Formation and movements of transpolar aurora

*Takahiro Obara[1]

1.Planetary Plasma and Atmospheric Research Center,Tohoku University

Formation and movement of the transpolar aurora, which appears under the condition of northward IMF, is investigated from the analysis of the numerical MHD simulation as well as IMAGE FUV observations. It seems that there will be at least three categories.
The 1-st type is the arcs at the poleward edge of the dawn or dusk side of main oval which was thickened on one side by a tilted plasma sheet by the strong IMF By (cf. Makita et al., 1991). This type of arcs do not move so much and remain there for a significant time interval.
The 2-nd type is the moving arcs, which is caused by the transient convection after a sign change of IMF By (Tanaka et al., 2004). This transient convection must include a replacement of lobe field lines from old-IMF-orienting fields, a rotation of plasma sheet to opposite inclination, and a reformation of ionospheric convection cells. In the midst of these reconfigurations, old and new convection system must coexist in the magnetosphere-ionosphere system. In this stage, the polar cap and tail lobes are continuously encroached by the new open field lines connected to the new IMF. Whereas magnetic field lines accumulated in new lobes tend to rotate the outer plasma sheet in the opposite direction, the old merging-cell convection still continues to generate closed field lines that must return to dayside against the new-lobe formation. As time progresses, the growth of new lobes results in the blocking of the return path toward dayside of closed field lines generated in the old merging cell to form the kink structure in the plasma sheet. Losing their return path, these closed field lines generated from old lobes accumulated on the night side.
The 3-rd type is the arc which forms in the midnight and develops toward the noon. Millan et al.(2005) proposed that transpolar arc is formed by the reconnection in the magnetotail, where the foot point of the reconnected field line is pre-midnight in one hemisphere and post-midnight in the other due to the magnetotail By component. The return flow of newly closed field line would be hindered and buildup of the closed flux that protrudes into the polar cap.
Based on the IMAGE observations, Fear and Milan (2012) listed polar cap arc events. We have tried to classify these 21 polar cap arc events into three types. Number of events for each Type is following; i.e. Type 1 (13 events), Type 2 (2 events), and Type 3 (6 events). We also examined the variation of IMF By components and found that the IMF By was almost constant for Type 1, the IMF By changed its polarity for Type 2, and no significant was seen for Type 3. We will demonstrate the results of analyses and will discuss the mechanism in detail in the talk.

Keywords: Polar Cap Aurora, IMF

Stable sun-aligned arcs equatorward of the cusp

*Satoshi Taguchi[1], Keisuke Hosokawa[2], Yasunobu Ogawa[3]

1.Department of Geophysics, Kyoto University, 2.Department of Communication Engineering and Informatics, University of Electro-Communications, 3.National Institute of Polar Research

A well-established feature of the aurora in the cusp is a transient poleward-moving auroral form. The initial brightening of this aurora occurs near the equatorward edge of the persistent east-west aligned aurora, and then the auroral form moves poleward. This aurora form often occurs at several minute intervals. When compared with this kind of active features, the aurora equatorward of the cusp may be thought to be generally quiet. In this study, we focus on auroral arcs that sometimes appear equatorward of the persistent cusp. By examining auroral image data obtained at wavelengths of 557.7 nm and 630.0 nm by an all-sky imager at Longyearbyen, Svalbard, we found several events in which sun-aligned arcs exist stably equatorward of the cusp in the noon sector. The sun-aligned arcs, which range between ~70 and ~76 MLAT, move from the postnoon to the noon sector slowly. The lifetime of the sun-aligned arcs is ~15 min or longer, which is much longer than that of the transient moving auroral form. The poleward portion of this arc, which is located at ~76 MLAT, is measured by the EISCAT Svalbard Radar. Simultaneous observations from the EISCAT Svalbard Radar and the all-sky imager show that fast plasma flow exists in the region of the auroral arc. Multiple sun-aligned arcs can also be observed. We discuss the spatial distribution of the plasma flow associated with the stable sun-aligned arcs equatorward of the cusp, and interpret the flow distribution in terms of temporal variations in the duskside convection cell.

Keywords: aurora, cusp, plasma convection

Statistical Analysis of Severe Magnetic Fluctuations in the near-Earth Magnetotail Observed by THEMIS-E

*Heqiucen XU[1], Kazuo Shiokawa[1], Dennis Fruehauff

1.Institute for Space-Earth Environmental Research, Nagoya University

We made a statistical analysis of severe magnetic fluctuations in the nightside near-Earth plasma sheet at |X| = 6 - 12 R_E, which is considered as a necessary cause for current disruption (CD) in the inside-out substorm model. We used magnetic field data for two years of 2013 and 2014 with a sampling rate of 4 Hz, obtained by the THEMIS-E satellite. The 1283 severe fluctuation events were identified as $sigma_B$ / $average_B$ > 0.5, where $sigma_B$ and $average_B$ are standard deviation and average value of magnetic field intensity during the time interval of local gyroperiods. We found that the occurrence rates of severe fluctuation events are extremely low (0.00118%, 0.00899% and 0.0238% at |X| = 6 - 8 R_E, 8 –10 R_E and 10 –12 R_E, respectively), and most of them last for no more than 15 s. The superposed epoch analysis of AL index and magnetic field variations indicate that they occur associated with sudden decrease of AL index value and magnetic field dipolarization. Meanwhile, 62% of events were accompanied by ion flow with v > 100 km/s. Superposed epoch analysis of the flow speed indicates that flow speed increases before the severe magnetic fluctuations. This fact suggests that the magnetic fluctuations are caused by the ion flow, and contradicts the suggestion of inside-out model that the fluctuations cause earthward ion flow by reducing the tailward pressure-gradient force. These results indicate that the inside-out model can only be suitable for relatively small amount of substorm cases. In the presentation, we plan to show the actual distance between event location and the neutral sheet, using Tsyganenko Model (T01).

Keywords: Inner Magnetosphere, Magnetic Fluctuation, Substorm

Global evolution and propagation of electric fields during sudden impulses using satellites and ground-based observations

*Naoko Takahashi[1], Yasumasa Kasaba[1], Yukitoshi Nishimura[2], Takashi Kikuchi[3,4], Atsuki Shinbori[3], Tomoaki Hori[4], Nozomu Nishitani[4]

1.Dep. Geophysics Graduate School of Science Tohoku University, 2.University of California, Los Angeles, 3.Research Institute for Sustainable Humanosphere, Kyoto University, 4.Institute for Space-Earth Environmental Research, Nagoya University

Sudden impulses (SI) are triggered by compression of the dayside magnetosphere, leading to fast mode wave propagation in the equatorial plane. Broadband fast mode waves generated in the magnetosphere propagate tailward from the dayside magnetopause, and the abrupt compression of the dayside magnetosphere induces Alfven wave propagation toward the polar ionosphere along magnetic field lines. Then the ionospheric electric field penetrates from polar toward low-latitude ionosphere at speed of light. These propagation processes have been supported by previous event and statistical studies using multi-point observations. However, there are few papers that performed a statistical analysis of the precise temporal evolution of the SI-associated MHD waves, particularly using satellites in the inner magnetosphere or ionosphere. Further, it is known that the Poynting flux plays a crucial role in the electromagnetic energy transport, but the detailed propagation path is still an open issue.
Motivated by these issues, we investigate global evolution and propagation of electric fields using in-situ satellites and ionospheric radars. In order to clarify the magnetospheric response, we obtain the magnetospheric electric and magnetic field data from THEMIS (5 probes) and Van Allen Probes (2 probes). Magnetospheric magnetic field data obtained from GOES 13 and 15 are also referred to. We identify the ionospheric response using the C/NOFS satellite, SuperDARN (high latitude) and HF Doppler (mid latitude) radars.
Seventeen events occurred from October 2012 to December 2014 show that both THEMIS and Van Allen Probes detect the westward electric field regardless of the local time. We also find time delay of onsets between dayside and nightside magnetospheric electric fields. In a representative event on 17 March 2013, the onset time of the dawnside electric field (~4.8 h LT, L~4) is 24 s later than the dayside one (~10.4 h LT, L~7). The nightside electric field (~1.8 h LT, L~5.5) starts to decrease 32 s after the onset of the dawnside electric field. These time lags can be explained by the fast mode wave propagation in the equatorial plane. However, in the eveningside, the onset of the nightside magnetic field (~19 h LT) is 20 s later than that of the midnight one. In the ionosphere, C/NOFS (~11 h LT) and HF Doppler radar (~15 h LT) detects the dusk-to-dawn electric field 19 s later than the onset of the midnight electric field. Although SuperDARN radar cannot detect the precise onset time due to the normal scan mode with time resolution of 1 min, we find the dusk-to-dawn electric field observed as the negative peak of the line-of-sight velocity. Since the ionospheric electric field propagates globally and simultaneously, it is speculated that the nightside ionospheric electric field also responds with 19-s delay from the onset of the nightside magnetospheric electric field. Estimated Poynting fluxes are directed toward the ionosphere along field lines, which indicates the Alfven wave propagation toward the ionosphere in both the dayside and nightside. Therefore, the possible propagation path is as follows: first, the fast mode wave propagates from dayside to nightside magnetospheres in the equatorial region through the dawnside, and then the Alfven wave propagates from the magnetosphere toward the ionosphere.
On the basis of such individual events, we statistically derive the spatial distribution of the time response of magnetospheric electric fields. In the dayside, the magnetospheric electric field

responds more gradually as the L-value of satellites becomes smaller. The estimated propagation velocity in the dayside is ~600-900 km/s, which is consistent with the fast mode wave speed. In the nightside, however, the post-midnight electric field responds faster than the pre-midnight one. The asymmetric distribution with respect to the midnight meridian may be associated with the plasmapause location.

