Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

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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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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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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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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Impact of interplanetary shock on ions in the inner magnetosphere

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Impact of interplanetary shock on ions in the inner magnetosphere
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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