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Possible energy-coupling of the protons between the low and high-energy particles in the inner magnetosphere

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The ring current is known to consist of mainly two components of ions; one having energy from keV to tens of keV (low-energy), and the other having energy from 100keV to several hundreds keV (high-energy) in the quiet time. According to past observations, the low-energy component increases during the storm main phase and decreases during the storm recovery phase. However, the behavior of the high-energy component and the relationship between the two components are less known. For the purpose of understanding the behavior of the ring current in detail, we use data from the ion mass spectrometer called MICS and the magnetometer called MFE aboard the Polar satellite. We focus on the differential flux of protons with 31-80keV (as a proxy of the low-energy component) and those with 125-173keV (as a proxy of the high-energy component) at a pitch angle of 90 degrees when the Polar satellite crossed the magnetic equatorial plane. Pre-storm condition (t1), the day of storm (t2), and decline time (t3) are identified based on the Dst index. We selected 27 subsets from January 1997 to March 2000 and from April 2001 to April 2002.

We obtained the result that in the low-energy component, the proton flux tends to increase during the developing phase and decrease during the declining phase with an exception in the pre-noon sector. On the other hand, in the high-energy component, the proton flux tends to be more or less constant during the developing phase. During the declining phase, the flux tends to increase back to, or occasionally exceeds that in the pre-storm condition. We think that the increase in the high-energy proton flux during declining phase is caused by radial transportation due to inductive electric field (drift-betatron) or adiabatic acceleration (gyro-betatron). To distinguish these two possible mechanisms, we performed detail analysis of the phase space density of protons and the magnetic field. We obtained the following results. 25% of the storm events can be reasonably explained by the adiabatic acceleration (gyro-betatron). Thus, the increase in the ambient magnetic field in the equatorial plane causes flux increasing for one quarter of the events. We suggest the energy coupling of the protons between the low and high-energy particles in the inner magnetosphere via ambient magnetic field during the declining phase as follows: First, the convection electric field is weakened abruptly in the magnetosphere and the supply of low-energy proton into the inner magnetosphere decreases significantly. Secondly, the ring current decays due to charge exchange. Thirdly, the ambient magnetic field increases gradually due to reduction of the ring current. Fourthly, the significant enhancement of high-energy flux via the adiabatic acceleration occurs in part. The ambient magnetic field variations produced by low-energy ion motion may strongly affect the motion of high-energy particles, including protons and electrons as well, trapped by the inner magnetosphere.