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PEM08-01 Room:302 Time:May 26 14:15-14:35

Energetic Particle Acceleration in the Inner Magnetosphere by ULF waves excited by interplanetary shock

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When an interplanetary shock or a solar wind dynamic pressure impulse impinges on the magnetophere, ultra low-frequency (ULF) waves can be excited in the magnetosphere and the solar wind energy can be transported from interplanetary space into the inner magnetosphere.

In this study, we have systematically studied ULF waves excited at in the magnetosphere by interplanetary shock or solar wind dynamic pressure impulse. We have found that the poloidal and toroidal waves excited by positive and negative pressure pulses oscillate in a similar manner of phase near 06:00 local time (MLT) and 18:00 M LT, but in antiphase near 12:00 M LT and 0:00 MLT. Furthermore, it is shown that excited ULF oscillations are in general stronger around local noon than those in the dawn and dusk flanks. It is demonstrated that the poloidal wave amplitudes are stronger than the toroidal wave amplitudes except in the magnetotail.

We have investigated the response of the Earths ring current ions including oxygen ions to ULF waves induced by interplanetary shocks. Both Earths ring current ions - hydrogen and oxygen ions are found to be accelerated significantly with their temperature enhanced by a factor of two and three immediately after the shock arrival respectively. Multiple energy dispersion signatures of ring current ions were found in the parallel and anti-parallel direction to the magnetic field immediately after the interplanetary shock impact. The energy dispersions in the anti-parallel direction preceded those in the parallel direction. Multiple dispersion signatures can be explained by the flux modulations of local plasmaspheric ions (rather than the ions from the Earths ionosphere) by ULF waves. It is found that both cold plasmaspheric plasma and hot thermal ions (10 eV to 40 keV) are accelerated and decelerated with the various phases of ULF wave electric field. We then demonstrate that ion acceleration due to the interplanetary shock compression on the Earths magnetic field is rather limited, whereas the major contribution to acceleration comes from the electric field carried by ULF waves via drift-bounce resonance for both the hydrogen and oxygen ions. The integrated hydrogen and oxygen ion flux with the poloidal mode ULF waves are highly coherent ($>$0.9) whereas the coherence with the toroidal mode ULF waves is negligible, implying that the poloidal mode ULF waves are much more efficient in accelerating hydrogen and oxygen ions in the inner magnetosphere than the toroidal mode ULF waves.

Keywords: Energetic particle, ULF waves, Inner magnetosphere, Acceleration, Wave-Particle Interaction

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PEM08-02 Room:302 Time:May 26 14:35-14:55

Impact of High-Energy Particle Precipitation on the Upper Atmosphere

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Various forms of high energy particle precipitation into atmosphere present a coupling process between atmospheric layers and near-Earth space, where energy input into atmosphere is often controlled not only by the original source of the particles, but also by interactions occuring in the inner magnetosphere. Here we first review shortly the impact of energetic particles in atmosphere in general, and present the current status of knowledge in chemical variations of atmosphere caused by these particles, including galactic cosmic rays, solar protons and electrons of magnetospheric origin. The effects are both direct and indirect by first generating chemically active minor constituents of the atmosphere, such as odd nitrogen and odd hydrogen, which in turn can affect atmospheric ozone via catalytic reactions either directly in-situ, or after transport in atmosphere to lower altitudes and lower laitudes. Then we discuss recent advance in studying the effects of high-energy electron precipitation (EEP) in atmosphere, the global role of which still is quantitatively largely unknown. Recent published research has shown evidence about energetic electron precipitation causing statistically significant decrease of upper stratospheric and mesospheric ozone during extended periods of time, so that one would need to include EEP as a process in general atmospheric circulation models, if we want to understand our atmosphere as a whole. It is pointed out how importantly we need new measurements characterizing more accurately the energy and flux, as well as spatial and temporal variations of the energetic electron precipitation, both at high and subauroral latitudes. Such new data would be given by the Japanese ERG satellite mission. Combined studies using ground-based measurements and theoretical modeling together with ERG mission measurements, are outlined.

Keywords: high-energy particle, energetic electron precipitation, atmospheric chemistry, magnetosphere, ionospheric modelling, ERG satellite

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PEM08-03 Room:302 Time:May 26 14:55-15:10

A method for direct measurements of wave-particle interactions in the Earth's inner magnetosphere

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Whistler-mode chorus emissions are one of frequently-observed plasma waves in the Earth's inner magnetosphere. Generally, chorus emissions are characterized by a sequence of intense and coherent emissions with frequency shift. Chorus emissions are generated near the magnetic equator by nonlinear wave-particle interactions and are emerged from whistler-mode waves generated through an instability driven by a temperature anisotropy of energetic electrons in the kinetic energy range from a few to tens of keV. Chorus emissions have a potential to accelerate relativistic electrons from the kinetic energy range of several hundred keV to a few MeV. Furthermore, chorus emissions induce the pitch angle scattering of energetic electrons and relativistic electrons. Precipitation of electrons as a result of the pitch angle scattering is one of candidate processes causing diffuse or pulsating auroras observed at the ground. A number of previous studies treat the acceleration (or wave-generation) and the pitch angle scattering of energetic electrons as the diffusion problem of the phase space density and calculate the diffusion coefficients from the wave spectrum. However, the location where the wave-particle interaction occurs efficiently has not been identified yet by the direct observation. Direct measurements of both the energy exchange and the pitch angle scattering of energetic electrons contribute the thorough understanding of wave-particle interactions in the Earth's inner magnetosphere.

