【Grant-in-Aid for Scientific Research (S)】

Science and Engineering (Mathematical and Physical Sciences)

Title of Project : Analyses and Verification of Particle Acceleration and Scattering by Electromagnetic Cyclotron Waves in Space Plasmas

Yoshiharu Omura
(Kyoto University, Research Institute for Sustainable Humanosphere, Professor)

Research Project Number : 17H06140 Researcher Number : 50177002
Research Area : Earth and Planetary Science
Keyword : Waves in space plasma, Earth's magnetosphere

【Purpose and Background of the Research】

There exist various kinds of electromagnetic waves in space plasmas. Among them, electromagnetic cyclotron waves resonate with energetic electrons with their transverse wave fields forming helical structures along the magnetic field. When energetic electrons of 10-30 keV are injected into the inner magnetosphere at times of geomagnetic disturbances, they generate chorus emissions with rising-tone frequency as shown in Figure 1. A fraction of resonant electrons are effectively accelerated to MeV energy through nonlinear trapping by the excited chorus waves. It is understood that the accelerated relativistic electrons form the outer radiation belt. We verify the acceleration mechanism through analysis of wave and particle data obtained by multiple spacecraft. We also try to test the applicability of the nonlinear acceleration process to different regions in space. Based on the acquired insights, we develop new instruments for observation of wave-particle interaction in space plasmas. The short title of this project is PCWAVE (Particle and Cyclotron Wave Analyses and VErification).

【Research Methods】

We perform a series of test particle simulations of electron trajectories under wave models based on wave and particle observation by Arase spacecraft in the radiation belts. We also analyze data from MMS spacecraft in the magnetic reconnection regions of the Earth's magnetosphere. While miniaturization of the plasma wave instruments has been performed by forming integrated circuits on semiconductor, a critical issue of the particle instruments is how to ensure the detection area for particle fluxes with the miniaturized parts. We will solve the issue by forming multi-layer structures of the parts.

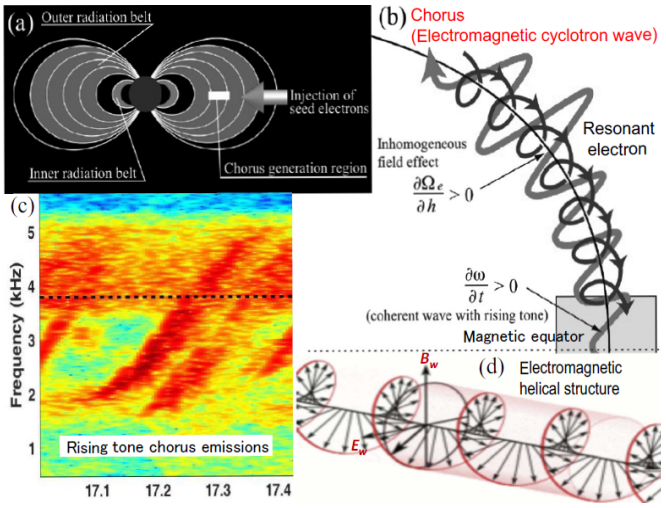

Figure 1 Chorus waves

【Expected Research Achievements and Scientific Significance】

Fundamental energy conversion processes through nonlinear wave-particle interactions in different regions of space plasmas will be clarified. Very small and light instruments for observation of wave-particle interactions will be developed, enabling us to propose new missions for space exploration with multiple small spacecraft.

【Publications Relevant to the Project】

・Omura, Y., Y. Miyashita, M. Yoshikawa et al., Formation process of relativistic electron flux through interaction with chorus emissions in the Earth's inner magnetosphere, J. Geophys. Res. Space Physics, 120, 9545-9562, 2015.
・Foster, J. C., P. J. Erickson, Y. Omura, D. N. Baker, C. A. Kletzing, and S. G. Claudepierre, Van Allen Probes observations of prompt MeV radiation belt electron acceleration in nonlinear interactions with VLF chorus, J. Geophys. Res. Space Physics, 122, 324-339, 2017.

【Term of Project】 FY2017-2021

【Budget Allocation】 133,700 Thousand Yen

【Homepage Address and Other Contact Information】

http://pcwave.rish.kyoto-u.ac.jp/
omura@rish.kyoto-u.ac.jp