RECENT RESEARCH ACTIVITIES

Simulations and Modeling of Geospace Environment

(Laboratory of Computer Space Science, RISH, Kyoto University)

Yoshiharu Omura, Yusuke Ebihara, and Satoko Nakamura

We have conducted a series of test particle simulations of obliquely propagating whistler mode wave-particle interaction [1], showing that the perpendicular wave electric field can play a significant role in trapping and accelerating relativistic electrons through Landau resonance. A further theoretical and numerical investigation verifies that there occurs nonlinear wave trapping of relativistic electrons by the nonlinear Lorentz force of the perpendicular wave magnetic field. We have performed a subpacket analysis of chorus waveforms observed by the Van Allen Probes [2], and calculated the energy gain by the cyclotron acceleration through Landau resonance. We compare the efficiencies of accelerations by cyclotron and Landau resonances in typical events of rapid electron acceleration observed by the Van Allen Probes. By performing test particle simulations of relativistic electrons scattered by electromagnetic ion cyclotron (EMIC) rising tone emissions, we find a nonlinear scattering process named SLPA (Scattering at Low Pitch Angle) totally different from the nonlinear wave trapping. The nonlinear wave trapping, occurring for high pitch angles away from the loss cone, scatters some of resonant electrons to lower pitch angles, and a fraction of the electrons is further transported into the loss cone by SLPA after being released from the wave trapping [3].

Geomagnetically induced currents (GIC) is known to be hazardous to the power grid system. When great magnetic storms occur, the magnitude of GICs increases in particular at high latitudes where auroral electojet flows in the ionosphere. Previously, the power grid system in Japan is regarded to be safe to the GICs because Japan is situated at geomagnetically low latitude. In order to assess whether the power grid system in Japan is definitely safe for extreme geomagnetic storms, we have conducted numerical simulations. First, we modeled propagation of the electomagnetic fields transmitted from the ionosphere to the ground by the Finite-difference time-domain (FDTD) method. A global relief model provided by NOAA and a global map of sediment Thickness provided by Gabi Laske and Guy Masters were incorporated to derive a three-dimensional electrical conductivity that is required to calculate the geomagnetically induced electric field (GIC). Secondly, we modeled the 500 kV power grid system consisting of >100 substations and power lines. From the requirement of continuity of the electric current, we calculated the GIC flowing in the power grid system in Japan for given GIE and the power grid model. Figure 1 shows an example of the simulation result. The distribution of GIC appears to be complex because of non-uniform ground conductivity, and uneven distribution of the power grid system.

.

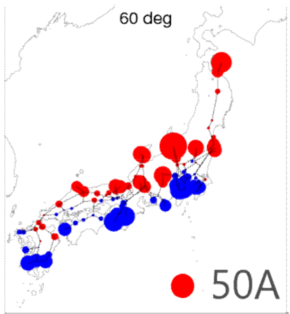

Figure 1. Example of simulated GIC in the power grid system in Japan. The radius of the circle represents the magnitude of GIC.

References

[1] Hsieh, Y.-K, and Y. Omura, Nonlinear dynamics of electrons interacting with oblique whistler-mode chorus in the magnetosphere, *J. Geophys. Res. Space Physics*, *122*, 675-694, 2017.

[2] Foster, J. C., P. J. Erickson, Y. Omura, D. N. Baker, C. A. Kletzing, S. G. Claudepierre, Van Allen Probes Observations of Prompt MeV Radiation Belt Electron Acceleration in Non-Linear Interactions with VLF Chorus, *J. Geophy. Res. Space Physics*, *122*, 324-339, 2017.

[3] Kubota, Y., and Y. Omura, Rapid precipitation of radiation belt electrons induced by EMIC rising tone emissions localized in longitude inside and outside the plasmapause, *J. Geophys. Res. Space Physics, 122*, 293-309, 2017.