Fukuhara et al. (2009) proposed Wave-Particle Interaction Analyzer (WPIA), which is a new instrumentation measuring a relative phase angle between a wave magnetic field vector and a velocity vector of each particle and calculates the energy exchange between waves and particles. The WPIA, which enables us to directly detect wave-particle interactions in space plasmas, will be installed on the ERG satellite of JAXA/ISAS. Katoh et al. (2013) formulated measurable values of the WPIA as the Joule heat W_{int} and discussed the feasibility of measuring W_{int}. In the present study, in addition to the method to detect the energy exchange, we propose a method to directly detect the pitch angle scattering of resonant particles. The method is calculating G that is the pitch angular component of the time variation of the momentum of particles.

We apply the proposed method to results of the one-dimensional electron hybrid simulation reproducing the generation process of chorus emissions around the magnetic equator [Katoh and Omura, 2007]. In the result of the analysis, we obtain significant values of G for electrons in the kinetic energy and pitch angle ranges satisfying the cyclotron resonance condition with the reproduced chorus emissions. We compared the result of the analysis of G with the temporal variation of both the pitch angle distributions and the wave spectra observed at fixed points in the simulation. While the velocity distribution function varies similarly in both hemispheres, the obtained time variation of the momentum is only significant in the pitch angle range corresponding to electrons moving northward (southward) in the southern (northern) hemisphere, indicating the pitch angle scattering of electrons by chorus emissions propagating away from the equator. The results of the present study demonstrate that the proposed method enables us to identify the location where wave-particle interactions occur in the simulation system. Furthermore, we re-examine the formula of the measurement values W_{int} to detect the energy exchange, based on the discussion of the quantity G.

Keywords: whistler-mode chorus emissions, pitch angle scattering, WPIA, ERG mission, electron acceleration, wave-particle interactions

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PEM08-04 Room:302 Time:May 26 15:10-15:25

Characteristics of drift resonance in the outer radiation belt with Pc5 waves based on GEMSIS-RC and RB simulations

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Radial transport of relativistic electrons due to Ultra Low Frequency (ULF) waves in the Pc5 frequency range (1.67mHz - 6.67mHz) is one of important candidates to accelerate and decelerate the outer radiation belt electrons. It is considered as a result of the drift resonance process caused by a resonant interaction between the magnetic drift motion of electrons in the dipole-dominated magnetic field configuration and the electromagnetic fluctuations of Pc5 waves. The Pc5 amplitude decreases rapidly with decreasing radial distance, and the recent studies has pointed out that the efficiency of radial transport caused by the Pc5 waves can be highly depending on the characteristics of the waves [e.g., Ukhorskiy and Sitnov, 2008]. They indicated that collective motion of the outer belt electrons can exhibit large deviations from radial diffusion. Thus, it is important to understand the fundamental behavior of collective motion of the electrons against the Pc5 waves in the inner magnetosphere.

In this study, we combine two simulation models of the inner magnetosphere: GEMSIS-RC (ring current) and RB (radiation belt) models. The GEMSIS-RC model is a self-consistent and kinetic numerical simulation code solving the five-dimensional collisionless drift-kinetic equation for the ring-current ions in the inner-magnetosphere coupled with Maxwell equations [Amano et al., 2011]. The GEMSIS-RB code conducts test particle trajectory tracings of relativistic electrons in arbitrary magnetic and electric field configurations [Saito et al., 2010]. Hence, we can conduct Pc5 wave simulation with GEMSIS-RC, and then the obtained time variations of the magnetic and electric fields are used as an input to GEMSIS-RB code to understand the transport of relativistic electrons due to the Pc5 waves. For simplicity, we investigated effects of monochromatic wave on the drift resonance. Using the simulation results, we evaluated between radial profiles of electron phase space density. The results show that the resonant electrons continuously obtain or lose energy, but the range of energy variation due to the drift resonant scattering of relativistic electrons are wider in the simulation than in the simple theoretical estimations. It is also shown that these electrons have local peaks in the radial distribution in phase space density. This implies the non-linear effect due to the variation of electrons' drift velocity must be considered in the radiation belt.

Keywords: Radiation belt electrons, Drift resonance, Pc5 waves, GEMSIS-RC and RB simulations

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PEM08-05 Room:302 Time:May 26 15:25-15:40

Cold M/Q=2 ion distribution in the inner magnetosphere estimated from lightning-induced EMIC waves observed by Akebono

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Ion cyclotron whistlers are electromagnetic ion cyclotron (EMIC) mode waves induced by lightning discharge. They are generated by mode conversion from lightning whistler waves to EMIC waves. It is well known that their propagation characteristics can be explained by the dispersion relation. Particularly, the dispersion relationship of EMIC, or determination of the bands that can be propagated by EMIC, depends strongly on the ion composition of the plasma. Hence, information on the variation of ion composition can be obtained through ion cyclotron whistler wave observation.