Forecast of AU/AL index with real time data assimilation

*Ryota Yamamoto[1], Yoshizumi Miyoshi[1], Shinobu Machida[1], Genta Ueno[2], Yukinaga Miyashita[1], Masahito Nose[3]

1.The Solar-Terrestrial Environment Laboratory, 2.The institute of Statistical Mathematics, 3.Kyoto-University

The AU index is a proxy of substorm as well as auroral activity, so that the forecast of the index is important for the space weather research and forecast. In this study, we have developed a data-assimilation code to estimate variations of the AU index based on Goertz’s model. In the Goertz’s model, there are several parameters, and these parameters are related to the ionospheric conductivity. From the estimation of the developed data-assimilation code, we found a seasonal dependence of these parameters in the model. It is expected that these seasonal variations are caused by the seasonal variations of ionospheric conductivity as indicated by Goertz et al. The original Goerts model assumed the constant amplitude for these parameters, and seasonal dependence derived from our data assimilation may contribute the improve the forecast score.

Keywords: data assimilation, AU index

Bi-modal distribution of substorm intensity

*Akira Morioka[1], Yoshizumi Miyoshi[2], Masahito Nose[3]

1.Planetary Plasma and Atmosphere Recearch Center,Guraduate School,Tohoku University, 2.Institute for Space-Earth Environmental Research, Nagoya University, 3.Graduate School of Science, Kyoto University

One of the essential issues in substorm study is how is the substorm intensity distributed and what determines the distribution. In this study, the substorm intensity (AL index at substorm) distribution is statistically studied using the Wp index provided by WDC for Geomag, Kyoto University and OMNI data base. The results showed that substorm intensity distribution is composed of bi-modal peaks with lognormal distribution. The major peak is in small AL range around 100 nT (named group-S substorm) and the secondary peak is around 300 nT (named group-L substorm). The bi-modal distribution of substorm intensity means that substorm is not a continuum state between pseudo-substorms and full substorms as has been discussed. The solar cycle variation of the substorm intensity distribution showed that group-S substorms occure rather constantly during a solar cycle, whereas the appearance of group-L substorms is strongly dependent with the solar activity. These observations suggest that two different substorm processes are working in the magnetosphere or different solar wind-magnetosphere interaction processes are operating.

Keywords: substorm, intensity distribution, lognormal distribution

Ion cyclotron waves detected by Kaguya and Geotail in the Earth’s plasma sheet boundary layer

*Tomoko Nakagawa[1], Hideo Tsunakawa[2]

1.Information and Communication Engineering, Tohoku Institute of Technology, 2.Deparment of Earth and Planetary Sciences, Tokyo Institute of Technology

Nearly monochromatic, narrowband ion cyclotron waves found by Apollo 15 and 14 Lunar Surface Magnetometers (Chi et al., 2013) were detected in the magnetic field data obtained by GEOTAIL in the distant tail lobe as well as in the data obtained by Kaguya orbiting around the moon in the tail lobe of the Earth’s magnetosphere. They have common characters such as the frequency range near the local proton cyclotron frequency, significant compressional components, and wave forms comprising discrete packets. They are also similar to the waves found by Cassini during its Earth swing-by (Bogdanov et al., 2003). Polarization of the narrowband ion cyclotron waves was predominantly left-handed at far downstream, while near the lunar orbit, both right-handed and left-handed polarization was detected.

Keywords: ion cyclotron wave, plasma sheet boundary layer, lobe, Kaguya, GEOTAIL, left-handed polarization

Simultaneous observations of magnetospheric ELF/VLF emissions at Canada, Finland, and Syowa Station

*Yusuke Yonezu[1], Kazuo Shiokawa[1], Martin Connors[2], Mitsunori Ozaki[3], Jyrki K Manninen[4], Hisao Yamagishi[5], Masaki Okada[5]

1.Institute for Space-Earth Environmental Research, Nagoya University, 2.Athabasca University, 3.Faculty of Electrical and Computer Enginnering, Institute of Science and Engineering, Kanazawa University, 4.Sodankylä Geophysical Observatory, 5.National Institute of Polar Research

Whistler mode wave emissions in the ELF/VLF range, such as chorus, hiss, and quasi-periodic (QP) emissions, accelerate relativistic electrons in the inner magnetosphere. Relativistic particles drift around the Earth in the longitudinal direction with time scales from tens of minutes to hours and interact with ELF/VLF emissions. However, global extent of ELF/VLF emissions has not been well understood. We investigate this by analyzing the data obtained at 2 longitudinally-separated stations in the northern hemisphere and 1 station in the southern hemisphere in the auroral and subauroral latitudes, i.e., Athabasca, Canada (54.7N, 113.3W, magnetic latitude (MLAT): 61.3N), Kannuslehto, Finland (67.7N, 26.3E MLAT: 64.4N) and Syowa Station, Antarctica (69.0S, 39.6E, MLAT: 70.5S). Simultaneous data at these stations are available for total 48 days during December 10-14, 2012, January 9-19 and January 29-February 5, 2013, and February 26-March 21, 2014.
As an initial analysis, we evaluated the simultaneous wave occurrence rate of ELF/VLF emissions at Athabasca and Kannuslehto, which have about 11 hour differences in MLT. The wave occurrence rate was about 4 % in all available hours of the simultaneous observations. We found that the MLT dependence of simultaneous wave occurrence was basically a superposition of wave occurrence distribution at two stations.
In order to study details of the simultaneous wave occurrence features, we report intense hiss emissions observed at three stations associated with a sudden impulse event with enhancement of solar wind dynamic pressure with northward IMF on January 18, 2013. The hiss emissions were observed at frequencies expanding from below 1 kHz to over 2.5 kHz starting at 1235 UT (1240MLT) at Syowa Station, 1236 UT (1524 MLT) at Kannuslehto, and 1240 UT (0440MLT) at Athabasca during the recovery phase of a weak geomagnetic storm. We compared the timings of wave generation and the increase of magnetic field intensity at these 3 stations. At Syowa station and Kannuslehto, there were no discernible timing differences. At Athabasca, however, the wave was generated 4 minutes after the local magnetic field enhancement.
These results suggest that 4 % of ELF/VLF emissions may have a spatial extent of more than 11 hours. The event suggests that the timing of wave generation and magnetic field variation is not necessarily coincident. In the presentation, we will report statistical results of simultaneous occurrence of ELF/VLF emissions using all three stations.

Keywords: ELF/VLF emissions, Whistler mode wave emission, simultaneous wave occurrence

Local time and seasonal dependence of occurrence rate for the zero-order mode of tweek atmospherics

*Hiroyo Ohya[1], Tohru Araki, Kazuo Shiokawa[2], Yoshizumi Miyoshi[2], Takashi Kikuchi[2]

1.Graduate School of Engineering, Chiba University, 2.Institute for Space-Earth Environmental Research, Nagoya University

Tweek atmospherics are VLF/ELF electromagnetic waves originated from lightning discharges and propagate in the Earth-ionosphere waveguide for long distances. So far, there are few studies for the zeroth-order mode of the tweeks. The preliminary reverse impulse (PRI) electric field of the geomagnetic sudden commencement (SC) is transmitted by the TM0 mode waves propagating at the speed of light in the Earth-ionosphere waveguide (Kikuchi et al., 1978; Kikuchi and Araki, 1979). In this study, we investigate the local time and seasonal dependence of the tweek zero-order mode to understand the characteristics of the zero-order mode. For statistical analysis, we developed the automatic detection procedure for the zero-order mode. In this session, we will discuss the results for the tweek zero-order mode in detail.

