Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

PEM09-01 Room:304 Time:May 20 15:30-15:50

The Magnetic and Shielding Effects of Ring Current on Radiation Belt Dynamics

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The ring current plays many key roles in controlling magnetospheric dynamics. A well-known example is the magnetic depression produced by the ring current, which alters the drift paths of radiation belt electrons and may cause significant electron flux dropout. Little attention is paid to the ring current shielding effect on radiation belt dynamics. A recent simulation study that combines the Comprehensive Ring Current Model (CRCM) with the Radiation Belt Environment (RBE) model has revealed that the ring current-associated shielding field directly and/or indirectly weakens the relativistic electron flux increase during magnetic storms. In this talk, we will discuss how ring current magnetic field and electric shielding moderate the radiation belt enhancement.

Keywords: Radiation Belts, Ring Current, magnetic Storm, Relativistic electrons

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PEM09-02 Room:304 Time:May 20 15:50-16:10

Simultaneous Global Observations of Ring Current Dynamics

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Studying the structure and evolution of magnetospheric plasmas is fundamental to understanding our near Earth space environment. The Two Wide-angle Imaging Neutral-atom Spectrometers (TWINS) mission provides a unique opportunity to image global ring current plasmas by measuring energetic neutral atoms (ENAs) created when ions trapped on geomagnetic field lines undergo charge exchange with cold neutral hydrogen. The ion distribution can be deconvolved from the ENA images using a modern inversion technique. In this talk, we use data from a variety of orbiting spacecraft to investigate ring current ion dynamics during the main and early recovery phases of several recent ICME-driven geomagnetic storms. Global proton distributions deconvolved from simultaneous TWINS ENA observations are used to provide context to GOES and THEMIS in-situ energetic particle and magnetometer observations of the ring current. Several aspects of inner magnetospheric dynamics are quantified from a global perspective, including equatorial ion pitch angle anisotropy, density and temperature throughout a typical ICME-driven storm.

Keywords: ring current dynamics, proton pitch angle anisotropy, inner magnetosphere, energetic neutral atoms

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PEM09-03 Room:304 Time:May 20 16:10-16:30

Pc1/EMIC waves observed at subauroral latitude during sudden magnetospheric compressions

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It is generally accepted that sudden compressions of the magnetosphere cause electromagnetic ion cyclotron (EMIC) wave growth by increasing the proton temperature anisotropy. These compression-associated EMIC waves are expected to be on higher latitudes (i.e., higher-L regions close to the magnetopause). In this study we examine Pc1 pulsations, which are believed to be generated by the EMIC instability, observed at subauroral latitude near the nominal plasmapause when the magnetosphere is suddenly compressed by solar wind dynamic pressure variations, using induction magnetometer data obtained from Athabasca, Canada (geomagnetic latitude = 61.7deg N, L ~ 4.5). We identified 9 compression-associated Pc1 waves with frequencies of ~0.5-2.0 Hz. The wave activity appears in the horizontal H (positive north) and D (positive eastward) components. All of events show low coherence between H and D components. This indicates that the Pc1 pulsations in H and D oscillate with a different frequency. Thus, we cannot determine the polarization state of the waves. We will discuss the occurrence location of compression-associated Pc1 pulsations, their spectral structure, and wave properties.

Keywords: EMIC, Pc1, Magnetospheric compression, Temperature anisotropy, Plasmapause, Subauroral latitude

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PEM09-04 Room:304 Time:May 20 16:30-16:45

Effects of the ring current and plasmasphere on ULF waves in the inner magnetosphere based on the GEMSIS-RC model

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Electron acceleration mechanisms to cause drastic variation of the Earth's outer radiation belt is one of key issues of the geospace researches. While the radial diffusion of the electrons driven by ULF waves has been considered as one of the candidate mechanisms, efficiency of the mechanism under realistic ULF characteristics and distribution is far from understood. GEMSIS (Geospace Environment Modeling System for Integrated Studies) of STEL, Nagoya University, is the observation-based modeling project for understanding energy and mass transportation from the Sun to the Earth in the geospace environment. Aiming at understanding the dynamics of the inner magnetosphere during the geospace storms, the GEMSIS-Magnetosphere working team has developed a new physics-based model for the global dynamics of the ring current (GEMSIS-RC model). 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.

