Energy Transfer Between Pc4-5 Geomagnetic Pulsations and Energetic Ions due to Drift-Bounce Resonance in the Earth's Magnetosphere

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Abstract

This thesis investigates the relations between Pc4-5 geomagnetic pulsations and energetic ions due to drift-bounce resonance interactions in the Earth's magnetosphere by using data from multi-satellites in the magnetosphere and ground-based magnetometers.

Chapter 1 provides an outline of the geomagnetic pulsations and drift-bounce resonance between the pulsations and charged particles. The purpose of the thesis is also stated in this chapter.

Chapter 2 describes the overview of the instruments and data, which are used in the thesis. I have analyzed the data obtained by the Van Allen Probes, Arase, and MMS satellites, and the magnetic field data from six geomagnetic stations located in the northern high latitude.

In Chapter 3, I show the Van Allen Probes observations of the energy transfer between poloidal Pc4 waves and protons through drift-bounce resonance. I have found second harmonic poloidal Pc4 waves and concurrent proton flux oscillations by analyzing data obtained by the Van Allen Probe A in the dayside inner magnetosphere in the storm recovery phase. The proton fluxes are modulated in the energy range of 67.0–268.8 keV with the same frequency of the poloidal Pc4 wave. The observed features of the proton flux oscillations have been explained by drift-bounce resonance. I have calculated the spatial gradient

of the phase space density in the outbound and inbound passes of the satellite. For this calculation, I have made use of the proton observation for multiple pitch angles. The result demonstrates that energy is transferred from the unstable proton distributions to the Pc4 waves. During the Pc4 wave event, the solar wind dynamic pressure corrected Dst index, i.e., Dst* index shows rapid increase. The estimations of the ring current energy loss from the Dst* increase and from the proton flux variations by drift-bounce resonance suggest that drift-bounce resonance contributes to the rapid increase of Dst*.

Chapter 4 shows evidence of drift-bounce resonance of the oxygen (O^+) ions at multiple energies, which were observed by the Arase satellite in the nightside inner magnetosphere. To investigate energy transfer between geomagnetic pulsations and O^+ ions, I have examined a Pc5 wave event. Azimuthal wave number (*m*-number) of this wave event is estimated by two different methods to be –8 and –15, showing that the waves propagate westward. The flux oscillations of O^+ ions at $\geq$56.3 keV are caused by drift resonance, and those of O^+ ions at $\leq$18.6 keV by bounce resonance. Resonances of O^+ ions at multiple energies are simultaneously observed for the first time. The enhancement of O^+/H^+ flux ratio at $\leq$18.6 keV indicates that the selective acceleration of O^+ ions occurs due to bounce resonance.

Chapter 5 explains the observational results of drift-bounce resonance of O^+ ions in the outer magnetosphere. To study the detailed characteristics of O^+ drift-bounce resonance, I have examined large amounts of the data obtained by the MMS satellite during one year and seven months, and found 12 events of O^+ drift-bounce resonance. The O^+/H^+ energy density ratio shows a high correlation with the power of the wave electric field, but low correlations with the Dst index and the F10.7 index. These indicate that the selective acceleration of O^+ ions occurs due to drift-bounce resonance.

Chapter 6 summarizes the results obtained from this study. Drift-bounce resonance transfers energy between Pc4–5 geomagnetic pulsations and energetic ions, and has the possibility of making a contribution to the ring current decay.