Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

PEM007-01 Room:202 Time:May 27 08:50-09:10

Transport and Energization of O+ Ions in the Near-Earth Magnetosphere

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We discuss the energization and transport of energetic O+ ions in the night-side magnetosphere with an emphasis on geomagnetically active periods. The oxygen ENA flux from the storm-time ring current increases simultaneously with substorm activity, which suggests that this ENA flux enhancement is caused by the energization of local O+ ions rather than by the transport/injection of O+ ions from farther down the tail. Thus the transport of the O+ ions is a crucial issue for better understanding storm dynamics. In the present study we address this issue by statistically comparing the characteristics of energetic protons and O+ ions in the nightside magnetosphere. Energetic ion flux measurements made by the Geotail/EPIC instrument are used. The results are summarized as follows: (1) Whereas the average proton energy does not change significantly during a solar cycle, the average O+ energy is lower during solar maximum and higher during solar minimum; (2) The O+-to-proton ratios of the number density and energy density are several times higher during solar maximum than during solar minimum; (3) The average proton and O+ energies and the O+-to-proton ratios of number and energy densities all increase with geomagnetic activity. The solar phase dependence of the average proton energy is found only for geomagnetically active times and it is higher during solar minimum. The differences of other quantities among different solar phases not only stay but also increase with geomagnetic activity. (4) Whereas the average proton energy increases toward Earth, the average O+ energy decreases toward Earth. The average energy increases toward dusk for both the protons and O+ ions; (5) The O+-to-proton ratios of number density and energy density increase toward Earth during all solar phases but most clearly during solar maximum. These results suggest that the effects of geomagnetic activity and solar illumination on the ionospheric ion outflow are synergetic rather than additive and that a significant portion of O+ ions is transported directly from the ionosphere to the near-Earth region rather than through the distant tail.

Keywords: Oxygen ions, Ring current, Plasma sheet, Magnetospheric Storm, Ion outflow, Solar Cycle

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PEM007-02 Room:202 Time:May 27 09:10-09:25

Non-adiabatic ion acceleration in the Earth's inner magnetosphere on a substorm time scale

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In order to investigate non-adiabatic ion acceleration in the Earth's inner magnetosphere on a short time scale (<30min) and its contribution to ring current development, we examine the temporal variations of energy spectra of energetic neutral atoms (ENAs) during substorms that occur in the storm main phase. ENAs are detected by the High Energy Neutral Atom (HENA) imager onboard the Imager for Magnetopause-to-Aurora Global Exploration (IMAGE) satellite. The ENA energy used in the present study ranges from 10 keV to 198 keV for hydrogen and from 29 keV to 222 keV for oxygen. We use ENA data obtained from two independent areas of a HENA image, for which HENA line-of-sights pass through the inner magnetosphere (˜-6 RE<X<˜-3 RE around the magnetic equator) and the outer magnetosphere (X<˜-6 RE around the magnetic equator).

Case studies for three substorms on 21 October 2001 and two substorms on 19 March 2002 [Keika et al., 2010, JGR] showed that (1) the oxygen ENA flux displays 20 to 30-min bursts during all substorms, while the hydrogen ENA flux did not increase or less significantly increased than the oxygen flux; (2) the temporal evolution of energy spectra is mass dependent for all examined substorms; (3) for two of the substorms, the oxygen flux ratio between before and after a substorm increases with increasing energy, indicating the hardening of an O+ energy spectrum; and (4) the flux ratio for the inner image area is comparable to or higher than that in the outer area. The results confirm that nonadiabatic acceleration with regard to the first adiabatic invariant did occur in the near-Earth magnetotail (X>-8 RE) and that the acceleration is mass-dependent.

This paper presents statistical results of the energy spectral evolution during storm-time substorms that occur in 2001 - 2003. We study how frequently, in which storm phase, and under what solar wind and magnetospheric conditions the non-adiabatic acceleration occurs. We then discuss for what energies/species the violation of the first adiabatic invariant occurs and what field variations/fluctuations cause such non-adiabatic acceleration.