Seasonal variation in equatorial plasma mass density in the New Zealand meridian

*Yuki Obana[1], Mayumi Nakata[1], Kazuya Terauchi[1]

1.Department of Engineering Science, Faculty of Engineering, Osaka Electro-Communication University

We present a statistical analysis on the plasma mass density derived from the ULF wave observations by the CRUX magnetometer array. The array consists of magnetometer stations along the 170°E longitude, spanning L-values between 2.2 and 2.8. Using the cross-phase method and an automated procedure for FLR detection, we studied 13 months of observations between March 2013 and March 2014. We found a semi annual variation in plasma density with equinoctial maxima. Similar semi annual variation in electron density was reported by the previous studies. Bouriot et al., 1967 studied whistler data recorded at Poitier (0°E) and showed clear semi annual variation. On the other hand, Park et al., 1978 found unclear semi annual variation from the whistler data recorded at Stanford University (~110°W). The plasmaspheric density may require more specification of longitude. This is the first statistical study of plasma mass density in the New Zealand meridian.

Mapping of the small scale magnetic fluctuations observed by LEO satellites to the equatorial plane of magnetosphere

*Yoshihiro Yokoyama[1], Toshihiko Iyemori[2], Kunihito Nakanishi[1], Tadashi Aoyama[1]

1.Department of Earth and Planetary Sciences, Graduate School of Science, Kyoto University, 2.Data Analysis Center for Geomagnetism and Space Magnetism, Graduate School of Science, Kyoto University

In regions of high-beta (i.e., the plasma sheet and the boundary layer) in the magnetosphere,it can be expected that the plasma behaves as turbulence due to the effects of various plasma instabilities, non-linear development of Alfven waves and so on. Satellites in plasmasheet also have observed the fluctuations in velocity and magnetic field that have the characteristics of fluid turbulence. If the plasma always behaves as turbulence, the distribution and the spectrum become important for understanding phenomena in the magnetosphere. However, it is almost impossible to have sufficient simultaneous satellite observations that could physically cover the huge magnetospheric domain. On the other hand, we confirmed that the magnetic fluctuations over the high-latitude ionosphere observed by low-altitude satellites almost can be regarded as the manifestation of the spatial structure of field aligned currents by using the magnetic data obtained by SWARM satellites during December,2013 when the SWARM satellites flew on nearly the same orbits with slight time separations. In addition, the low-altitude satellites scan wide range on the equatorial plane of the magnetosphere in short time.therefore, by projecting these fluctuations into the equatorial plane of the magnetosphere,i.e., the source regions of Field aligned currents, we try to estimate the distribution and the characteristics of plasma there.
We made statical maps of the amplitude of magnetic fluctuations having period shorter than 8s for both quiet(AE<50nT) and disturbed(AE>50nT)condition. We found that the large amplitude regions exist to the same extent in both conditions. This result suggest that the plasma might behave as turbulence even in quiet condition. In order to examine in more detail, we also calculated the spectral index of these fluctuations.

Keywords: field aligned currents, low altitude satellites, small scale magnetic fluctuations

Seasonal dependence of the plasmaspheric density along the 210MM: Observations in the northern and southern hemispheres

Sakiko Onoue[2], *Hideaki Kawano[1], Teiji Uozumi[3], Boris Shevtsov[4], Sergey Khomutov[4], Igor Poddelskiy[4], Richard Marshall[5], Akimasa Yoshikawa[1], group MAGDAS/CPMN[3]

1.Department of Earth and Planetary Sciences, Faculty of Science, Kyushu University, 2.Department of Earth and Planetary Sciences, School of Science, Kyushu University, 3.International Center for Space Weather Science and Education, Kyushu University, 4.IKIR FEB RAS, Russia, 5.Space Weather Services section, Bureau of Meteorology, Australia

In this paper we have applied the cross-phase method and the amplitude-ratio method to the MAGDAS/CPMN ground-magnetometer pairs MGD-PTK (Magadan and Paratunka, located in the Russian Far East) and CAN-HOB (Canberra and Hobart, located in eastern Australia), both along the 210MM (Magnetic Meridian), and identified FLR (field-line resonance) events.
MGD is located at (53.6, 219.1) magnetic latitude and longitude [deg], and PTK is located at (46.2, 226.2). Their L values are 2.9 and 2.1. CAN is located at (-45.7, 226.6), and HOB is located at (-54.2, 226.5). Their L values are 2.1 and 2.9. We have identified the FLR events by using both visual inspection and an automatic-identification computer code.
Although the MGD and PTK (CAN and HOB) are separated by about seven (nine) degrees in magnetic latitudes, which is larger than the typical separation (about 1-2 degrees) to which the cross-phase and amplitude-ratio methods are efficient, but we could identify more than a hundred FLR events a year from the both station pairs, and the FLR events had a fairly continuous coverage.
In this paper we estimate the plasmaspheric density from thus obtained FLR frequencies, and examine their seasonal dependence. The result suggests a weak, but marginally significant seasonal dependence with maxima in winter and minima in summer for the both hemispheres. More details will be discussed at the presentation.

A new perspective of MI-coupling in auroral zone associated with Pi2 pulsations

*Osuke Saka[1]

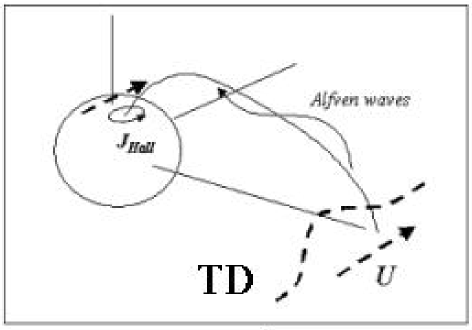
1.Office Geophysik

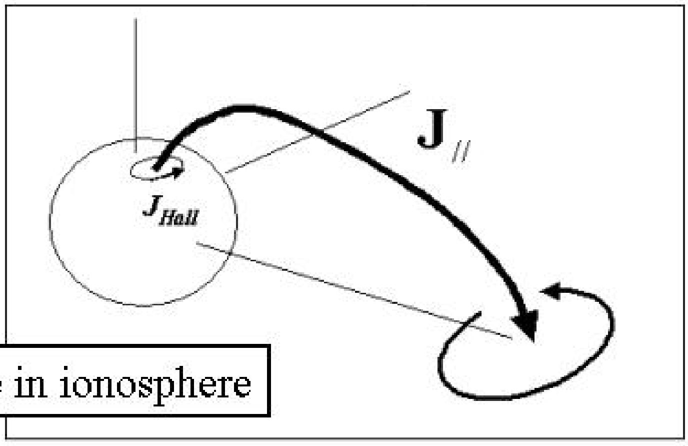
A new perspective of MI coupling in auroral zone proposed in our model includes:
(1). During the substorm onset, the surface waves are excited in the nighttime sector by the K-H instability at the earthward interface of the flow diversion.
(2). The surface waves were coupled to the Alfven waves in the magnetosphere, where a strong wave coupling that leads to FLR was not assumed.
(3). The weakly coupled Alfven waves may not carry field-aligned currents (FAC) from the magnetosphere but generate the convergent electric field regions in the ionosphere by the combined modes of the field line oscillations.
The convergent electric fields produce loop currents in the ionosphere, as well as upward FAC at the center and downward FAC in the peripheral. The FAC system may be sustained directly by the enhanced parallel flows of plasma sheet electrons and their returns. The convergent electric field regions correspond to the westward traveling surge (WTS) in the active auroras.
References:
Saka et al., JASTP, 2007, 2010, 2012
Saka et al., JGR, 2012, 2015
Saka et al., AnnGeo, 2014

Keywords: substorm, MI coupling, Auroras

New perspective of MI coupling associated with Pi2

- Shear flow (U) supported by TD
- K-H instability
- Surface waves





- FAC source in ionosphere

Auroral activity observed during the SC event on June 22 in 2015

*Akira Kadokura[1]

1.National Institute of Polar Research

Auroral activity observed at Syowa Station during the SC event on June 22, 2015 will be analyzed.
Some features of this event are as follows:
(UT)
18:03 Shock arrival at ACE position
18:33 SSC at Kakioka, maximum:+104nT
18:33:30 SC magnetic variation start at Syowa
18:34 Auroral variation appear at lowest horizon
18:40 Poleward expansion of auroral arc
18:40:30 Break of arc, N-S aurora; diffuse spread
19:32 poleward expansion again
19:54 spread from higher latitude to lower latitude
20:30 going back to calm
During this period, following optical instruments were operated at Syowa Station:
- All-sky Monochromatic imagers(427.8,557.7,485.0,480.5nm)
- All-sky panchromatic TV camera
- Multi-color Scanning Photometer
During this period, very bright proton auroral emission over 500 R was observed.
In our presentation, details of temporal variation of auroral activity will be shown..

