solar wind and earth's magnetosphere in order to study response of the magnetosphere to oscillations of the IMF Bz component. The configuration and dynamics of the magnetosphere depending on oscillations of the IMF are demonstrated.

Keywords: MHD, IMF, CIR

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PEM027-P07

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## Reciprocal ionospheric convection cells during northward interplanetary magnetic field periods

Masakazu Watanabe<sup>1\*</sup>, Suzuna Ikeda<sup>2</sup>, Shigeru Fujita<sup>3</sup>, Hiroyuki Shinagawa<sup>4</sup>, Takashi Tanaka<sup>5</sup>

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It is known that the dayside ionospheric convection at small interplanetary magnetic field (IMF) clock angles (less than or equivalent to 30 degrees) exhibits twin reverse cells in both hemispheres. Traditionally, this convection pattern has been interpreted in terms of lobe cells circulating in the open field line region of the ionosphere. Recently, the lead author has shown a flaw of this conventional view and suggested the existence of a new magnetic flux circulation mode that involves reconnection between open and closed field lines. This circulation mode is termed the interchange cycle. A consequence of the interchange cycle is the appearance of a reverse cell circulating in the closed field line region. This convection cell is called reciprocal cells. The reciprocal is unique to the interchange cycle and can be used as an identifier of the circulation mode. The lead author has also shown a "proof of existence" of the ionospheric situation that is expected for the interchange cycle. However, an observational approach is always subject to various limitations. For example, determining the open-closed field line boundary is suggestive but not definitive. The purpose of this paper is to check whether global magnetohydrodynamic (MHD) simulations can reproduce reciprocal cells as observed, to further support the existence of the interchange cycle. For this purpose, we performed several simulation runs, changing IMF clock angles. We found that MHD simulations could reproduce reciprocal cells qualitatively, but the reproduction was not perfect quantitatively. For example, the reciprocal cell intensity (potential drop) was much smaller than the observations. In this paper, we compare simulation results with observations in various aspects and discuss their differences.

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## Reproducing substorm-related changes of the near-Earth magnetotail field structure in a global MHD simulation

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We reproduce the magnetospheric reconfiguration under a southward and duskward interplanetary magnetic field (IMF) condition by a numerical magnetohydrodynamics (MHD) simulation.

To investigate the relative displacements of the geomagnetic conjugate points, we trace both footprints of the geomagnetic field lines during the magnetospheric reconfiguration under positive and negative IMF By conditions. Several substorm-like features, namely the formation of a near Earth neutral line, fast Earthward flows and tailward release of the plasmoid, occur about 1 hour after southward turning of the IMF. The field line traced from the near-Earth magnetotail was strongly distorted toward dusk (dawn) in the north and toward dawn (dusk) in the south after the substorm onset under the positive (negative) IMF By conditions. The maximum relative displacement in the longitudinal direction of both footprints is 4.5 (5.5) hours in magnetic local time for the positive (negative) IMF By case.

While observational studies have indicated that the IMF orientation is the main controlling factor of the relative displacement of the conjugate points, this simulation study with constant IMF orientation shows that the substorm-related magnetic field variations and the field aligned currents (FACs) are likely to play a major role.

Keywords: aurora, substorm



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## Eigenfrequency of geomagnetic field line in a global MHD simulation

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Shear Alfvén waves propagating along the geomagnetic field line form standing waves along field line. The magnetic field intensity and the plasma mass density affect the velocity of shear Alfvén waves. Thus temporal and latitudinal variations in the field-line eigenfrequency are potentially caused by variations in the field-line length, the magnetic field intensity, and the mass density along the field line.

We estimated the eigenfrequency by numerically solving the standing Alfvén wave equation along the geomagnetic field in a global MHD simulation. The magnitude of diurnal variation in the eigenfrequency becomes larger according as the latitude increases. In low latitudes, the eigenfrequency agrees with that estimated with empirical magnetospheric model (TS04). However, in high latitudes, the rate of variability estimated in a global MHD simulation is larger than the empirically-based assessment.

In this study, we compared the diurnal variations in the eigenfrequencies observed at the vicinity of Syowa Station, Antarctica, and Dunedin, New Zealand with the estimated eigenfrequencies. We found that the global MHD simulation is adequate to reproduce variations in the eigenfrequency at dawn and dusk. The geomagnetic field lines started are extend toward the night sector.

These distorted field lines are not adequately reproduced by the empirical models.

