Abstract

Electromagnetic ion cyclotron (EMIC) waves effectively scatter relativistic electrons in the Earth's radiation belts and energetic ring current ions. Previously, two main EMIC wave populations were included in the magnetospheric simulations: the population generated by plasma sheet injections and the population generated by the magnetosphere compression by the solar wind. Alternatively, EMIC waves can also be generated by another mechanism on the dayside. This mechanism is the primary focus of this thesis and involves intense, compressional ultra-low frequency (ULF) waves that may magnetically trap anisotropic, hot-ion populations and transport them into the inner magnetosphere.

In the first part of this thesis, a third class of EMIC waves generated by hot plasma sheet ions modulated by compressional ultra-low frequency (ULF) waves is investigated. Such ULF-modulated EMIC waves are mostly observed on the dayside, between magnetopause and the outer radiation belt edge. The results show that ULF-modulated EMIC waves are weakly oblique (with wave normal angle $\approx 20° \pm 10°$) and narrow-banded (with spectral width of $\sim 1/3$ of the mean frequency). We further construct an empirical model of EMIC wave characteristics as a function of L-shell and MLT. This Empirical model parameterizing EMIC wave characteristics is an important element of the inner magnetosphere simulations to understand the near-Earth dynamics. The low ratio of electron plasma frequency to electron gyrofrequency ($f_{pe}/f_{ce} \sim 5-10$) around the EMIC wave generation region does not allow these waves to scatter energetic electrons. However, these waves provide very effective (comparable to strong diffusion) quasi-periodic precipitation of plasma sheet protons.

In the second part, the generation of EMIC waves from the ion-scale magnetic holes (MHs) is studied. MHs are nonlinear plasma structures commonly observed in the solar wind and Earth's magnetosphere. These holes are characterized by the magnetic field depletion filled by hot, transversely anisotropic ions and electrons, and are likely formed during the nonlinear stage of ion mirror instability. Due to the plasma thermal anisotropy within magnetic holes, they serve as a host of electromagnetic ion cyclotron waves, whistler-mode waves, and electron cyclotron harmonic waves. This makes magnetic holes an important element of the Earth's inner magnetosphere, where electromagnetic waves generated within may strongly contribute to energetic ion and electron scattering. Such scattering, however, will modify the hot-ion distribution that is trapped within magnetic holes and responsible for the magnetic field stress balance. Therefore, hot ion scattering within magnetic holes likely determines the hole lifetime. The question of how ion scattering by electromagnetic waves affects the stress balance and lifetime of magnetic holes is discussed. For illustration, we used typical characteristics of magnetic holes, ion populations, and ion cyclotron waves observed in the Earth's magnetosphere. It is demonstrated that ion distribution isotropisation via scattering by waves does not change significantly magnetic hole magnitude, but ion losses due to scattering into atmosphere may limit the hole life-times to $10-30$ min in the Earth's inner magnetosphere.