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

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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

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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

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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

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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

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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

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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

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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

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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

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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

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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

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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

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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

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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

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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

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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''

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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