We applied the GEMSIS-RC model for simulation of global distribution of ULF waves to test its capability of describing fast time scale phenomena like SCs and ULF waves. Two cases of background profile, i.e., cases without/with plasmapause in the simulation domain, are compared. The result shows that existence of plasmapause strengthens ULFs outside the plasmapause and widens the MLT region where the E_r (toroidal) component is excited from initially-given E_{phi} (poloidal) component. Comparison between runs with/without ring current ions show that the existence of hot ring current ions can deform and amplify the original sinusoidal waveforms. The deformation causes the energy cascade to higher frequency range (Pc4 and Pc3 ranges). The cascade is more pronounced in the high beta case. Combination with GEMSIS-RB model reproduced rapid radial transport by the drift resonance for ions with drift period of 600 seconds as theoretically expected.

Keywords: inner magnetosphere, ring current, radiation belt, ULF wave, Pc5, drift resonance

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PEM09-05 Room:304 Time:May 20 16:45-17:00

Behaviors of Plasma and High Energy Electron Distributions During Magnetic Storms

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By analyses of plasma density distribution detected from upper hybrid wave data of PWS instruments onboard the Akebono satellite, dynamical behavior of plasma motions and distributions associated with magnetic storms are verified. That is, during main phase, the plasma distributions show signatures of outward flows that are called exodus while plasma distributions show the inward flows that are called immigration. The origin of these behaviors of plasma is attributed to occurrence of ring feature electric fields raised by induction effects due to time varying geomagnetic fields. During the main phase of the magnetic storm, the plasmas make outward ExB drift due to existing eastward sense ring feature electric field while plasmas make inward ExB drift due to westward sense ring feature electric fields.

The present study is further developed to investigate the effects of the ring feature electric field by analyzing summary plots of GOSAT satellite data of high energy electrons, and proposes the drifts motions of high energy electrons that are not responsible to ring current formation by raised ring feature electric fields during storm times. In main phase of the storm, the electrons with energy higher than 400keV show the effects of outward drift while these are clearly concentrated inside region during recovery phase of the magnetic storm. These behaviors show characteristics features depending on the time varying rates of the magnetic fields. For the case of gradual variation with a rate of 80nT/20hour the limiting energy of non-contributing electrons is about 600keV while the limiting energy becomes low to be about 300keV for the case of severe time variation of the magnetic field intensity as a case of 170nT/3hour.

Keywords: Plasmaspheric Plasam, Induction Electric Field, High Energy Electrons, Ring Feature Electric Field, Main Phase of Magnetic Storm, Recovery Phase of Magnetic Storm

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PEM09-06 Room:304 Time:May 21 09:00-09:20

Rapid radiation belt losses occurring during high speed solar wind stream driven storms: loss mechanisms

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Despite being discovered at the dawn of the space age, there are still fundamental questions concerning the acceleration and loss of highly energetic electrons; Energetic electron fluxes can increase or decrease by several orders of magnitude on time scales of less than a day.The coupling of the Van Allen radiation belts to the Earth's atmosphere through precipitating particles is an area of intense scientific interest, principally due to two differing research activities: 1) radiation belt physics and 2) the response of the atmosphere to precipitating particles.

Recently, more evidence has been found for the highly dynamic nature of the outer radiation belt electron fluxes. Studies undertaken by Steve Morley and coauthors combined observations from as many as 9 particle detectors flying onboard GPS spacecraft to show a rapid losses of energetic (>230 keV) electrons from the outer radiation belt ($4<L*<6$). These electron flux "dropout" were associated with a geomagnetic storm triggered by the arrival of a high speed solar wind stream interface which separates the leading slow solar wind and trailing fast solar wind. A superposed epoch analysis was undertaken of this data around the arrival of 67 solar wind stream interfaces (SWSIs), showing a strong repeatable "signal" of a rapid electron flux dropout. While the SWSI triggered geomagnetic storms, these are comparatively small (Dst =-40 nT, Kp=4) showing that even small geomagnetic disturbances can lead to major radiation belt changes. Candidate causes for the dropouts which have been put forward are losses through the magnetopause (by either magnetopause shadowing or outward diffusion) and energetic electron precipitation (EEP) into the atmosphere due to wave-particle interactions.