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## Activity of ECH waves near the equatorial magnetosphere seen by THEMIS: Implications for diffuse auroral emissions

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It has been thought that the source of diffuse auroral emissions is scattered plasma sheet electrons into the loss cone by some wave-particle interactions. Both ECH waves and whistler-mode chorus have been thought to be the contributors to the production of diffuse auroral electrons since they can resonate with plasma sheet electrons. A question which wave mode dominantly contributes to the production of diffuse auroral electrons has been discussed for more than four decades and there is still controversy on the magnetospheric physics. A recent study done by Thorne et al. [2010] reveals that whistler-mode chorus is dominantly responsible for the production of diffuse auroral electrons. While, there are some observational suggestions that ECH waves cause diffuse auroral electron precipitations. [e.g., Nishimura et al., 2010; Liang et al., 2010]. Furthermore, the diffuse auroral electron precipitations derived by Newell et al. [2009] can be observed where no intense chorus emissions are occurred as shown by the THEMIS statistical survey [Li et al., 2009].

The scope of this study is to investigate distributions of average amplitudes of ECH waves near the equatorial magnetosphere in the region of  $5 < L < 10$  to consider their role in production of diffuse auroral electrons. This study is an extended work done by Meredith et al. [2009] that investigated ECH wave intensity and occurrence in the region of  $4 < L < 7$  near the equator ( $|\text{MLAT}| < 3$  deg) by the CRRES wave measurements. The THEMIS Filter Bank (FBK) data were used to investigate the ECH wave distributions and the data obtained from June 1 2007 to November 30 2010 were used for the analyses. The magnetic equator is determined from the T89 magnetic field model and the magnetic latitude is also estimated from the ratio of the local magnetic field intensity to the equatorial magnetic field intensity based on the model.

We firstly derived the magnetic latitude distributions of ECH waves and their dependence on the geomagnetic activity. We set selection criteria of ECH emissions since the FBK data have very low frequency resolution which prevent us from determination of wave mode precisely. The results are consistent with the previous study about the latitudinal distributions. The magnetic local time distributions of ECH waves near the equator ( $|\text{MLAT}| < 3$  deg) were derived using the same selection criteria. The derived magnetic local time distributions showed that ECH waves are observed at higher L-shells ( $L > 7$ ) on the night side and the mean amplitudes enhance as geomagnetic activity level increases. Furthermore, as geomagnetic activity level increases, ECH emissions tend to be observed on the dusk side magnetosphere. The regions mentioned above correspond to the region where there are no intense chorus waves [Li et al., 2009] but diffuse auroral electrons are observed by the low altitude satellite measurements [Newell et al., 2009]. This indicates that ECH waves contribute to the production of the diffuse auroral precipitations to some degree. Thus, it is suggested that the spatially combined electron precipitations due to resonant interactions with ECH waves and whistler-mode chorus make the global morphology of diffuse aurora.

Keywords: Diffuse aurora, wave-particle interaction, ECH wave, Whistler-mode chorus, pitch angle scattering, pitch angle diffusion

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## Characteristics of Pc 4 Range Magnetic Pulsations Observed by ETS-VIII Satellite and MAGDAS/Yap Station

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Pc 4 is a continuous pulsation with a period from 45 to 150 seconds, and Pi 2 is an impulsive pulsation with a period from 40 to 150 seconds (cf. Saito, 1969). In the present paper, we compared magnetic north-south Y-component data obtained from ETS-VIII (Engineering Test Satellite-VIII ; Koga and Obara,2008) satellite (GG Lon.=146, L=6.6) and H-component data at the MAGDAS/Yap station (GG Lat.=9.50, GG Lon.=138.08, GM Lat.=1.49, GM Lon.=209.06, L= 1.00 ; K. Yumoto et al.,2006 and 2007) during one month of April, 2009, in order to clarify wave characteristics of Pc 4 range pulsations observed at the geosynchronous orbit and near its projection point on the surface of the earth. Moreover, we investigated the local time dependence of occurrence of Pc 4 range pulsations with 20 min. shorter and longer durations at the ETS-VIII orbit. The longer duration Pc 4 pulsations were furthermore analyzed to examine the correlation of Pc 4 waveforms between the ETS-VIII satellite and the Yap station on the ground.

The following results were found;

(1) Pc 4 range pulsations with 20 min. longer duration at the ETS-VIII satellite occur frequently around 09 h and 13-16 h local time(LT). The occurrence frequency shows a dawn-dusk asymmetry with a dusk-side peak.

(2) The occurrence distribution of Pc 4 range pulsations with duration less than 20 min. at ETS-VIII shows a similar local time dependence of Pi 2 pulsations observed at the CPMN/GUA station in the nighttime (see Yumoto et al., 2001), where the GUA station is located near the geomagnetic longitude of ETS-VIII.

(3) Pc 4 range pulsations with duration more than 20 min. show an in-phase relation between ETS-VIII and YAP during 09h -15 h LT, while out-of-phase relationship during 16h - 24 h LT.

These observational results suggest that the longer- and shorter-duration Pc 4 range pulsations can be explained by using Pc 4 excited by K-H instability in daytime and Pi 2 during substorm onset in nighttime, respectively.