In our previous study, we found that $M/Q = 2$ ion cyclotron whistlers were frequently observed by the Akebono satellite at an altitude region around 3100-10000 km. In the current study, we examine spatial occurrence distributions of observed ion cyclotron whistler wave. We detected 845 H^+, 933 $M/Q = 2$ ion, 1888 He^+ band ion cyclotron whistler waves by visual inspection during the period from March 1989 to September 1995. It is found that each band of ion cyclotron whistler wave was observed in almost exclusive regions. We explain these characteristics by considering the wave generation mechanism along the geomagnetic field line. We estimate ion composition by considering the conditions necessary for ion cyclotron whistler generation, and we determine that a certain amount of $M/Q = 2$ ions exist at the restricted L shell region in the plasmasphere.

We show that the spatial occurrence distribution of observed $M/Q = 2$ ion cyclotron whistlers changes depending on the magnetic local time. It is determined that a certain amount of $M/Q = 2$ ions exist at L inside 2.4 in the local dayside and inside 3.0 in the local nightside. Therefore, there seems to be the density enhancement process in the local nightside region.

Keywords: ion cyclotron whistler, EMIC wave, M/Q = 2 ion, ion composition, Akebono satellite, inner magnetosphere

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PEM08-06 Room:302 Time:May 26 15:40-15:55

Spatial and temporal variation of Sub-Auroral Polarization Streams: Initial results from the SuperDARN HOP radars

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Super Dual Auroral Radar Network (SuperDARN) is a network of HF radars deployed in both hemispheres. The SuperDARN Hokkaido West radar, one of SuperDARN HOkkaido Pair of (HOP) radars, is the newest SuperDARN radar located in Rikubetsu, Hokkaido, Japan, which began its operation in October 2014. Longitudinal coverage of subauroral ionosphere over several hours of magnetic local time by the SuperDARN HOP radars, together with other midlatitude SuperDARN radars, will enable us to study the detailed characteristics of Sub-Auroral Polarization Streams (SAPS), and to find clues to their generation, growth and decay mechanisms. In this paper initial results of the SuperDARN Hokkaido Pair of (HOP) radars observation of SAPS, with focus on the location / timing of SAPS activity relative to geomagnetic activity such as substorms, will be presented.

Keywords: SuperDARN HOP radars, sub-auroral polarization streams, substorm

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PEM08-07 Room:302 Time:May 26 16:15-16:35

Recent results from the NASA Van Allen Probes and the NSF FIREBIRD missions

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The NASA Van Allen Probes began its two-year prime science mission phase following its launch into the inner magnetosphere in August 2012. Designed to study and understand radiation belt structure and dynamics ideally to the point of predictability, the dual-spacecraft Van Allen Probes mission comprises a comprehensive suite of charged particle and fields measurements needed to achieve closure on critical science questions. The Radiation Belt Storm Probes ? Energetic Particle, Composition, and Thermal Plasma (RBSP-ECT) suite consists of three primary instrument types that collectively provide clean, robust measurements of the electrons and key ions in the inner magnetosphere, with high energy spectral and pitch angle resolution, spanning energy ranges covering the cold/warm plasmasphere populations, the hot ring current populations, the medium-energy electron seed population, as well as the core relativistic and ultra-relativistic radiation belt populations. The Van Allen Probes orbit near the magnetic equator, optimized for probing the source regions of particle acceleration and the location through which virtually all particles must pass. However, because the atmospheric loss cone is so small at the magnetic equator, even such an ambitious mission cannot completely explore that loss process without additional measurements away from the magnetic equator. In a complimentary fashion, the NSF Focused Investigation of Relativistic Electron Burst Intensity Range and Dynamics (FIREBIRD) mission orbits at low altitudes, measuring radiation belt electrons precipitating into the atmosphere. The twin FIREBIRD spacecraft were launched in late January 2015 when they began probing the spatial-temporal variability of electron precipitation from the radiation belt. In this paper, we provide a summary of the science accomplishments from the combined RBSP-ECT instrument suite and FIREBIRD missions, specifically focusing on radiation belt loss processes.

Keywords: Radiation Belt, Inner Magnetosphere, Particle Precipitation

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PEM08-08 Room:302 Time:May 26 16:35-16:50

Data assimilation of ionospheric magnetic field perturbations into a global magnetospheric model.

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Ionosphere is tightly coupled with the magnetosphere and is the only region of geospace where in situ observations approaching global scale are possible. This capability is owing to the emergence of new datasets of key ionospheric measurements with global spatial and high-frequency temporal coverage, such as AMPERE (Active Magnetosphere and Planetary Electrodynamics Response Experiment) magnetic field data measured onboard Iridium satellites. We are reporting first results for assimilation of low-altitude ionospheric measurements of magnetic field perturbations into a Lyon-Fedder-Mobarry (LFM) global magnetospheric model coupled with Rice-Convection Model (RCM).

We adopt optimal interpolation approach and rely on quasi-steady, linear approximation between equatorial magnetospheric pressure and field-aligned currents in the ionosphere. This approximation is estimated numerically by perturbing the LFM-RCM model and by considering only large-scale modes from Fourier decomposition of the ionospheric magnetic field and equatorial magnetospheric pressure.

The developed methodology was validated by using so called ”fraternal-twins” model-based assimilation tests. The numerical LFM-RCM model with one set of parameters is used to generate synthetic observations, while model with differing set of parameters is used for assimilation and to calculate magnetospheric pressure corrections to be applied in order to reproduce synthetic observations.