In this talk we will test the potential dropout causes by examining observations from multiple low-Earth orbit spacecraft, as well as ground-based instruments which are part of the AARDDVARK network.

Keywords: radiation belt, geomagnetic storms, solar wind interactions, energetic electron precipitation

PEM09-07 Room:304 Time:May 21 09:20-09:40

Recent observations of dropouts of the electron radiation belt and their implications

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Predicting losses or enhancements of relativistic electron fluxes during storm time has proven difficult, with only ~50% of Dst storms showing a net increase in fluxes and about 20% showing a net decrease. Under high-speed stream driving the predictability of net flux increases is enhanced by the Russell-McPherron effect but substantial variability is still observed. High-speed solar wind streams, which have their origins in the out?ow from coronal holes, form a large-scale repeatable driver for Earth's magnetosphere and the parts of geospace coupled to it. Up to 13 on-orbit dosimeters in the GPS constellation can be used to monitor the global state and evolution of the electron radiation belt at unprecedented temporal and spatial resolution. Recent observations using the GPS constellation have shown that dropouts extending to $L*$~4 are a consistent response to high-speed streams, irrespective of whether the stream drives a geomagnetic storm. Case studies have shown that these dropouts can occur on time scales of less than 3 hrs and recovery to pre-event count levels can take in excess of two weeks. Combining these observations with the modeling framework provided by the Dynamic Radiation Environment Assimilation Model (DREAM) gives additional capabilities to understand the variability of the radiation belt and the dominant processes. In particular, we focus on results of a statistical study of a set of prolonged electron dropouts observed with GPS, combined with insight from detailed case studies and modeling. What we have learned, and how we can extend this work, will be discussed.

Keywords: radiation belt, magnetosphere, space weather

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PEM09-08 Room:304 Time:May 21 09:40-10:00

Key Issues in Substorm Onset and Expansion

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Some key issues for understanding substorms are (1) substorm onset mechanism that includes the structure of growth phase magnetosphere, the structure and breakup of auroral onset arcs; and the structure of Pi2 waves and associated instabilities; (2) substorm expansion that includes depolarization and cross-tail current disruption and associated energetic particle injections in the ring current region. Observationally there has been much progress in the last few years on the pressure profile and magnetic field structure in the cross-tail current region, the structure of bright spots along the breakup arc, and the structure of Pi2 waves in the cross-tail current region and under the onset arcs, magnetic field dipolarization, and energetic particle injection. In this talk we present key features of substorm onset observation and their theoretical explanation. We will also discuss the possible mechanism of current disruption, magnetic field dipolarization and energetic particle injection during the substorm expansion phase.

Keywords: substorm, ring current, energetic particle injection, dipolarization, current disruption

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PEM09-09 Room:304 Time:May 21 10:00-10:15

Oxgen ion flux variation associated with a substorm on May 6, 1988

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The flux of O+ ions is known to increase in the inner mangetosphere during geomagnetically active periods, but the mechanism for the flux change is not well unerstood. To gain insight into the mechanism we examine the variation of the O+ flux observed with the Charge-Energy-Mass Spectrometer (CHEM) on the AMPTE/CCE spacecraft in association with a substorm on May 6, 1988. The substorm onset occurred at ~0607 UT during the main phase of a geomagnetic storm that reached the Dst minimum of -160 nT. CCE detected a clear dipolarization (delta-B ~ 140 nT over delta-T ~ 60 s) at L ~ 4.0, magnetic latitude ~ 6 degrees, and magnetic local time ~ 20 hr. After the dipolarization, the power spectral density of broadband magnetic field variation in the Pc1 band was ~1.5 orders of magnitude higher than the pre-onset level. In addition, there was a brief period of narrowband pulsation at a frequency about one half of the local proton cyclotron frequency. Across the dipolarization the O+ flux increased by 0.5-1.0 orders of magnitude at energies below 100 keV. No flux enhancement was observed for O+ at energies above 100 keV and there was no obvious flux change for H+ over the entire energy band, 1-300 keV, covered by the CHEM instrument. We add observations by the nearby satellites GOES-6, GOES-7, and DE-1 to discuss possible mechanism(s) for the O+ enhancement.