Keywords: Magnetic storms, substorms, ion acceleration, inner magnetosphere

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PEM007-03 Room:202 Time:May 27 09:25-09:40

Search for “oxygen torus” in the deep inner magnetosphere - Possible source of O^+-rich ring current

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Previous studies, employing the RIMS instrument onboard the DE-1 satellite, report that a large amount of thermal O^+ ions exist in the outer plasmasphere (L=2.0-5.0) [Horwitz et al., 1984, 1986; Roberts et al., 1987; Comfort et al., 1988; Fraser et al., 2005], in a region called “the oxygen torus”. These thermal O^+ ions can be observed frequently, even during low Kp periods (Kp=0-2+), in the late evening hours. Since the termination of the DE-1/RIMS operation about 25 years ago, there have been no instruments that make direct measurements of the oxygen torus, because of difficulty in measuring thermal ion flux with mass and charge state information.

In this study, we intend to detect the oxygen torus with an indirect method using the magnetic field data and the plasma wave data obtained by the CRRES satellite. We estimate the magnetospheric local mass density (rho) from the frequency of the toroidal standing Alfven waves. The local electron number density (n_e) is derived from the plasma wave spectra. Combining these two quantities makes it possible to infer the local average ion mass ($M=rho/n_e$). We find that M is approximately 3 in the outer magnetosphere (or the plasma trough), while it sometimes shows an enhancement to 5-15 around the plasmapause. This implies the existence of the oxygen torus near the plasmapause. The above method, adopting the toroidal wave frequency, can be considered a powerful tool to detect the oxygen torus and to examine the ion mass in the inner magnetosphere.

A recent study by Nose et al. [2010] presumed that the preexisting thermal O^+ ions in the oxygen torus are locally and nonadiabatically accelerated by fluctuations associated with dipolarization in the deep inner magnetosphere, resulting in formation of the O^+-rich ring current. We will also discuss analysis results of CRRES data in the context of the oxygen torus as an important source of the O^+-rich ring current.

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PEM007-04 Room:202 Time:May 27 09:40-09:55

Estimation of temporal evolution of the plasmasphere using IMAGE/EUV data

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In order to model the dynamics of the plasmasphere, it is important to know the spatial structure of the electric potential. However, it is generally difficult to directly measure the electric potential distribution. Thus, it is a challenge to grasp the temporal evolution and the dynamics of the plasmasphere. Aiming at providing a comprehensive picture of the dynamics of the plasmasphere, we are developing a data assimilation technique which incorporates remote imaging data of extreme ultra-violet (EUV) from the IMAGE satellite into a simulation model of the plasmasphere. In this technique, an initial state of the plasmasphere is guessed via an inversion of the EUV data. The temporal evolution of the plasmasphere is then estimated by incorporating a sequence of EUV data into a numerical simulation model initiated with the guess of the initial state. This technique treats the magnetospheric electric potential distribution as unknown. The electric potential distribution thus can also be estimated in the course of the assimilation process.

Keywords: plasmasphere, data assimilation, inner magnetosphere, particle filter

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PEM007-05 Room:202 Time:May 27 09:55-10:10

Global Scale Ring Feature Electric Fields Raised in Plasmasphere

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1.Introduction

For long periods in study fields of the plasmasphere , a regime to understand the plasmasphere as quiet features of the plasma distribution has been accepted. That is, the plasma is filled by transportation from the ionosphere and lost by magnetospheric convection which control the formation of the plasmapause being associated with corotation of the plasmasphere.

The observation results of plasmaspheric plasma distribution by the Akebono satellite, however, are revolutionarily changing the previously formed concept of the plasmasphere dynamics that is based on the convection ?refilling processes of the plasma. We here propose a extremely dynamical feature of plasma dynamics in the plasmasphere including behavior of the high energy particles in the inner magnetosphere by presenting new concept called the betatron drift that is caused by global scale ring feature electric fields raised in the periods of magnetic storms.

