修士論文

Dynamics of near-Earth plasma sheet electrons seen by the THEMIS spacecraft
- Transport, loss and contribution to diffuse aurora -

(THEMIS衛星観測から得られた地球近傍プラズマシート電子のダイナミクス
- 輸送、損失とディフューズオーロラへの寄与 -)

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The plasma sheet is the primary reservoir of hot plasma in the magnetosphere and is believed to be a source of the energetic particles in the inner magnetosphere. It is thought that the injected energetic ions and electrons into the inner magnetosphere contribute to the ring current population and the seed population of the relativistic electrons in the radiation belts, respectively. The plasma sheet particles also act a source of instabilities which generates various plasma waves. Furthermore, the plasma sheet electrons are an important source of the precipitating electrons which generate auroral emissions. Thus, the plasma sheet particles play an important role in the configuration of the particle populations and dynamics of particle and wave in the inner magnetosphere.

To understand dynamics of plasma sheet electrons in the inner magnetospheric region, we have investigated transport of plasma sheet electrons into he inner magnetosphere, loss processes of the electrons during the convective transport and their connections to the electron precipitations which generate the diffuse aurora. The electron and wave data obtained from the THEMIS spacecraft were used to achieve our science objectives. Our main objective is to understand the loss processes of the plasma sheet electrons and their connection to diffuse auroral precipitations. It has been discussed for about four decades but it is still controversy on the magnetospheric physics.

The transport of the electrons was examined by using the high resolution, large amount of the THEMIS electron data combining with the concept of the Alfven boundary. The result showed that the access of the plasma sheet electrons inferred from the electron measurements was well consistent with the theoretical Alfven boundary that was calculated from the combination of a dipole magnetic field and simple electric field (the Volland-Stern electric field) models. It is confirmed that transport of the plasma sheet electrons is controlled by the large scale convection field. This also suggests that the simple electric field model works well and the parameterization of convection strength by Kp index is good approximation in statistical sense. The loss of plasma sheet electrons is seen from the night side to the dayside in the derived global distributions. We investigated the cause of the loss of electrons as the next step.

The loss time scales estimated from the distributions in the morning side magnetosphere depend on the geomagnetic activities, suggesting enhancement of the precipitation loss through some wave-particle interactions. The loss mechanism of the electrons are investigated by using the electron loss time scales in the morning side derived from the global distributions of the electrons and the drift orbits calculated from global magnetic and electric field models. The estimation of the loss time scales of plasma sheet electrons is conducted for the first time by this study. The estimated loss time scales are compared with a chorus wave model lifetime and the required wave amplitudes that can explain the measured loss time scales are derived. The required wave amplitudes are then compared

with the previous statistical survey of the chorus wave amplitudes based on the CRRES measurements. The result showed that the required wave amplitudes well agree with the CRRES statistical survey of the chorus wave amplitudes within a factor of 3. This strongly suggests that the precipitation loss of the plasma sheet electrons and the diffuse auroras in the morning side are mainly controlled by the pitch angle scattering due the resonant interaction with whistler-mode chorus.

Although whistler-mode chorus has sufficient power to cause the loss of plasma sheet electrons seen in the derived distributions, there seems to be some discrepancies between the distribution of whistler-mode chorus and the global morphology of the diffuse aurora. Therefore, we also derived the global distributions of ECH waves near the equatorial plane using the THEMIS wave data to evaluate their role in the production of the diffuse auroral electron precipitations. The investigation of the ECH was distributions were extended to the outer magnetosphere ($L \geq 7$) where previous studies have not covered sufficiently. The derived distributions of averaged ECH wave intensity show that there are ECH waves in the dusk side and the outer magnetosphere where there is no intense whistler-mode chorus. This indicates that ECH waves may contribute to the production of the diffuse auroral precipitations to some degree. Thus, we suggest that the spatially combined electron precipitations due to resonant interactions with ECH waves and whistler-mode chorus form the global morphology of diffuse aurora. We accomplished the understanding of the loss mechanism of the plasma sheet electrons quantitatively in statistical sense but further analyses are needed to understand the production mechanism of the diffuse aurora. One way to access the goal is the statistical analysis of the precipitating electron spectra based on the low altitude satellite measurements since it is expected the precipitating electrons spectra depend on the wave mode that scatters the electrons into the loss cone. The results from the analysis would be useful to construct the precise model of the processes of diffuse auroras and energy transfer from the magnetosphere to the upper atmosphere. The other way is the coordinate analysis of the plasma wave observations near the equator and the precipitating electron measurements in the low altitude at a footprint along a field line. We expect that the coordinate analysis using the ground-based, low altitude, and equatorial observations provide more accurate knowledge of the relationship among the pitch angle scattering, electron precipitations, and generation of diffuse aurora. The knowledge obtained from the coordinate analysis would be useful for understanding of the nature of the wave-particle interaction and validity of our current understandings on it. These knowledges are also useful for understanding radiation belt dynamics which wave-particle interactions are thought to have significant contributions to.