Keywords: substorm, oxygen ions, inner magnetosphere

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PEM09-10 Room:304 Time:May 21 10:15-10:30

Direct impact of substorm on outer radiation belt

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We use a four-dimensional drift kinetic simulation coupled with a global magnetohydrodynamics (MHD) simulation to investigate the direct impact of a substorm on relativistic electrons in the heart of the radiation belt. During the substorm growth phase, energetic electrons moved earthward from the plasma sheet because the dawn-dusk convection electric field overcame the dusk-dawn induction electric field. During the expansion phase, energetic electrons traversed the quasi-trapping region and encountered the stable trapping region due to persistent and variable electric field, which is dominated by the westward component on the nightside. Finally, relativistic electrons initially located at L~4 were replaced by newly injected ones within 1 hour. We will discuss the generation mechanism of the persistent and variable electric field that appear during the expansion phase and formation of the outer radiation belt.

Keywords: Radiation belt, Substorm, energetic electrons, inner magnetosphere

PEM09-11 Room:304 Time:May 21 10:45-11:00

Formation process of relativistic electron flux through interaction with whistler-mode chorus emissions

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We perform test particle simulations of energetic electrons interacting with whistler-mode chorus emissions. We first obtain a spatial and temporal profile of a chorus wave packet based on the nonlinear wave growth theory for parallel propagation. We assume the lower band chorus emissions by terminating the rising tone at half the electron cyclotron frequency because of the nonlinear damping due to the quasi-oblique propagation. We then calculate trajectories of a large number of electrons with the same initial energy and pitch angle launched at different locations of the magnetic field line and different timings with respect to a pair of chorus emissions generated at the magnetic equator. By casting the pitch angles after the interaction to the equator, and by taking into account the phase space volume including the bounce motion along the magnetic field line, we compute the equatorial distribution function of the electrons started from the delta function. The distribution function can be regarded as a numerical Green's function for one cycle of chorus wave-particle interaction. We obtain the Green's function for the energy range 10 keV - 6 MeV and all pitch angles greater than the loss cone angle. By taking the convolution integral of the Green's functions and the distribution of the injected electrons, we can obtain the time evolution of the distribution function due to interaction with one cycle of chorus emissions. Repeating the convolution integral of the Green's functions and the evolving distribution function, we can follow a long time evolution of the electron distribution function in the radiation belts. We find that the effective acceleration processes of the relativistic turning acceleration and the ultra-relativistic acceleration through interaction with chorus emissions contribute to a rapid formation of the relativistic MeV electron flux within an hour after the injection of tens of keV electrons.

Keywords: whistler-mode chorus, simulation, magnetosphere, nonlinear, relativistic electrons, radiation belts

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PEM09-12 Room:304 Time:May 21 11:00-11:15

Simulation on the IMF Bz control of the whistler mode wave excitation associated with the high-speed

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The outer belt electron flux tends to increase largely during the high-speed coronal hole streams. The flux enhancements depend on not only the solar wind speed but also the IMF Bz; the southward-dominant streams (SBz-HSS) cause the large flux enhancement rather than the northward-dominant streams (NBz-HSS) [Miyoshi and Kataoka, 2008]. Considering the acceleration process via whistler-wave particle interactions, key parameters including hot electrons, plasmasphere, and whistler mode waves should have similar differences between SBz/NBz-HSS, and we have confirmed these differences by the statistical analysis. In this study, we will simulate the relativistic-RAM electron model [Jordanova and Miyoshi, 2005] to confirm these parameter dependences on the key parameters. Firstly, we prepared the superposed LANL/MPA data about SBz/NBz-HSS as a boundary condition at L=6.6 to model the differences of the plasma sheet between SBz/NBz-HSS. In the SBz-HSS, we observe enhancements of hot electrons of ~30 keV and lower-band whistler mode waves around L=4 at dawn-side. On the other hand, in the NBz-HSS, the enhancements of ~30 keV electrons and whistler mode waves are observed at $L>5$. These differences primarily come from the magnetospheric convection. The betatron acceleration of the convective transport is the main driver to generate the whistler mode waves. We found that the plasma sheet temperature in the SBz-HSS is higher than that in the NBz-HSS, but the differences of the plasma sheet temperature do not cause clear differences of the whistler mode wave excitation between SBz/NBz-HSS.