Keywords: SC event, Shock Aurora, Syowa Station

Conjugate observation of auroral finger-like structures by ground all-sky cameras and the THEMIS sarellite

*Katsuki Nishi[1], Kazuo Shiokawa[1], Erick Donovan[2]

1.Institute for Space-Environmental Research Division for Ionospheric and Magnetospheric Research, 2.Department of Physics and Astronomy, University of Calgary

Aurora dynamics is a manifestation of plasma dynamics in the magnetosphere and auroral emissions are caused by electrons precipitating from the magnetosphere. Investigation of auroral structure helps to deepen our knowledge of dynamical variation of magnetospheric plasma and their connection to the Earth's atmosphere. We expect that these knowledges will be useful for space developments.

In this study, we observed finger-like structures of aurora using the THEMIS satellites and ground all-sky imagers to investigate physical processes that cause auroral fragmentation. We succeeded the first conjugate observation of auroral finger-like structures with magnetospheric satellites and investigated dynamical variation of magnetospheric plasma.

We searched conjugate ground-satellite events for the interval between October 2007 and December 2014. However, we found only one conjugate event that is observed at Narsarsuaq (MLAT: 69.3) in Greenland at 0720-0830UT (0506-0616LT) on 17 February 2012. Investigation of the event produced following observation facts: plasma pressure and magnetic pressure fluctuate in anti-phase with time scales of 5-20min, parallel electron flux and plasma pressure fluctuate in same time scales, and perpendicular ion velocity is very small (less than 50km/s) during the event.

Keywords: THEMIS, All-sky imager, auroral finger-like structure, magnetosphere

Plasma density enhancements in the period of Pc 2 observed near the plasmapause in association with Pi 2 and auroral breakup

*Tohru Sakurai[1]

1.Tokai University

Plasma density enhancements in the period range of Pc 2 (T = ~ 10 sec) were observed near the plasmapause around midnight in association with Pi 2 oscillations and the initial auroral brightening at 0826 UT on 04 April 2009. During this substorm the THEMIS B satellite took an inbound-pass and crossed the plasmapause, observed extraordinary large plasma density oscillations with the period of Pc 2, which enhanced in close association with Pi 2 oscillations. Enhancements of the Pc 2 oscillations were observed with the magnetic, electric field and plasma instruments on board the satellite. Large amplitude plasma density oscillations well correlated with the electric field oscillations and the polarization of the magnetic field Pc2 oscillations showed a left-hand polarization through the event. Therefore the oscillations seem to be the ion-cyclotron oscillations. Auroral breakup and associated Pi 2 oscillations were observed at the THEMIS GBO stations covering over the wide range longitudes from east to west of the Canada. The dominant period of Pi 2 oscillations was almost similar at both these THEMIS GBO stations and the satellite location. The relationships between the Pc2 enhancements and Pi 2 oscillations will be discussed in the presentation in more detail.

Keywords: substorm, aurora, Pc2 oscillations, Pi2 oscillations, Plasmapause

Ionospheric electric field oscillation associated with Sudden Impulse seen by SuperDARN radars

*Kouhei Iida[1], Nozomu Nishitani[1], Tomoaki Hori[1]

1.Institute for Space-Earth Environmental Research, Nagoya University

Sudden Impulse (SI) is a sudden increase of H-component geomagnetic field often seen at low latitudes. Past studies showed that it is caused by a sudden compression of the magnetosphere associated with rapid increases of the solar wind dynamic pressure. At middle and high latitude, SIs cause some kind of perturbation in twin vortex type ionospheric currents. It was reported that the disturbance of the ionospheric current and the electric field associated with SI consists typically of the Preliminary Impulse (PI) and the Main Impulse (MI). Examining SI-associated flow variations observed by SuperDARN radars in the present study, we find that some of them show only two successive pulses, while some others are accompanied by damped oscillations of the ionospheric electric field lasting for about several tens of minutes to an hour with periods of several minutes, which is consistent with the past geomagnetic field observations of damped oscillations known as Psc’s. However, the cause of this difference is not understood. We examine the cause of the difference between the two kinds of SI events, using SuperDARN radars in north hemisphere covering ~40 to 90 geomagnetic latitudes. From January 2012 to December 2014, 161 SI events were identified and 30 events out of them were accompanied by the ionospheric electric field oscillations as observed by at least one SuperDARN radar immediately following SIs. We have statistically investigated the relation between the ionospheric oscillations after SI and solar wind dynamic pressure. As a result, it is found that presence/absence of ionospheric electric field oscillations do not much depend on solar wind dynamic pressure. We will discuss the MLT dependence, comparison with previous studies of Pc5 pulsations, spatial displacement of the magnetopause and oscillations of the solar wind dynamic pressure as the external factor.

Keywords: SuperDARN, Sudden Impulse, ionospheric electric field oscillation

High-resolution auroral acceleration signatures within a highly dynamic onset arc

*Tetsuo Motoba[1], Masafumi Hirahara[1]

1.Nagoya University

Auroral acceleration processes and structures related to onset auroral arcs remain poorly understood mostly due to the lack of adequate observations. The Reimei spacecraft has so far offered the best possibility to perform detailed high-resolution particle measurements conjugate to detailed fine-scale optical measurements with a small field of view. In this study we present simultaneous conjugate Reimei observations of fine-scale optical and particle signatures of a structured, highly dynamic onset arc that occurred on 16 March 2006. The favorable Reimei observations for the active arc crossing within a few seconds provide a detailed picture of the relationship between the structuring arc emissions and the causal particle acceleration processes.

Keywords: aurora

A statistical study of near-earth magnetotail variations during substorm based on THEMIS data

*Kento Fukui[1], Shinobu Machida[1], Yukinaga Miyashita[1], Akimasa Ieda[1], Yoshizumi Miyoshi[1], Yukitoshi Nishimura[2], Vassilis Angelopoulos[2]

1.Institute for Space-Earth Environmental Research. Nagoya university, 2.University of California, Los Angeles

The energy imparted from the solar wind is stored as a form of magnetic energy in the magnetotail. When this process has progressed excessively, the energy release in which the magnetic energy is transferred to the kinetic energy of the particles begins. A part of physical mechanisms of this phenomenon called a substorm, is still not known.
In this study, we investigate the temporal and spatial development of the near-Earth magnetotail during substorms based on a superposed-epoch analysis of THEMIS data in the interval from November 2007 to April 2010, using a substorm onset as a time reference. To investigate the transport of the magnetic flux, we evaluated the ion flow velocity vector perpendicular to the magnetic field and perform the superposed epoch analysis for its three components. In addition, we carry out similar analysis by collecting data of positive and negative values of three velocity components separately to investigate relative timings of the flows with respect to the substorm onset.
The result shows that earthward flows increase just before the substorm onset, and tailward flows increase just after the onset in the region of -10 > X(GSM) > -12 Re (Earth radii). Furthermore, the fraction of the earthward flow events to the total events (earthward and tailward flow events) increases just before the onset, followed by increase of the fraction of tailward flow events. These results supports the validity of the NENL (Near-Earth Neutral Line) model and CCSR (Catapult Current Sheet Relaxation) model in which the earthward flows start earlier than the substorm onset. As for the increase of the tailward flows, it can be interpreted by reflection model proposed by Ohtani et al. (2009). Concerning the flows in Y-direction, they increase in the dawnward direction just before the onset, and duskward flows increase just after the onset in -10 > X(GSM) > -12 Re . It is possibly because our dataset contains more events in the dusk-side than those in the dawn-side, thereby, the initial flow is in the earthward and slightly dawnward directions reflecting the magnetic field structure in that region.
It is also found that immediately after the onset, it is found that the number of earthward flows becomes almost the same to the number of tailward flows in -8> X> -9Re. This can be the result of the ballooning instability which causes the current disruption (CD). Combining, this result with those forementioned, we can conclude that the NENL or CCSR model is more appropriate than the CD model to explain the onset of substorm.