Keywords: data assimilation, ionosphere, MHD, magnetosphere

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PEM08-09 Room:302 Time:May 26 16:50-17:05

Impulsive enhancements of oxygen ions in the inner magnetosphere: Van Allen Probes RBSPICE observations

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We investigate enhancements of O^+ ions in the inner magnetosphere (L<6) during magnetic storms. Previous in-situ and remote-sensing observations by several investigators have confirmed that the O^+ pressure increases on a substorm time scale (<10 min) rather than on a storm time scale (>hours). Such temporally impulsive enhancements can be caused by adiabatic, impulsive transport and/or non-adiabatic acceleration. The relative significance of these two processes, however, remains an open question and might even vary from event to event. We perform a case study of the 6 June 2013 storm, during the main phase of which the RBSPICE instrument onboard the Van Allen Probes spacecraft observed short time-scale (<10 min) enhancements of energetic (>50 keV) proton and oxygen ion fluxes.

The ion injection event occurred at ~2000 UT in the course of the main phase which started at about 16 UT. The Van Allen Probes A and B were located at $(X, Y, Z)_{SM}$ = (-5.4, 1.5, 0.6)RE and $(X, Y, Z)_{SM}$ = (-5.3, 2.1, 0.7) RE, respectively. The flux enhancements display only small energy dispersion, indicating that the westward edge of the injection region was close to the spacecraft but at a later MLT. The duration of the flux enhancements differ between the two spacecraft; the flux at ~100 keV continued for ~5 min and ~10 min at spacecraft A and B, respectively. The difference in the end time of the flux enhancements enables us to estimate the ion drift speed to be ~0.4 RE/min, suggesting that the eastward edge of the injection region was <1 RE eastward of spacecraft A. We thus estimate the spatial scale of the injection region to be <1 RE in the MLT direction. We also compare energy spectra (phase space density vs. mu, the first adiabatic invariant) to identify whether ion acceleration is adiabatic or not. The energy spectral slope for both ion species did not change during the injection event. The oxygen spectra were also shifted toward higher PSD by a factor of ~3.

The results suggest that both ion species were accelerated adiabatically and that oxygen ions increased in density. We conclude that, for this storm event, energetic (ring current) oxygen ions in the inner magnetosphere were enhanced by adiabatic, fast transport of oxygen-rich plasma sheet plasma and/or adiabatic heating of preexisting cold/warm oxygen ions due to temporally impulsive, spatially localized electric field fluctuations.

Keywords: ring current, oxygen ions, injections in the inner magnetosphere, magnetic storm and substorms, Van Allen probes RBSPICE

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PEM08-10 Room:302 Time:May 26 17:05-17:20

One-year statistical analysis of ELF/VLF emissions at subauroral latitudes at Athabasca, Canada

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Whistler mode waves in the ELF and VLF frequency range are naturally observed in the Earth's magnetosphere. They are generated around the equatorial plane and then propagate into the ionosphere along the field lines and can sometimes be detected on the ground. Whistler mode waves play an important role for both generation and loss of energetic electrons in the inner magnetosphere. Especially, chorus waves outside the plasmapause cause non-adiabatic accelerations of MeV electrons of the outer belt, while plasmaspheric hiss contributes to the formation of the slot region through the pitch angle scattering. Additionally, quasi-periodic (QP) emissions have also been associated with electron precipitation.

Using a 100 kHz-sampling loop antenna, we have continuously monitored ELF/VLF emissions at subauroral latitudes in Athabasca, Canada (MLAT=61.31, L=4.3) since September 2012. Using the data from 1 November 2012 to 31 October 2013, we have made the first statistical analysis of ELF/VLF emissions at subauroral latitudes, taking into account their spectral features, occurrence rates, and correlations with solar wind and magnetic variations.

We found that the occurrence is maximum in the morning sector (~07 MLT) and minimum in the night sector (after 18 MLT) with no particular dependence on seasons or AE and Dst indices. Chorus and hiss show a maximum occurrence rate at 07-08 MLT, while the highest occurrence of QP emissions is found around noon MLT. Even though these results show similarities with satellite measurements in the inner magnetosphere, the occurrence rates obtained in this study show that the rates at ATH can be up to 7 times lower than those in the magnetosphere. This suggests that not all waves that are generated in the magnetosphere can be detected on the ground. Additionally, a superposed epoch analysis shows that AE index and solar wind speed slowly increases up to several days before we start seeing the emissions in ATH. These results suggest that substorm activities associated with solar wind high-speed streams can contribute to the generation of ELF/VLF waves that are detected at subauroral latitudes.

Keywords: ELF/VLF, statistics, subauroral latitudes, chorus, hiss, qp

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PEM08-11 Room:302 Time:May 26 17:20-17:35