2.Evidences of Dynamical Motion of Plasmaspheric Plasma

After the launching of the Akebono satellite in February 1989, in the semi-polar orbit with initial apogee of 10500km, the PWS experiments on board the satellite havecurrently provided plasma density which are deducted from the detected upper hybridfrequency surrounding the spacecraft(Oya et al, 1991). One of remarkable results forlong term observations of plasma distribution in the plasmasphere are storm time behaviors of the plasma distribution which suggest the exodus and immigration of the plasma between plasmasphere and outer magnetosphere. That is, in the main phase of the magnetic storm, the plasmaspheric plasma moves towards the outer magnetosphere and the plasmapause is disappeared while the hot plasma in the outer magnetosphere moves deep inside plasmasphere.

The behavior of the movement of the plasma is explained as results of betatron drift which are caused by the global scale ring feature electric fields generated by the induction effects of the time varying ring currents. In the time of growing ring currents during the main phase of the magnetic storm, the plasma start to move towards outside by ExB effect with the ring feature electric fields having unti-clock wise sense, observed from the north pole, while the plasma drifts inwards by the ring feature electric fields which show clock wise sense. The existence of these global scale ring feature electric fields indicate the temporal violation of the MHD condition in the plasmasphere. For the underlying physics of this violation of the MHD condition we consider the microscopic processes caused by the local plasma waves that impede the free movement of electrons.

3. Effects of Betatron Drifts on High Energy Particles in the Inner Magnetosphere

Interaction modes of high energy particles to plasmaspheric plasma are understood to be two holds depending on the energy range. An apparent effects are made by group of ring current particles. The time varying feature results in the time varying ring current; therefore distribution of these group of particles contros the movement of plasma in the plasmasphere. The particles with higher energy but fewer flux than the ring current forming group of the energetic particles show the same tendency of drifts with warm plasma in the plasmasphere. Thus, we can give the interpretation for the storm time behavior of high energy group particles ,with energy larger than 500keV, in the inner magnetosphere as results of the betatron drifts that are caused by global scale ring feature electric fields.

.Reference

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Keywords: Ring Feature Electric Fields, Plasmasphere, Plasma Drifts, Highenergy Particles, Magnetic Storm, Plasma Waves

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PEM007-06 Room:202 Time:May 27 10:10-10:25

Simulation of Electromagnetic Ion Cyclotron Triggered Emissions in the Earth's Inner Magnetosphere

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In a recent observation by the Cluster spacecraft, electromagnetic ion cyclotron (EMIC) triggered emissions were discovered in the inner magnetosphere. We perform hybrid simulations to reproduce the EMIC triggered emissions. We develop a self-consistent one-dimensional (1D) hybrid code with a cylindrical geometry of the background magnetic field. We assume a parabolic magnetic field to model the dipole magnetic field in the equatorial region of the inner magnetosphere. Triggering EMIC waves are driven by a left-handed polarized external current assumed at the magnetic equator in the simulation model. Cold proton, helium, and oxygen ions, which form branches of the dispersion relation of the EMIC waves, are uniformly distributed in the simulation space. Energetic protons with a loss cone distribution function are also assumed as resonant particles. We reproduce rising tone emissions in the simulation space, finding a good agreement with the nonlinear wave growth theory. In the energetic proton velocity distribution we find formation of a proton hole, which is assumed in the nonlinear wave growth theory. A substantial amount of the energetic protons are scattered into the loss cone, while some of the resonant protons are accelerated to higher pitch angles, forming a pancake velocity distribution.