Keywords: substorm, THEMIS

Study on structures of the dayside magnetic reconnection using GEOTAIL data

*Ryu Tanaka[1], Shinobu Machida[1], Hirotoshi Uchino[1,2], Shinsuke Imada[1], Yoshizumi Miyoshi[1], Kanako Seki[3], Akimasa Ieda[1], Yukinaga Miyashita[1], Kunihiro Keika[1], Yoshifumi Saito[4]

1.Institute for Space-Earth Environmental Research, Nagoya Univ., 2.Solar-Planetary Electromagnetism Laboratory, Kyoto Univ., 3.Graduate School of Science, University of Tokyo, 4.ISAS/JAXA

In the present study, we have investigated the magnetic reconnection structure in the dayside magnetosphere that has not been studied intensively compared to nightside, by analyzing the GEOTAIL data. In the nightside magnetosphere (magnetotail), it is considered that a symmetric reconnection will occur because the characters of plasmas of two upsteram sides are almost the same. On the other hand, in the dayside magnetosphere (magnetopause), it is considered that the asymmetric reconnection will occur because the magnetospheric plasma and the solar wind plasma are both involved in the reconnection. It is considered that the nightside reconnection has a quadrupole structure produced by Hall effect, and the dayside reconnection has a dipole structure. We selected reconnection events based on the simultaneous sign inversions of the ion outflow velocity and the magnetic field from the GEOTAIL data. We obtained 32 cases from the year 1995 to 2014, and found that they have either quadrupole or dipole structure in the duskward magnetic field component (B_y). In the LMN coordinate system, we further investigated the magnetic field structure near the neutral line by analyzing changes in the ion density and magnetic field when GEOTAIL passed near the neutral line. In the quadrupole structures cases, the averaged value of the ion density ratio is 7.5 (Density in the magnetosheath / Density in the magnetopause) and the averaged value of the magnetic field ratio is found to be 1.53 (B_z in the magnetopause /$|B_z|$ in the magnetosheath). On the other hand, in the dipole-structure cases, the averaged value of ion density ratio is 36.1, and the averaged value of the magnetic field ratio is 2.68. These values are greater than those with the quadrupole structure. We also investigated hot fast outflow component and cold inflow in the velocity distribution function of the ions in the selected event. We will discuss the difference between the symmetric reconnection and the asymmetric reconnection based on these results.

Keywords: magnetic reconnection, Hall effect, asymmetry, GEOTAIL spacecraft

Characteristics of Magnetic Field Oscillation of Pc5 Wave at the GEO Associated with MeV Electron Flux Enhancement

*Kentarou Kitamura[1], Yoshimasa Tanaka[2], Satoko Saita[3], Akira Kadokura[2], Hisao Yamagishi[2]

1.National Institute of Technology, Tokuyama College, 2.National Institute of Polar Research, 3.National Institute of Technology, Kitakyushu College

It is well known that MeV electron flux in the radiation belt increases during the recovery phase of magnetic storms. Acceleration process of MeV electron has been widely studied to understand the wave-particle interaction in the magnetospheric plasma process. In particular, the ULF wave is recently recognized as one of the possible cause of the MeV electron flux enhancement. The acceleration process by ULF wave is predominant during the magnetic storm driven by high speed solar wind such as CIR (Corotating Interaction Region). The Pc5 wave driven by high-speed solar wind is often interpreted as a subsequence of Kelvin-Helmholtz instability. However, the detailed process of the acceleration by ULF have not well understood while it has suggested that the oscillation mode of Pc5 wave must play an important role for the acceleration.
In this study we analyze the magnetic variation observed by GOES 10 and 11 satellites in the ENP coordinate system to compare the Pc5 pulsation observed at H057 (Maglat.=-66.42, L=6.25) and Skallen (Maglat.=-66.42, L=6.25) in Antarctica. In the case of the MeV electron flux enhancement occurred on February 26 –March 2, 2008, the P component (perpendicular northward from the orbital plane) of Pc5 power is almost comparable between the afternoon and noon sectors at the very beginning of the magnetic storm, while the Pc5 power in the N component (Eastward) is predominant in noon sector compared to that in the evening sector. During the recovery phase of the magnetic storm, the N-component Pc5 power in the in the evening is much larger than that in the noon sector, and the phase lag of the Pc5 shows the wave propagation from the evening to the noon sectors. The similar signatures also appear in the magnetic variations at H057 and Skallen.
These results suggest that the troidal oscillation of the Pc5 generated not only by KHI but also by another source in the night side play an important role of the drift resonance acceleration of the MeV electrons during the recovery phase of the magnetic storms.

Keywords: MeV electron, Radiation Belt, ULF Wave

Rapid acceleration of outer radiation belt electrons associated with solar wind pressure pulse: A Code coupling simulation of GEMSIS-RB and GEMSIS-GM

*Masahiro Hayashi[1], Yoshizumi Miyoshi[1], Shinji Saito[1], Yosuke Matsumoto[2], Kunihiro Keika[1], Tomoaki Hori[1], Takanobu Amano[3], Kanako Seki[3], Shinobu Machida[1]

1.Institute for Space-Earth Environmental Research,Nagoya University, 2.Chiba University, 3.University of Tokyo

Relativistic electron fluxes of the outer radiation belt dynamically change in response to solar wind variations. There exist several time scales for the outer belt flux enhancement. One of the shortest processes is caused by wave-particle interactions between drifting electrons and fast-mode waves induced by compression of magnetosphere caused by interplanetary shock (e.g., Li et al., 1993). In recent years, Van Allen Probes spacecraft observations indicated that electrons whose drift velocity is close to the fast-mode velocity are selectively accelerated (Foster et al., 2015). In this study, we performed a code coupling simulation using GEMSIS-RB test particle simulation (Saito et al., 2010) and GEMSIS-GM global MHD magnetosphere simulation (Matsumoto et al., 2010) to investigate how relativistic electrons are accelerated by fast-mode waves induced by solar wind pressure pulses. We simulated electron motions with different initial L-shells and initial energies and investigated how electrons are accelerated effectively by fast-mode waves launched at dayside magnetopause . As a result of the analysis, we found that electron acceleration strongly depends on both initial positions and initial energies of electrons. Effective accelerations are observed at high energy electrons at larger L-shells. We suggest that the effective acceleration occurs when electron’s drift velocity is faster than fast-mode velocity.

Keywords: outer radiation belt, acceleration of electron, GEMSIS

Study of the magnetic storm phase dependence of the inner boundary of the plasma sheet electrons based on THEMIS satellites observations

*Kento Ohki[1], Atsushi Kumamoto[1], Yuto Katoh[1]

1.Department of Geophysics, Graduate School of Science, Tohoku University

The locations of the inner boundary of the plasma sheet electrons during magnetic storm have been analyzed by using the dataset from THEMIS satellites. Plasma sheet electrons are carried toward the Earth due to magnetospheric convection, and then drift toward the morning sector in the vicinity of the Earth. The location of the inner boundary of the plasma sheet particles has been investigated as an indicator of the variations of the drift path of the plasma sheet particles, part of which causes ring current in the inner magnetosphere.

In several previous studies, the dependence of the location of the inner boundary of the plasma sheet electrons on geomagnetic indices such as Kp and AE index was investigated [Korth et al., 1999; Jiang et al., 2011]. In this study, we investigated the dependences of the plasma sheet electrons not only on geomagnetic indices such as Dst index but also on the phase of magnetic storms.

In order to investigate the relation between the dynamics of the plasma sheet electrons and the magnetospheric convection electric field, we focused on the position of the inner edges of the plasma sheet electron during the main phase and the recovery phase of the magnetic storm by using the electron flux data in an energy range from 0.7 keV to 9 keV obtained by Electrostatic Analyzer (ESA) onboard the THEMIS satellites.

As a result of event studies and statistical analyses, we found that the dependences of the plasma sheet electron inner edge on Dst index in the main phase and the recovery phase of the magnetic storm were different: Even if the Dst index is in the same range, the plasma sheet electron inner edges identified in the main phase were significantly nearer to the Earth than in the recovery phase of the magnetic storm. In addition, we could point out that the gap between the locations of the inner edges of 1 keV electrons and 9 keV electrons became smaller in the main phase than in the recovery phase of the magnetic storm. These results suggest that the position of the plasma sheet electron inner edges are affected by the electric field which appears around the peak of the magnetic storm and cause the modification of drift paths of plasma sheet electrons to be nearer to the Earth, and to be similar without depending on the electron's kinetic energy.

In order to confirm how the difference between the location of the plasma sheet electron inner edges in the main phase and that in the recovery phase occurs, we performed comparison of the locations of the plasma sheet inner edges found in several cases with those estimated based on the steady state drift boundary model [Jiang et al., 2011] combined with Volland-Stern electric field model [Volland et al., 1973]. This comparison suggested that the steady state drift boundary model cannot fully explain the positions of the inner edges of the plasma sheet electrons. In addition, we could point out that the gap of the positions of the inner edges of 1 keV electrons and 9 keV electrons derived from the observations became smaller than that estimated based on the model. These results suggest that some electric fields are added to Volland-Stern large-scale electric field in the observation, which can cause the modification of drift paths of plasma sheet electrons to be nearer to the Earth, and to be similar without depending on the electron's kinetic energy.

And in order to confirm whether the small-scale strong electric fields reported by Nishimura et al. [2006], we performed back-tracing of the drift paths of plasma sheet electrons during the recovery phase of the magnetic storm using the test particle simulation. As a result, we could suggests that the actual open/close boundary of the drift path of the electrons with energy of 9

keV indicated by their inner edge was located nearer to the Earth than that expected based on Volland-Stern electric field due to the additional electric field.