Keywords: Pc 4, ETS-VIII, MAGDAS, local time dependence, geosynchronous orbit

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## Auroral surge at poleward edge in the first 10 min intervals of Pi2 onset

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We reported that Pi2 pulsations often observed on the ground and at the geosynchronous altitudes are mostly attributable to the bifurcation of the fast earthward flows. The flows are repeated at Pi2 periodicities and propagated either eastward or westward after the bifurcation (Saka et al., JASTP, 2010). At the same time, the auroral surge associated with the Pi2 was observed at the poleward edge (SGEPSS at Okinawa, 2010).

For auroral events taken at Manitoba, Canada in 24 and 27 Jan 1986, we made the following observations:

- (1) The surge propagated either westward or eastward at poleward edge.
- (2) The wave polarizations at geosynchronous altitudes were CW / CCW for westward / eastward surge, respectively.
- (3) At the equatorward part of the surge, vortex structures though to be caused by the plasma flows at poleward edge were observed.

Based upon these observations, we conclude that:

- (1) The surge is the Alfvénic aurora activated by the eastward/westward propagating burst of flows that repeated at the Pi2 periodicities.

Keywords: Pi2 pulsation, substorm, Alfvénic aurora, all-sky image, geosynchronous altitudes

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## the study of magnetotail fluctuation during substorms

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The Earth's magnetosphere takes energy from the solar wind and stores it as a form of magnetic fields in the magnetotail. However, when it progresses excessively, the energy release takes place suddenly converting the magnetic field energy to the kinetic energy of particles. This phenomenon is called a substorm, but the physical mechanism of the substorm triggering is still remains unsolved.

In this study, we investigate the plasma density, plasma temperature, three components of velocity and magnetic field vectors in the central plasma sheet using the data from the THEMIS probes in order to obtain some clues to understand the substorm triggering. We found earthward flows which accompany the increase of northward magnetic field in the region beyond  $X \sim -12 R_e$  about several minute before the auroral breakup, i.e., the substorm onset. However, the occurrence of such flows decreases around  $X \sim -11 R_e$ . The occurrence of earthward flows increases again inside the region of  $X \sim -10 R_e$ , but the flow becomes more oscillatory and it is also characterized by the increase of the northward magnetic field.

In this presentation, we will discuss on similarities and differences between those two earthward flows.

Keywords: substorm, dipolarization

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## Three dimensional distribution of magnetic reconnection region in the near-Earth magnetotail

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The positions of magnetic reconnection regions and relationship between geomagnetic substorm and magnetic reconnection have been studied using observations by a lot of satellites and computer simulations.

In these studies, single magnetic reconnection region usually has been assumed. In this study, three dimensional magnetic reconnection regions are studied using several observations of Bursty Bulk Flow events in the magnetotail. In particular, conjunction events by THEMIS and GEOTAIL satellites located at distant points in the dawn-dusk direction are examined in order to study about three dimensional magnetic reconnection regions.

Keywords: Magnetic reconnection, Diffusion region, Multi-satellite observation

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## Coordinated observations of PBIs and reconnection signatures in the magnetotail: THEMIS case studies

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Poleward boundary intensifications (PBIs) are nightside auroral disturbances at the poleward boundary of the auroral oval and have been suggested to be the manifestation of nightside reconnection. However, there have been no simultaneous observations of PBIs and nightside reconnection, so that the association between PBIs and the formation of the near-Earth neutral line (NENL:  $X \sim -20$  to  $-30$  Re) and distant neutral line (DNL:  $X \sim -100$  Re) is still unclear.

We have performed coordinated observation of PBIs and nightside reconnection, using the THEMIS all-sky imagers (ASIs) and outer spacecraft (THEMIS B and C). In the present study, we present two case studies on 23 February 2009 and 10 March 2010. We focused on enhancements of PBIs in the ionosphere along with fast tailward flows in the magnetotail that were suggested to be originated from the NENL.

On 23 February 2009, THEMIS B and C were located at  $X \sim -17$  and  $-23$  Re, respectively. In this event, pseudobreakup occurred  $\sim 7$  min after the PBI enhancements. Both spacecraft observed fast tailward flows associated with enhancements of the PBI. It suggests that the enhancements of the PBI were closely associated with the formation of the NENL. We found multiple bipolar signatures in the north-south component of a magnetic field during fast tailward flows. The signatures had a few min periods and were associated with periodic enhancements of the PBI. We suggested that the bipolar signatures of  $B_z$  represented successive plasmoid releases from a single NENL.

On 10 March 2010, THEMIS C was located at  $X \sim -50$  Re in the magnetotail, when enhancements of PBIs were detected in the field of view of ASIs. In this event, a substorm was identified at  $\sim 06:17$  UT. 20-60 min prior to the onset, enhancements of PBIs were associated with fast earthward flows at  $X \sim -50$  RE, which were suggested to be originated from the DNL. On the other hand, enhancements of PBIs several min before the onset were associated with plasmoid ejection from the NENL. These results suggested that both NENL and DNL could be the manifestation of PBIs.

Keywords: substorm, reconnection, aurora, poleward boundary intensification, fast flow