Keywords: EMIC wave, Triggered emission, Hybrid simulation, Inner magnetosphere, nonlinear wave growth

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PEM007-07 Room:202 Time:May 27 10:45-11:05

The Roles of Transport and Wave-Particle Interactions on Radiation Belt Dynamics

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Particle fluxes in the radiation belts can vary dramatically during geomagnetic active periods. Transport and wave-particle interactions are believed to be the two main types of mechanisms that control the radiation belt dynamics. Major transport processes include substorm dipolarization and injection, radial diffusion, convection, adiabatic acceleration and deceleration, and magnetopause shadowing. Energetic electrons and ions are also subjected to pitch-angle and energy diffusion when interact with plasma waves in the radiation belts. Important wave modes include whistler mode chorus waves, plasmaspheric hiss, electromagnetic ion cyclotron waves, and magnetosonic waves. We investigate the relative roles of transport and wave associated processes in radiation belt variations. Energetic electron fluxes during several storms are simulated using our Radiation Belt Environment (RBE) model. The model includes important transport and wave processes such as substorm dipolarization in global MHD fields, chorus waves, and plasmaspheric hiss. We discuss the effects of these competing processes at different phases of the storms and validate the results by comparison with satellite and ground-based observations.

Keywords: Radiation Belts, Space Weather, Wave-Particle Interaction, Storm and Substorm

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PEM007-08 Room:202 Time:May 27 11:05-11:25

Numerical Estimates of Outer Radiation Belt Electron Flux Dropouts during Geomagnetic Storms

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Satellite observations often show that relativistic electron fluxes that decrease during a geomagnetic storm main phase do not recover their pre-storm level even when the storm has substantially recovered. A possible explanation for such sustained flux dropout is that the electrons that move to larger shells (L shells) aided by the Disturbance Storm Time (Dst) effect associated with the main phase geomagnetic field depression may be suffering drift-lost to the magnetopause, resulting in irreversible (non-adiabatic) flux decreases during a geomagnetic storm. In addition, a possible radial diffusion can be induced after there is a drift loss at outer L-shells during the storm main phase, which then can redistribute the remaining particle fluxes during the storm recovery. In this study, we numerically evaluate the drift loss effect by combining it with the Dst effect and including off-equatorially mirroring electrons for three different storm conditions obtained by averaging 95 geomagnetic storms that occurred from 1997 to 2002. Using the Tsyganenko T02 model and our own simplified method, we estimate the storm time flux changes based on the guiding center orbit dynamics. Then by solving diffusion equations numerically, we investigate details of this diffusion process driven by the steep radial gradient across the trapping boundary after there is a fast drift loss during the storm main phase and its effectiveness in changing the particle flux level during the storm recovery. We also examine the radial diffusion process by comparing it to the results based on the combined adiabatic Dst and drift loss.

Keywords: Outer radiation belt, Relativistic electrons

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PEM007-09 Room:202 Time:May 27 11:25-11:40

ENERGETIC ELECTRON DYNAMICS IN THE INNER MAGNETOSPHERE INFERRED FROM JAXA SATELLITE OBSERVATIONS

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In order to investigate space environment and its temporal variation, JAXA has been installing radiation particle detectors on LEO satellites (GOSAT, ALOS, Jason-2), GEO satellites (ETS-V, DRTS), GTO satellites (ETS-VI, MSD-1) and Quasi zenith orbiting satellite (QZS-1). With these radiation particle data, some distinguished sciences of energetic electrons have been obtained. Intensity of highly energetic (MeV) electrons in the outer radiation belt increases drastically during the magnetic storms in a very wide region from L˜3 to L˜8. Increase of MeV electrons in the outer radiation belt (L˜3 to L˜8) seems to be controlled by solar wind velocity as well as magnetic activities. Seasonal variation of the increase in the intensity of MeV electrons was found with peaks of spring and autumn. This is understood as Russell-McPherron effect. With these relations, we have constructed an advanced (dynamic) outer radiation belt model, and compared it with observations. Strong injection or transportation of intermediate energy (40-100keV) electrons from the plasmasheet into the heart of outer radiation zone (L˜4) was identified during the major and big storms. These intermediate energy electrons should be seeds of highly energetic (MeV) electrons in the outer radiation belt. Thus means that seed electrons should be accelarated internally in the outer radiation zone via wave particle interaction. It was found that MeV electrons penetrated into the inner radiation belt across the slot region during the big magnetic storm. We also found that low energy (40keV) electrons have been transported to very near Earth region; i.e. a few thousand km above sea level. We will make comparison with simulation results to interpret observations.