Keywords: Inner Magnetosphere, simulation, solar wind - inner magnetosphere

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PEM09-13 Room:304 Time:May 21 11:15-11:30

Relativistic electron microbursts driven by whistler chorus: GEMSIS-RBW simulations

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Electron microbursts, which are bursty enhancements of precipitated electron flux during several tens ms, are likely to make an important contribution to high-energy electron flux loss in the outer radiation belt. The SAMPEX satellite frequently observed that the relativistic electron microbursts (>1MeV) were accompanied with the lower band whistler chorus (Lorentzen et al. (2001)). The observations suggest that whistler chorus not only accelerate radiation belt electrons, but also decrease the electron flux. As discussed in Horne et al. (2003), relativistic electrons with small pitch angle close to a loss cone resonate with the lower band whistler chorus at relatively high magnetic latitudes (> 30 deg.). Considering that the whistler chorus propagates at the high magnetic latitudes, we investigate wave-particle interaction process between the whistler chorus and the relativistic electrons bouncing along the magnetic field lines using the GEMSIS-RBW code. This code is a three-dimensional relativistic test particle simulation code demonstrating electron scattering by whistler chorus in a realistic time and spatial scales. We show that a rising tone of whistler chorus scatters electrons at the high magnetic latitudes and produces a bursty enhancement of relativistic electron precipitation flux. The duration of the burst corresponds to that of the rising tone, which are several tens ms. Our simulation results suggest that whistler chorus propagating at high magnetic latitudes precipitates the relativistic electrons showing the relativistic electron microbursts.

Keywords: wave-particle interaction, relativistic electron microburst, test-particle simulation

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PEM09-14 Room:304 Time:May 21 11:30-11:45

Recurrent and propagating SAPS/ SAID structures observed by the SuperDARN Hokkaido radar

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We study two events of the recurrent propagating SAPS/SAID structures at magnetic latitudes of ~60^o, which were observed by the Hokkaido radar at 0830 - 0930 UT (1730 - 1830 MLT) on April 23, 2008 and at 1100-1500 UT on March 1, 2011. Both events occurred during the main phases of moderate geomagnetic storms with minimum Dst about -37 nT and -75 nT respectively. The IMF was southward and turned to northward just prior to the first event, whereas it was constantly southward for the second event. For both events the period, velocity of westward progression and wavelength are 30 min, 700 m/s and 1200 km respectively. They have similar characteristics to those of the 'auroral giant undulation' at the equatorward edge of the auroral oval although some numbers, for example the periods, are slightly different. The radar data presented strongly support an idea that the recurrent SAPS / SAID structures are generated through internal processes in the inner magnetosphere, due to probably some kind of plasma instability, rather than due to externally-driven processes.

Keywords: Hokkaido HF radar, SuperDARN, SAPS / SAID, plasma instability in the inner magnetosphere

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PEM09-15 Room:304 Time:May 21 11:45-12:00

Precipitation of Highly Energetic Protons by Helium Branch Electromagnetic Ion Cyclotron Triggered Emissions

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In the Earth's inner magnetosphere, the electromagnetic ion cyclotron (EMIC) triggered emissions scatter energetic protons around the equatorial region. We perform a one-dimensional hybrid simulations with cylindrical parabolic magnetic geometries to investigate the precipitation of energetic protons controlled by the EMIC triggered emissions in the He^+ branch. We generate the EMIC triggered emissions in the He^+ branch of the dispersion relations around the equatorial region of the simulation space. The nonlinear wave growth theory shows a good agreement with the simulation result. Due to the difference of the resonance velocity between the H^+ and He^+ branch triggered emissions, the He^+ branch triggered emissions scatter highly energized protons around the equatorial region, resulting in the precipitations of the particles into the polar regions. Estimation of the kinetic energy of the resonant particles predicts that the energy reaches around 3 MeV outside the plasmapause although the H^+ branch triggered emissions can interact with the particles with 1MeV.

Keywords: EMIC triggered emission, hybrid simulation, proton precipitation, nonlinear wave particle interaction, inner magnetosphere