Keywords: magnetospheric convection, magnetic storm, plasma sheet

Propagation of electric fields during Pi2 pulsations using satellites and ground-based observations

*Naoko Takahashi[1], Yasumasa Kasaba[1], Yukitoshi Nishimura[2], Mariko Teramoto[3], Takashi Kikuchi[4,5], Tomoaki Hori[4], Yoshizumi Miyoshi[4], Nozomu Nishitani[4]

1.Dep. Geophysics Graduate School of Science Tohoku University, 2.University of California, Los Angeles, 3.ISAS/JAXA, 4.Institute for Space-Earth Environmental Research, Nagoya University, 5.Research Institute for Sustainable Humanosphere, Kyoto University

Pi2 pulsations are irregular oscillations of magnetic field with the period of 40-150 s, generated in the nightside magnetosphere. Their generation and propagation processes have been investigated using numerical simulations and observations from ground and space. Pi2 pulsation is often discussed in the framework of the cavity mode or directly driven hypotheses. The high-latitude Pi2 pulsations are driven by Alfven waves toward the ionosphere, carrying transient field-aligned currents at the substorm current wedge. Low-latitude Pi2 is explained by the cavity mode or current wedge oscillation. While the latter transient response model has mainly been proposed by previous results using magnetometer data, there are only a limited number of papers using in-situ observations at the magnetosphere. Therefore, the path from the initial fast mode waves in the plasma sheet through the shear Alfven waves to Pi2 pulsations that penetrate into the ionosphere have not been directly studied yet.

The electric field is a key parameter to identify the propagation direction associated with Pi2 pulsations. Thus, in this paper, we investigate the spatial and temporal variations of electric fields associated with Pi2 pulsations using multi-point observations at ground sites and multi-point spacecraft in the magnetosphere. For the former, we identify the ionospheric response using SuperDARN (high latitude) and HF Doppler (mid latitude) radars. We obtain the magnetospheric electric and magnetic field data from THEMIS (5 probes) and Van Allen Probes (VAPs, 2 probes). Magnetospheric magnetic field data are also obtained from GOES 13 and 15.

As a case study, we find a typical Pi2 structure on 25 December 2014. In this event, all satellites at the magnetosphere were located in the nightside: THEMIS probes were in the outer magnetosphere (L~10), while VAP-A and VAP-B were outside and inside the plasmasphere (L~5 and 4), respectively (identified by electron number density data). Electric and magnetic field variations observed by VAPs show a good correlation with geomagnetic field at Kakioka (~23 h LT). The phase lags between azimuthal component of electric field and parallel component of magnetic field are ~90^{o} at VAP-B (~23 h LT) and ~150^{o} at VAP-A (~2 h LT), respectively, while the phase lags between radial component of electric field and azimuthal component of magnetic field are ~150^{o} at VAP-B and ~90^{o} at VAP-A (~2 h LT), respectively. Therefore, cavity mode resonance is dominant near the midnight meridian inside the plasmasphere, and shear Alfven waves propagate along magnetic field lines and supply energy for high-latitude Pi2 pulsations. In contrast, at post-midnight region outside the plasmasphere, fast mode waves propagate into the inner magnetosphere, and shear Alfven waves reflect at the ionosphere and form the field line resonance. In addition, THEMIS-A (L~9), D (L~10.5), and E (L~11) detect increases of electron flux with the onset of magnetospheric electric field, which indicates that they observe the structure of the substorm current wedge. In summary, our result may support the transient response model, but further studies are still required.

We also estimate the direction and magnitude of Poynting flux for the identification of the electromagnetic energy transport direction and to investigate their relationships to the ionospheric response based on SuperDARN observations. In this paper, with additional event studies, we will suggest the propagation path of Pi2 pulsations from the outer magnetosphere to the ground

via the ionosphere, and compare statistical results with the several models.

Shape characteristics analysis of proton aurora by using the level set method

*Tomohiro Inoue[1], Mitsunori Ozaki[2], Satoshi Yagitani[2], Kazuo Shiokawa[3], Yoshizumi Miyoshi[3], Ryuho Kataoka[4], Yusuke Ebihara[5], Reiko Nomura[6], Kaori Sakaguchi[7], Yuichi Otsuka[3], Martin Connors[8]

1.School of Electrical and Computer Engineering, College of Science and Engineering, Kanazawa University, 2.Institute of Science and Engineering, Kanazawa University, 3.ISEE, Nagoya University, 4.National Institute of Polar Research, 5.RISH, Kyoto University, 6.ISAS / JAXA, 7.National Institute of Information and Communications Technology, 8.Athabasca University

Electromagnetic ion cyclotron (EMIC) waves are generated by ion temperature anisotropy at the magnetic equator. EMIC waves propagate along the magnetic field line from the source region and are observed as Pc1 geomagnetic pulsations on the ground. The EMIC waves cause the pitch angle scattering of high-energy (several keV ~ tens of keV) ions via wave-particle interaction. A part of precipitated ions travel to the ionospheric altitude along the magnetic field lines. Then, proton aurora is observed. The variation of proton aurora would show a time and spatial evolution of wave-particle interaction region in the magnetosphere. We have been observing HB emission of proton aurora by using an all-sky EMCCD camera (486.1nm) with a low time resolution (60seconds), secondary electron aurora using another all-sky EMCCD camera with a high time resolution (110 Hz sampling) and the geomagnetic pulsations by an induction magnetometer (64 Hz sampling) on the ground at Athabasca in Canada (L value=4.3). In this study, in order to reveal a time and spatial evolution of wave-particle interaction region, we have analyzed proton aurora related to Pc1 geomagnetic pulsations. Proton aurora and Pc1 geomagnetic pulsations were simultaneously observed on the ground at 7:40-8:40 UT on 12 November 2015 at Athabasca. The Pc1 geomagnetic pulsations showed a rising tone structure in the frequency domain and a left-hand circular polarization. The intensity variations of proton aurora and the Pc1 geomagnetic pulsations showed one-to-one correspondence with each other in this event. This result suggests that the observed Pc1 geomagnetic pulsations and proton aurora are generated by the EMIC instability in the magnetosphere. Both intensity variations have a clear period of about 1 minute. Moreover, the proton aurora showed a fast modulation of about 10 seconds with the main fluctuations of about 1 minute. Next, to investigate a relationship between the intensity and luminous area of the proton aurora, we use the level set method, which is a kind of optimization methods for modeling dynamic objects. The analysis result shows that the luminous area has a strong correlation with the intensity. This would be caused by the effects of charge exchange interaction for energetic protons (below 200 keV). On the other hand, the strong correlation may be caused by the effects of variations of flux tube in the magnetosphere modulated by the Pc1 pulsations.
In this presentation, we will discuss the analysis results of the proton aurora and the Pc1 geomagnetic pulsations at Athabasca in detail.

Keywords: Proton aurora, Level set method

The estimation of the altitude of auroral emission from grand-based multiple optical observation and EISCAT UHF radar

*Hirona Kondo[1], Takeshi Sakanoi[1], Yasunobu Ogawa[2], Yoshimasa Tanaka[2], Kirsti Kauristie[3], Urban Brändström[4], Björn Gustavsson[5]

1.Planetary Plasma and Atmospheric Research Center,Graduate School of Science,Tohoku University, 2.National Institute of Polar Research, 3.Finnish Meteorological Institute, Finland, 4.Swedish Institute of Space Physics, Sweden, 5. UiT The Arctic University of Norway, Tromsø, Norway

We report the estimation of the altitude of auroral emission from grand-based multiple optical observation and EISCAT radar. Although pulsating aurora would be generated by relatively high energy (greater than 10 keV) electrons, precise characteristics of precipitating electrons producing pulsating aurora have not been understood well. Ground-based optical triangulation is useful to estimate the auroral peak height, which is responsible to the energy of precipitating electrons. In this study, we analyzed the data of N2+ 428nm auroral emission that obtained with ground-based all-sky EMCCD cameras at three stations in Northern Scandinavia (Kilpisjarvi, Abisko and Tromso), for the pulsating auroral event during 26th February, 2014 to estimate the pulsating auroral height with the triangulation method.
We chose an auroral patch which was identified near the center of images taken by all the EMCCD cameras. We used data in the latitudinal range of 69.1-69.4° and longitudinal range of 19.2-20.5°, where an auroral patch was clearly identified. The patch area also overlapped the FOV of EISCAT Tromso UHF radar.
Next, we normalized the auroral intensity for each image data obtained at the two stations (Tromso and Kilpisjarvi) and mapped the image data at a certain altitude. We estimated the variance between two image data at the same latitude and longitude. Changing the mapping altitude at intervals of 2km, we calculated the variances. Finally we determined the auroral emission height when the variance showed minimum. From the data obtained during 02:00 -03:00 UT on Feb. 26, we found the auroral emission height in the range of 102 -110km. When the auroral patch located near the center of the horizontal range, emission height was stable at 104km. On the other hand, when the patch strayed from the center of the range, emission height rose approximately 110km. This estimation of emission height reflected existence or nonexistence of the auroral patch. This result indicates that the auroral patch were produced by precipitating electrons with stable energy.
In addition, we derived the energy distribution of precipitating electrons from the EISCAT UHF radar observation using the CARD method [Fujii et al., 1994]. he results are summarized as follows: (1) With or without the auroral patch, the energy around 10keV maintained. (2) When the patch in the FOV of EISCAT radar, the width of energy peak increased 30keV. (3) We often found significant flux in energy band up to 100keV, and the high-energy flux depended of existence or nonexistence of the auroral patch. In this presentation, we discuss the relationship between the energy distribution of precipitating electrons from EISCAT radar and auroral emission height from optical observations.