Mechanics of magnetic storms and particles in the inner magnetosphere

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Magnetic storms are known to occur when the southward component of the interplanetary magnetic field (IMF) lasts for a few hours and more. The most common manifestation of magnetic storms is the development of the ring current. The convection electric field plays an essential role in transporting the seed ions from the near-earth plasma sheet to the ring current. Relativistic electrons, however, show a different behavior. In some cases, the differential flux of relativistic electrons decreases during the storm main phase, and recovers during the storm recovery phase. Sometimes, the flux exceeds the pre-storm level. The rebuild of the radiation belt is thought to result from two different ways; one is non-adiabatic acceleration of electrons from the keV range to the MeV range. The other one is adiabatic transport of relativistic electrons from the near-earth plasma into the radiation belt. For both cases, transport of particles is a key in understanding the particle environment in the inner magnetosphere. By performing the global magnetohydrodynamics (MHD) simulation and the bounce-averaged particle transport simulation, we have focused on the following 3 unsolved processes regarding particles trapped in the inner magnetosphere in terms of mechanics of the magnetosphere. 1) First, we need to understand the origin of the convection electric field that is responsible for the transport of keV particles. The MHD simulation result shows that no steady convection electric field appears even though IMF is steady. The contribution from the ionosphere is significant in the inner magnetosphere, and that associated with the MHD process is significant in the near-Earth plasma sheet. 2) Secondly, we need to evaluate the influence of substorms on the transport of particles. If the dipolarization is governed by the MHD processes, it will progress in accordance with overall force balance in the magnetosphere, so that the storm-time substorm will be different from an isolated substorm. 3) Thirdly, we need to grasp the particle distribution function in the near-earth plasma sheet because most of them are the direct/indirect source of the ring current and the radiation belt. According to the MHD simulation, the plasma sheet temperature becomes hot when the IMF is steadily southward. The temperature exceeds 20 keV after elapsed time of several hours from the beginning of the southward turning of IMF. The particle transport simulation predicts that the extremely hot plasma sheet gives rise to the enhancement of relativistic electrons in the radiation belt.

Keywords: Magnetic storm, MHD simulation, Inner magnetosphere, Substorm, Convection electric field

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PEM08-12 Room:302 Time:May 27 09:00-09:15

The ERG project: current progress and the mission strategy

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The ERG (Exploration of energization and Radiation in Geospace) is Japanese geospace exploration project. The project focuses on relativistic electron acceleration mechanism of the outer belt in the context of the cross-energy coupling via wave-particle interactions. The ERG satellite will be launched in FY2016. In this presentation, we report the current progress of the ERG project including the development of the flight model of the satellite. Moreover, we present the strategy for the observations. Since the geospace phenomena strongly depend on the local time and L-shell, we have a plan for the campaign observations that focus on the specific phenomena. Possible coordinated observations with other geospace satellites and ground-based observations are also discussed.

Keywords: ERG project, international collaborations

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PEM08-13 Room:302 Time:May 27 09:15-09:30

Nonlinear wave growth theory of coherent hiss emissions in the plasmasphere

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Recent observations of plasmaspheric hiss emissions by the Van Allen Probes show that broadband hiss emissions in the plasmasphere comprise short-time coherent elements with rising and falling tone frequencies [1]. Based on nonlinear wave growth theory of whistler-mode chorus emissions [2], we examined the applicability of nonlinear theory to the coherent hiss emissions. We have generalized the derivation of optimum wave amplitudes for triggering rising tone chorus emissions for both falling and rising tone hiss elements. The amplitude profiles of the hiss emissions are well approximated by the optimum wave amplitudes for triggering rising or falling tones. Through formation of electron holes for rising tones and electron hills for falling tones, the coherent waves grow up to the optimum amplitudes. We find an excellent agreement between the optimum amplitudes and the observed amplitudes as a function of instantaneous frequency. We calculate nonlinear growth rates at the equator, and find that nonlinear growth rates for rising-tone emissions are much larger than the linear growth rates. The frequency sweep rates and time scales of observed hiss emissions also agree those predicted by the nonlinear theory. Based on the theory, we can infer properties of energetic electrons generating hiss emissions in the equatorial region of the plasmasphere.

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Keywords: plasmasphere, wave-particle interaction, hiss, chorus, nonlinear wave growth, radiation belt

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PEM08-14 Room:302 Time:May 27 09:30-09:45

Relativistic radiation belt electron precipitation induced by EMIC triggered emissions in the plasmasphere

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Electromagnetic ion cyclotron (EMIC) triggered emissions have been observed by *Pickett et al.* [2010]. EMIC triggered emissions are characterized by large wave amplitudes, rising-tone frequencies, and coherent left-hand circularly polarized waves. EMIC triggered emissions are generated by energetic protons with a temperature anisotropy. A nonlinear wave growth theory proposed by *Omura et al.* [2010] can explain the generation and growth mechanisms of EMIC triggered emissions. *Shoji and Omura* [2011] have reproduced EMIC triggered emissions by hybrid simulations in agreement with the nonlinear wave growth theory. The wave potential generated by coherent EMIC triggered emissions can trap some of electrons and guide them down to lower pitch angles efficiently [*Omura and Zhao,* 2012]. Repeated interactions occur due to the mirror motion, and result in the scattering of particles into the loss cone. Test particle simulations of electrons interacting with EMIC triggered emissions with a variable frequency and constant amplitude have been performed and the results show efficient electron precipitation induced by the wave trapping in a parabolic magnetic field [*Omura and Zhao,* 2013]. From recent observations by THEMIS, it is found that some EMIC triggered emissions have sub-packet structures [*Nakamura et al.,* 2014]. We perform test particle simulations of relativistic electrons interacting with EMIC triggered emissions which form sub-packets in a dipole magnetic field. We include the convective growth of the waves in setting up the EMIC wave model for test particle simulations [*Omura et al.,* 2010; *Shoji and Omura,* 2013]. By utilizing a three dimensional dipole magnetic field, we can trace electrons drifting in the longitudinal direction. We study trajectories of longitudinally distributed relativistic radiation belt electrons drifting eastward interacting with local EMIC triggered emissions. We obtain the relativistic electron distribution in equatorial pitch angle and in pitch angle at the atmosphere.