Keywords: Inner Magnetosphere, High Energy Electrons, JAXA Satellite Observation

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PEM007-10 Room:202 Time:May 27 11:40-11:55

Simulation study on the evolution and propagation of whistler waves during storm time

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In the inner magnetosphere, plasma waves play an essential role for cross-energy coupling processes of different plasma/particle populations via wave-particle interactions. In order to understand the temporal-spatial variation of whistler mode waves in the inner magnetosphere, we simulate the evolution of the electron distribution function and the linear growth rate due to the anisotropies with the RAM electron code [Jordanova and Miyoshi, 2005]. Since the linear growth rate depends on the ratio of the plasma frequency to the gyro-frequency, the intense whistler mode emissions are observed near the plasmapause. In fact, the simulation results for a magnetically active period indicate that whistler mode waves are generated from post-midnight to the dawn-side outside the plasmapause. On the other hand, we do not observe significant wave excitation inside the plasmapause, because hot electrons from the plasma sheet do not access inside the plasmapause. The three-dimensional ray-tracing study indicates that the whistler waves excited outside the plasmapause can propagate into the plasmasphere through multiple reflections at LHR resonance point. Therefore, one of the origin of plasmaspheric hiss is whistler mode waves generated outside the plasmasphere, as suggested by Bortnik et al.[2008].

Keywords: inner magnetosphere, whistler mode waves, simulation, cross-energy coupling

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PEM007-11 Room:202 Time:May 27 11:55-12:10

Self-consistent particle simulation of whistler mode triggered emissions

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Self-consistent electromagnetic particle simulations were performed to analyze whistler mode triggered emissions in the magnetosphere. Triggering whistler mode waves injected at the magnetic equator induces a nonlinear absolute instability that results in rising tone emissions similar to natural whistler mode chorus emissions. The triggering wave causes a depletion of resonant electrons at the resonance velocity. The phase-organized resonant electrons released by the triggering waves generate coherent waves that undergo nonlinear growth with increasing frequencies. The essential mechanism is the same as that for the generation of chorus emissions. Saturation of the nonlinear wave growth is caused by enhancement of resonant electrons at high pitch angles that have been trapped and guided along the resonance velocity by the triggered emissions. Because of the decreasing resonance velocity resulting from the increasing frequency, trapped electrons are accelerated to higher pitch angles. Saturation of the nonlinear wave growth thereby results in electron acceleration.

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PEM007-12 Room:202 Time:May 27 12:10-12:25

Statistical analysis of energetic electron precipitation and VLF emissions at Syowa station during sudden commencements

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Sudden commencements (SC) are caused by a rapid increase of the dynamic pressure of the solar wind. To understand loss processes of energetic electrons during SC, we have examined VLF data at 750 Hz, 1.2kHz, and 2.0kHz from the VLF receiver and Cosmic Noise Absorption (CNA) data from the riometer, which reflects variations of energetic electron precipitation, at Syowa station (L=6.1). Statistical variations of CNA distributions as a function of magnetic local time (MLT) during 277 SC in 1999-2009 show that enhanced energetic electron precipitating region occurs at the noon side with time evolution of SC. VLF variations at 750Hz, and 1.2kHz are consistent with the CNA variations although those at 2.0kHz are not consistent with those. In addition to these characteristics of the VLF emissions and energetic electron precipitation during SC, solar wind parameters and electron temperature anisotropy will be discussed in this presentation.

Keywords: Syowa station, energetic electron, VLF emissions, SC, electron precipitation