Keywords: Pulsating aurora, EISCAT radar, Auroral emission height, Energy distribution of precipitating electrons

Electron density enhancement in the polar region during a geomagnetic storm

*Yuki Ishigaya[1], Atsushi Kumamoto[1], Yuto Katoh[1]

1.Department of Geophysics, Graduate School of Science, Tohoku University

In the polar region from the ionosphere to the magnetosphere of the Earth, the electron density enhancement during geomagnetic storms was reported by several studies [Tu et al. 2007; Kitamura et al. 2010a; 2010b]. Kitamura et al. [2010a; 2010b] reported that the electron density enhancement occurred depending on geomagnetic activity, and suggested that the high density plasma were generated by cleft ion fountain in the cusp and transported widely in the polar cap due to ionospheric convection. They also reported that the electron density enhancement was found not only around the cusp region but also in the nightside auroral region. The following two explanations were suggested: (1) The enhanced convection transported the high density plasma generated by cleft ion fountain into the auroral region. (2) The auroral particle precipitations caused the ion outflow from the ionosphere and generated the high density plasma in the auroral region.
In order to perform detailed investigation on what cause the electron density enhancement in the polar region during geomagnetic storms, we compared electron density distributions in the polar region in geomagnetically disturbed (Kp>4) and quiet (Kp<3) conditions. In the analysis, we used the electron number density data derived from plasma wave data measured in an altitude range from 275 to 10500 km and in a geomagnetic latitude range larger than 75 deg. in periods from November 1989 to February 1990 and from November 1990 to February 1991 by the Plasma Waves and Sounder (PWS) experiment onboard the Akebono satellite. In the event of electron density enhancement observed on February 15, 1990 during geomagnetic storm (Dst:-99n), the electron number density was 811 /cc at an altitude of 7384 km, at geomagnetic latitude of 75.37 deg., and in 10.85 MLT. According to Kitamura et al. [2009], the average electron density in this region is 17 /cc. This event can be explained to be caused by cleft ion fountain since it was found around cusp region. In the event of electron density enhancement observed on January 28, 1990 during geomagnetic storm (Dst:-55nT), the electron number density was 700~1500 /cc in auroral region (geomagnetic latitude: 70-75 deg.). The enhancements of auroral electron and ion fluxes were found by Low-Energy Particle (LEP) detector onboard the Akebono satellite at the same time as the electron density enhancement. Quantitative comparison among the enhanced electron density, the ionospheric convection velocity in the polar cap, and flux of auroral particles will be needed in order to clarify which factor is dominant.

Bifurcation of the nightside auroral oval toward the noon during southward IMF

*Masaki Miyamoto[1], Satoshi Taguchi[1]

1.Department of Geophysics, Kyoto University

We examined the features of the bifurcation of the nightside auroral oval during southward IMF by using remote-sensing measurements made by TIMED/GUVI and in situ observation of the precipitating particles by DMSP spacecraft. Clear bifurcation from the nightside toward the noon sector is seen when IMF is very large and negative. The length of the bifurcated oval is estimated to be approximately 3000 km. We report statistical results on the location of the bifurcation point and the length of the bifurcated oval, including their relationship with IMF conditions.

Keywords: polarcap, aurora oval, particle precipitation, southward IMF

Drifting cusp auroral spot associated with reverse convection

*Yushin Oda[1], Satoshi Taguchi[1], Keisuke Hosokawa[2]

1.Department of Geophysics, Kyoto University, 2.The University of Electro-Communications

We examined features of “drifting cusp auroral spot” by using observations of an auroral form from an all-sky imager at Longyearbyen, Svalbard, and in situ observations of the precipitating particles and plasma flow from DMSP spacecraft that flew over the aurora. Drifting cusp auroral spot means an auroral form that moves to both high and low latitudes during its lifetime. Our result shows that the poleward motion of the drifting cusp auroral spot is associated with sunward plasma flow, i.e., reverse convection. This appears to be inconsistent with a general view of the poleward-moving auroral form. We discuss this seemingly-contradictory motion in terms of lobe reconnection.

Keywords: aurora, cusp, polar cap, plasma convection, reconnection

Frequency and source height of MF/HF auroral radio emissions estimated from the results of EXOS-D/PWS sounder experiments

*Kazuki Mikami[1], Yuto Katoh[1], Atsushi Kumamoto[1], Yuka Sato[2]

1.Graduate School of Science, Tohoku University, 2.National Institute of Polar Research

The Earth’s auroral ionosphere is an abundant source region of radio emissions related to the auroral activity. A variety of auroral radio emissions (e.g., auroral hiss, MF burst and auroral roar) have been reported by previous ground-based radio observation [e.g., Sato et al., 2008]. Auroral roar is narrowband emissions observed in the MF/HF ranges and is believed to be generated through the mode conversion from electrostatic upper hybrid waves to LO-mode electromagnetic waves at an altitude where the condition that the local upper hybrid resonance frequency is equal to the integral multiple of the local electron cyclotron frequency (f_{UHR}=nf_{ce}, where n=2,3,4 and 5) is satisfied. Since the condition should be satisfied not only at the bottomside but also at the topside ionosphere, the mode conversion has been applied to the generation mechanism of Terrestrial Hectometric Radiation (THR) [Oya et al., 1985] radiated from the topside ionosphere to the space. Sato et al. [2010] analyzed radio emissions observed by Plasma Wave and Sounder experiments (PWS) of the AKEBONO (EXOS-D) satellite and reported an example of THR whose spectral characteristics is similar to auroral roar. Although previous studies suggested that THR is considered to be the counterpart of auroral roar, which was identified up to $5f_{ce}$ [LaBelle et al., 2012], THR has been reported only as $2f_{ce}$ emissions except for the RX-mode THR. The plasma environment of the source region of THR should be clarified so as to understand this difference.

In this study, we analyze data obtained from topside sounder experiments by PWS on board the AKEBONO satellite from March 19 to April 18, 2015. We analyze observed ionograms to obtain the height profiles of plasma density. Compared to empirical models such as the International Reference Ionosphere (IRI) model, the sounder experiments can provide more accurate plasma density profiles. The derived density profiles are converted to f_{UHR} profiles in order to estimate the possible frequency and source height of THR. We focus on data obtained in the region of latitude 50-80°N and longitude 50°W-50°E, while the simultaneous ground-based observation has been carried out at Svalbard (latitude 78.15°N, longitude 16.04°E) and Iceland (latitude 64.67°N, longitude 21.03°W). We have obtained 50 density profiles in the selected area and estimated that the expected frequency and the source height of THR corresponding to $2f_{ce}$ are 440-1090km and 1.9-2.5MHz, respectively. We have also found that the matching condition f_{UHR}=$3f_{ce}$ was satisfied in 2 cases out of 50 analyzed profiles, which suggests the possibility of the generation of THR corresponding to $3f_{ce}$. From that 2 cases, we have estimated that the expected frequency and the source height of THR corresponding to $3f_{ce}$ are 330-450km and 3.8-3.9MHz, respectively. In addition, we analyze radio emissions observed by PWS in the selected area during the analyzed period. We have identified 1 event which is considered to be THR corresponding to $2f_{ce}$, and have found that the emission frequency is within the frequency range estimated by the present study.