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Keywords: relativistic electron, radiation belt, EMIC, EMIC triggered emission, precipitation, pitch angle

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PEM08-15 Room:302 Time:May 27 09:45-10:00

Statistical analysis of plasmaspheric EMIC waves

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We investigate statistically the plasmaspheric EMIC wave using the Akebono/VLF measurements. The plasmaspheric EMIC waves are mainly observed at lower L-shell region ($L<2$). There are no significant MLT dependences and geomagnetic activities, which are different from the EMIC waves outside the plasmapause. We also investigate statistically the magnetosonic mode waves (MSW), and MSW are typically observed at $L>2.5$. There are some events to show that EMIC waves and MSW are simultaneous observed, suggesting that MSW convert to EMIC waves inside the plasmasphere. Considering the results from the statistical survey, we propose two different mechanisms on the origin of the plasmaspheric EMIC waves. One possibility is the cyclotron resonance with energetic ions. The estimated resonance energy of ions is a few hundred keV that are radiation belt ions. Another possibility is the mode conversion from MSW. MSW propagate radially into the inner magnetosphere after the generation at the outer portion of the plasmasphere, and then MSW convert to EMIC waves.

Keywords: EMIC wave, statistical analysis, occurrence mechanism, magnetosonic wave, spatial distribution

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PEM08-16 Room:302 Time:May 27 10:00-10:15

A study of the Pc1 pearl structure using conjugate ground-satellite observations

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We have investigated the generation mechanism of the pearl structure of Pc1 geomagnetic pulsations using conjugate observations of an event with the ground induction magnetometers located at Athabasca (ATH, L = 4.3) in Canada and Magadan (MGD, L = 2.7) in Russia and the Van Allen Probes (RBSP) A and B satellites located in the inner magnetosphere. The event was observed at ATH and MGD from 1500 to 1700 UT on October 6, 2012. During this event, the footprints of RBSP-A and -B were located near ATH and MGD, respectively. However, EMIC waves having frequencies close to that of the ground Pc1 waves were detected only at RBSP-B, from 1632 to 1640 UT as it crossed the L=4 magnetic shell in the morning sector. On the ground, the Pc1 waves exhibited a classical pearl structure with a repetition period of about 15 s. At both stations, the polarization angle exhibited a large standard deviation, and a cross correlation analysis using the upper envelops of the wave amplitude reveals that the correlation coefficient between the two stations is higher than 0.7 10 % of the time. The EMIC waves at RBSP-B also exhibited a periodic variation in amplitude, but its period (about 5 s) differed significantly from that observed on the ground. The direction of the Poynting vector parallel to the magnetic field alternated between northward and southward. This result indicates that bouncing wave packet can generate a Pc1 pearl structure in the magnetosphere. We suggest that Pc1 pearl structures can be generated in the magnetosphere in the early stage but the beating of waves propagating in the ionospheric duct is responsible for the peal structure observed on the ground.

Keywords: Pc1 pearl structures, Pc1 pulsations, EMIC waves, Multi-Point observations at the ground and space

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PEM08-17 Room:302 Time:May 27 10:15-10:30

Isolated proton auroras and Pc1/EMIC waves at subauroral latitudes

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Isolated proton aurora (IPA) in the subauroral ionosphere is created by energetic proton precipitation through wave-particle interactions with electromagnetic ion cyclotron (EMIC) waves in the conjugate inner magnetosphere. In this study, spatial distribution and occurrence probability of IPAs were statistically investigated as a proxy for regions of EMIC wave occurrence using ground-based imaging data in 2006-2012 at Athabasca, Canada. The seven-year average of the IPA occurrence probability over the total observation interval was estimated to be 0.83% and a factor of five change was found between maximum and minimum years. Local time (between 16 and 06 MLT) distribution shows double peaks at pre-midnight and at dusk. The occurrence probability increases with Kp and the MLT location tends to shift duskward. The statistical distribution of IPA size shows a clear peak at a spatial size of 10,000 km^2, and latitudinal and longitudinal lengths have peaks at 56 and 340 km, respectively, at the ionospheric altitude. The equatorial projections of IPA source locations and two-dimensional structures are estimated by magnetic field tracing. These spatial structures are essential to quantitatively estimate the loss rate of energetic particles, contributing to space weather studies.

Keywords: proton aurora, EMIC wave, Pc1 pulsation, subauroral latitude, ring current proton, wave-particle interaction

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PEM08-18 Room:302 Time:May 27 10:30-10:45

Fine structure of plasmaspheric hiss

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Plasmaspheric hiss has been widely regarded as a broadband, structureless, incoherent emission. By examining burst-mode vector waveform data from the EMFISIS instrument on the Van Allen Probes mission,we show that plasmaspheric hiss is a coherent emission with complex fine structure. Specifically, plasmaspheric hiss appears as discrete rising tone and falling tone elements.

Our study comprises the analysis of two 1 hour samples,within which a total of eight 1 second samples were analyzed. By means of waveform analysis on two samples,we identify typical amplitudes ,phase profiles, and sweep rates of the rising and falling tone elements. The new observations reported here can be expected to fuel a reexamination of the properties of plasmaspheric hiss,including a further reanalysis of the generation mechanism for hiss.

Keywords: plasmaspheric hiss, Van Allen Probes, EMFISIS

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PEM08-P01 Room:Convention Hall Time:May 26 18:15-19:30

Van Allen Probes observations of dipolarization and ion acceleration in the inner magnetosphere

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Recent study employing the MDS-1 satellite reveals that magnetic field dipolarization in the deep inner magnetosphere is not uncommon. When the MDS-1 satellite was located at L=3.0-6.5 near the auroral onset longitude (MLT difference of $\leq$2.5 h), the occurrence probability of local dipolarization was 25%. Surprisingly, an event was found at L$\sim$3.6, far inside the geosynchronous altitude. When dipolarization was found at L=3.5-5.0, magnetic storms were developing. This implies that it is difficult to find dipolarization signatures in the deep inner magnetosphere during a nonstorm period.

We study magnetic field dipolarization and associated ion acceleration in the deep inner magnetosphere, using magnetic field and ion flux data obtained by the Van Allen Probes. First, from the magnetic field data recorded on the nightside (1800-0600 MLT) we selected candidate events in which the magnetic field in the component antiparallel to the dipole axis (i.e., H component in VDH coordinates) increases by more than 20 nT in 5 minutes. Second, the candidate events were scanned visually to confirm if they are accompanied by magnetic fluctuations. Finally, the geomagnetic AL, ASY, and Wp indices were examined to ensure that substorm activity was registered around the candidates events. These procedures yield 96 dipolarization events from 1 October 2012 to 31 October 2013. We find that dipolarization mostly occurs at L=4.5-6.5 before midnight (2100-0000 MLT). Some events are accompanied by O^+ flux enhancements in the energy range of 1-10 keV, which is consistent with the AMPTE/CCE CHEM observation reported by Nosé et al. [2014]. We will discuss possible mechanisms of the selective acceleration of O^+ ions in the inner magnetosphere during dipolarization.

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PEM08-P02 Room:Convention Hall Time:May 26 18:15-19:30

The energy dependent enhancements of radiation belt electrons during weak magnetic storms: Van Allen Probes observations

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By analyzing in situ observation results by Van Allen Probes, we study the spatial and temporal evolution of the phase space density (PSD) of radiation belt electrons, the plasma environment, and plasma wave activities in the Earth ′ s inner magnetosphere during weak geomagnetic storms.

Radiation belts are the region where relativistic particles are trapped by Earth ′ s magnetic field. In general, the flux of outer radiation belt electrons decreases during the main phase of geomagnetic storms, while the flux variations during the recovery phase are observed differently in each storm [Reeves et al., 2003]. The variation of the flux of radiation belt electrons also occurs during weak storms (Dst˜-50nT), and we expect that the variation of radiation belt electrons can be clearly identified by analyzing the formation process during weak storms.

In the present study, we analyze Van Allen Probes observation data measured during 24 April 2013 storm. The minimum Dst index is -50 nT in this event. We use the flux of relativistic electrons measured by the Relativistic Electron-Proton Telescope (REPT) [Baker et al., 2012] and Magnetic Electron Ion Spectrometer (MagEIS)[Blake et al., 2012]. We also analyze plasma wave and background magnetic field data measured by Electric and Magnetic Field Instrument Suite and Integrated Science (EMFISIS) [Kletzing et al., 2012]. The second invariant K and the third invariant $L*$used in the present study are provided by the ECT Science Operations Center.

First, we analyze the radial distribution of PSD for particles of different first adiabatic invariants during the storm event. We also analyze wave magnetic field intensity of plasma waves in the frequency range from 0.1 fce to 0.5 fce, where fce is the cyclotron frequency of electrons, corresponding to the typical frequency range of lower-band whistler-mode chorus emissions. By comparing the analyzed data, we find that the activities of chorus emissions enhance concurrent with the timing of the PSD increase of relativistic electrons, suggesting a close relationship between them. We also identify two-step enhancements of relativistic electrons during this event. We find at the first step that the PSD of electrons in 1 MeV or less ($\mu \leqq 600$) enhances during the early recovery phase and at the second step that the PSD of electrons of several MeV increases simultaneously during the late recovery phase. To examine the PSD variation quantitatively, we analyze the ratio of the PSD from $L* = 4.2$ to $L* = 5.0$. We then find at the first step during the early recovery phase that the PSD of electrons of 1 MeV or less ($\mu \leqq 600$) increases more than that of the prestorm level. On the other hand, the PSD of electrons in several MeV did not increase to the pre-storm level during the early recovery phase but increases more than 10 times of magnitude larger than the pre-storm level during the late recovery phase. To understand the identified energy dependence in detail, we analyze details of the plasma environment in the inner magnetosphere, the correspondence between the PSD enhancements and the plasma wave activities, and the spectral characteristics of whistler-mode chorus during the event.