Keywords: auroral roar, Terrestrial Hectometric Radiation , AKEBONO satellite

Study on the noise reduction technique for VLF emissions by audio signal processing

*Takumi Dejima[1], Mitsunori Ozaki[2], Satoshi Yagitani[2], Kazuo Shiokawa[3], Yoshizumi Miyoshi[3], Masato Miyoshi[2], Akihiro Hirano[2], Martin Connors[4]

1.School of Electrical and Computer Engineering, College of Science and Engineering, Kanazawa University, 2.Institute of Science and Engineering, Kanazawa University, 3.ISEE, Nagoya University, 4.Athabasca University

VLF emissions are common phenomena in the magnetosphere. The VLF emissions greatly contribute to pitch angle scattering for the generation of pulsating aurora (tens of keV ~ 100 keV electrons) and acceleration for MeV electrons in the radiation belts. We have been conducting the ground-based observations of the VLF emissions (100 Hz ~ tens of kHz) at Athabasca (L = 4.3) in Canada. Ground-based observations can continuously observe the VLF emissions having propagated along the geomagnetic field line from the magnetospheric source region at a fixed L with a high time resolution. However, there is a disadvantage that the noise received along the by propagation path is included in the observed waveforms.
In this study, we have studied a noise reduction technique by using audio signal processing techniques. Observation data include stationary noises (white noise and line noise etc.) and pulse noises (atmospheric noise and artificial clock noise etc.). To remove the stationary noises, two audio noise reduction techniques are evaluated for the VLF emissions with added noise components. One is spectral subtraction (SS) and other is modulation frequency analysis (MFA). SS uses an average noise spectrum from the noisy data to remove noise components in the frequency domain. In this study, to estimate the average noise spectrum, spectral entropy method is used for classifying the signals and the noises. On the other hand, MFA does not require an average noise spectrum from the observation data. Time variations of the amplitude spectrum are calculated in MFA. The stationary noises concentrate around the DC component in the time variations of the amplitude spectrum. By removing the DC component, the stationary noise can be removed in MFA. Chirp signals (2 ~ 4 kHz) (simulated chorus waves) with added stationary noises are evaluated by using the two methods. Both methods show that the SNR is improved from 0 dB to 10 dB.
Both noise reduction techniques are used in the actually observed data including the chorus waves. The analyzed data show that the stationary noise is removed. However, the observed signals including hiss waves are also removed. Because the hiss wave is similar to the thermal noise spectrum, the noise reduction techniques cannot effectively remove only the noise components if the hiss exists. To classify the noise and the hiss waves, we make use of the polarization characteristics. Hiss and chorus waves have a right-handed polarization. As a result, both noise reduction techniques can effectively reduce only the noise for chorus and hiss events.
In this presentation, we will discuss our noise reduction techniques for the VLF emissions in detail. We believe that this study can significantly contribute to reduction in the cost and time for a conventional EMC test.

Keywords: VLF emission, Noise reduction, Audio signal processing

Development of the ground data processing/calibration system for the plasma wave measurements onboard ERG satellite

*Hiroki Okuda[1], Shoya Matsuda[1], Mamoru Ota[1], Yoshiya Kasahara[1], Yasumasa Kasaba[2], Fuminori Tsuchiya[2], Hirotsugu Kojima[3], Tomohiko Imachi[1], Yoshitaka Goto[1], Yoshizumi Miyoshi[4]

1.Kanazawa University, 2.Tohoku University, 3.Kyoto Univerisity, 4.Nagoya Univeristy

The SPRINT-B/ERG satellite is a Japanese small satellite mission to investigate dynamics of the inner magnetosphere. To achieve comprehensive observations of plasma/particles, fields, and waves, the Plasma Wave Experiment (PWE) is installed onboard the ERG satellite to measure electric field in the frequency range from DC to 10 MHz, and magnetic field in the frequency range from a few Hz to 100 kHz. A variety of operational modes are implemented in the PWE, and the telemetry data consists of several kinds of data such as power spectrum, waveform, spectral matrix and DC E-field. The PWE will generate two kinds of mission data; nominal data and burst data. The former will be generated 24 hours per day as survey data and all data will be downloaded to the ground. On the other hand, the latter are essentially raw waveform data and the data amount is quite huge. They will be once stored in the mission data recorder (MDR) and partial data will be downloaded after data selection. In order to obtain maximum science output, it is very important to check and analyze the nominal data quickly and select valuable data from burst data stored in the MDR.In the present paper, we introduce our data processing plan on the ground to achieve such requirement. The telemetry data from the ERG satellite will be stored in the Level 0 data archive system at ISAS/JAXA. We first divide the raw data into species of data products and convert them into CDF (Common Data Format) files. Those files are called Level 1 and they are non-calibrated data. Secondly we calibrate the Level 1 data and convert them into Level 2 data. As the Level 1 data are also important for quick data survey for selection of burst data, we designed the CDF files for Level 1 to meet the specification of “autoplot” [1], which is an interactive browser for data on the web. By using the function of autoplot, the Level 1 data will be readily surveyed for data selection. We plan to construct the process as an automatic pipeline. We also plan to apply similar pipeline processing to the data measured by the Plasma Wave Instruments (PWI) onboard the BepiColombo/MMO (Mercury Magnetosphere Orbiter). In the presentation, we introduce the current status of our system.

[1] Autoplot interactive browser, http://autoplot.org/

Keywords: Plasma Wave Experiment, SPRINT-B/ERG, Inner Magnetosphere, Ground data processing

Low frequency characteristics of a wire antenna with noise reduction shield

*Takayuki Kita[1], Tomohiko Imachi[1], Satoshi Yagitani[2], Mitsunori Ozaki[2], Ryoichi Higashi[3]

1.Kanazawa University, 2.Institute of Science and Engineering,Kanazawa University, 3.National Institute of Technology,Ishikawa College

The electric field observation of electromagnetic waves in space is an important purpose of scientific satellite. The electric field observed by a satellite is converted into a voltage by the electric field sensor, and it is transmitted to the earth after the A / D conversion. Therefore, in order to get the exact intensity of the electric field from the transmitted data, an accurate calibration is required. The effective length of the antenna is an important parameter for the calibration. For this reason, the effective length is assumed to be L in electrostatic field observations, and to be L/2 in wave observations in most of the actual analysis. A rheometry experiment is a method to estimate the effective length. The rheometry experiment is a method to measure the output voltage of an antenna generated from the known electric field which is provided by applying a low-frequency signal between two electrode plates arranged parallel to in the water. So that we calculate the effective length using the value of the known electric field and the output voltage. In previous studies using the rheometry experiment, we have found that the frequency characteristics of an effective length depends on the structure of the antenna. And we also found that the effective length becomes L at a low-frequency, and approaches to L/2 when the frequency becomes higher, in the case of a wire antenna which has insulation coating at the side of wire in conductive medium.
In this study, we analyzed the effect of a noise reduction shield in order to elucidate the effect of such an antenna structure further. In the many cases of actual satellite, the spacecraft body and near the base of wire are shielded, to prevent the antenna from being affected on its sensitivity by the artificial noise generated inside of the satellite. Therefore, we performed experiments for shielded wire antennas to analyze the frequency characteristics of the effective length.
According to the results of the experiments, we found that the output voltage becomes small compared to the case of non-shield one, when the frequency becomes higher. As the cause, there are two possible factors. One is the distortion of the potential distribution around the satellite which is caused by the shield. The other is the capacitance between the shield and the core wire. In order to analyze quantitatively, we analyzed potential distribution by computer simulations and calculated the output voltage theoretically by the equivalent circuit. As a result of simulation, we found that the potential distribution in the vicinity of the wire is non-linear, that is different from the linear distribution of the non-shield. And next, we made a theoretical calculation applying the potential distribution, which is the result of the simulation, to the equivalent circuit that includes the effect of the capacitance due to shield. Comparing the calculation result to the experimental results, the transition frequency in which the value of the effective length changes is very much consistent, and the difference of the output voltage value is below a few percent at all frequencies. From these results, it was clear that the capacitance between the shield and the core wire affects the impedance of the antenna, and it is the cause of decay of the output voltage when the frequency is high.
In our presentation, we will report the results of the experimental, the simulation and theoretical calculation in detail.

Keywords: wire antenna, effective length, rheometry experiment, noise reduction shield, satellite, quasi-electrostatic field

Preflight perfomance of stacked silicon strip detectors for MeV electron on board the Geospace exploration satellite ``ERG''

*Takefumi Mitani[1], Satoshi Kasahara[1], Takeshi Takashima[1], Masafumi Hirahara[2], Wataru Miyake[3], Nobuyuki Hasebe[4]

1.Japan Aerospace Exploration Agency, Institute of Space and Astronautical Science, 2.Nagoya University, 3.Tokai University, 4.Waseda University

The Energization and Radiation in Geospace (ERG) project will explore how relativistic electrons in the radiation belts are generated during space storms. ``High energy particle (electron)'' instrument (HEP-e) on board ERG satellite will observe 70 keV -2 MeV electron, which cover energy range of electrons to be accelerated and accelerated electrons, and play an important role to understand electron acceleration. HEP-e provide three dimensional distribution of electron every spacecraft spin period.The sensor of HEP-e is a pin-hole type camera which consist of mechanical collimator, silicon semiconductor detectors and readout ASICs. In this presentation we introduce HEP-e and report the results of performace tests of the flight model.

Keywords: ERG, silicon semiconductor