Keywords: radiation belt, magnetic storm, Van Allen Probes, whistler mode chorus

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PEM08-P03 Room:Convention Hall Time:May 26 18:15-19:30

Occurrence characteristics of relativistic electron microbursts in association with storms and substorms

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Relativistic electron microbursts (REMBs) are short-lived (<1sec), bursty precipitations of relativistic (>1 MeV) electrons observed in the outer radiation belt. REMBs are first reported by the SAMPEX measurements [Nakamura et al., 1995; Blake et al., 1996] and preferentially observed on the dawn side magnetosphere during geomagnetic storms [Nakamura et al., 2000; Lorentzen et al., 2001]. Pitch angle scattering of relativistic electrons by discrete whistler mode wave emissions (chorus) has been considered as the primary candidate for REMBs [e.g., Lorentzen et al., 2001]. Chorus emissions can resonate with not only MeV electrons but also electrons with energies from several to tens keV, leading to diffuse and pulsating auroras [Thorne et al., 2010; Nishimura et al., 2010, Miyoshi et al., 2010]. Since diffuse and pulsating auroras are commonly observed during the recovery phase of substorms, it is expected that occurrence of REMBs depends on the substorm activity. To test the hypothesis, we have investigated occurrence characteristics of REMBs in association with the substorm activity using the data obtained from the SAMPEX spacecraft. Since REMBs are frequently observed during geomagnetic storms, we have also investigated differences of the occurrence characteristics between storm time and non-storm time substorms. We have derived occurrence rates of REMBs in L-value versus magnetic local time domain. AE*, which is the maximum value of the AE index in previous 3 hours, is used to represent the substorm activity levels. We have defined storm time and non-storm time by using the minimum value of the SYM-H index in previous 2 days. We found that REMBs are most frequently observed during strong substorm activities. The occurrence rates of REMBs do not depend on the levels of substorm activities, although chorus wave intensity increases as the AE*level increases [e.g., Li et al., 2009]. Comparison of the occurrence rates during storm time and non-storm time substorms for same AE*levels indicates that REMBs are preferentially observed during storm time substorms. Thus, it is concluded that REMBs most frequently occur during strong substorm activities associated with storms. We will discuss suitable magnetospheric conditions leading to the REMB occurrence considering the configuration of the inner magnetosphere during storm time substorms.

Keywords: relativistic electron microbursts, chorus, SAMPEX, storm, substorm, diffuse aurora

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PEM08-P04 Room:Convention Hall Time:May 26 18:15-19:30

Accumulated energetic protons and degradation of Akebono solar cells from a new model of trapped protons

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Output current of silicon solar cells of Akebono satellite orbiting in the inner magnetosphere decreased from 13 A in 1989 to about 7 A in 2009, due to accumulated damage by energetic protons. We worked on modelling of the L-shell distribution of trapped energetic protons which provides best-fit for the degradation of solar cells before 1996, where the correlation is clearly seen. We found that the modeling gives narrower distribution than given by the AP8 and, even, latest AP9 models, but is more consistent with the CRRES quiet model based on the observation before November 1991. Based on our model derived from observations before 1996, we assume a steady state of the proton radiation belt and calculate the integrated proton flux along the satellite orbit up to 2009. In this report, we present the relationship between the integrated proton flux and the degradation of solar cells for long years.

Keywords: proton radiation belt, Akebono satellite

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PEM08-P05 Room:Convention Hall Time:May 26 18:15-19:30

Impact of interplanetary shock on ions in the inner magnetosphere

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Impact of interplanetary shock on ions in the inner magnetosphere
Tsuji, H., Y. Ebihara, Y. Omura, T. Tanaka

Interplanetary (IP) shock is known to redistribute the charged particles trapped in the inner magnetosphere. As for ions with kinetic energy of the order of keV, observations have shown that the enhancement of the ion flux depends on the pitch angle and energy, and that the flux does not always peak at the equatorial pitch angle of 90 degrees after passage of the IP shock. We have performed test particle simulation under the electric and magnetic fields provided by the magnetohydrodynamics (MHD) simulation. The solar wind speed is increased from 372 to 500 km/s in order to reproduce the IP shock. The number density in the solar wind was set to a constant to be 5 cm-3, and the Z component of the interplanetary magnetic field (IMF) was turned from +5 to -5 nT. Just after the arrival of the IP shock, the fast mode wave propagates tailward in the magnetosphere. The amplitude of the electric field exceeds 20 mV/m. We started tracing oxygen ions at (7, 0, 0) Re in the GSM coordinates just before the arrival of the fast mode wave, and reconstructed a phase space density of ions. A summary of the simulation results is as follows. 1) In general, ions with initial pitch angles near 90 degrees are efficiently accelerated, but the degree of the acceleration depends on initial gyrophase, pitch angle, and energy, so that neither the bounce-averaged approximation nor the guiding-center approximation is valid. 2) Ions with small pitch angles are efficiently accelerated when the parallel velocity of the ion is closed to the parallel component of the propagation velocity of the fast mode wave. 3) The phase space density initially given by an isotropic Maxwellian distribution is redistributed to the one that is dominated by the perpendicular component. For initial distribution with temperature of 5 keV, the temperature anisotropy (Tperp/Tpara-1) is increased to 0.33 at an elapsed time of 1 minute from the arrival of the fast mode wave, which may favor the excitation of electromagnetic waves. We will discuss the overall impact of the IP shock on the major ion species in the inner magnetosphere such as protons and oxygen ions, as well as contribution of the electric field that is propagated by way of the field-aligned current and the polar ionosphere.

Keywords: Inner magnetosphere, interplanetary shock, keV ions