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CubeSat project PCUBE for probing, controlling, and understanding of radiation belt environments

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All magnetized planets have radiation belts consisting of electrons at relativistic energies. Recent studies clarified that the Earth's radiation belt varies more dynamically than conventionally expected due to the rapid loss process by electromagnetic plasma waves (whistler-mode chorus, electromagnetic ion cyclotron waves, etc.) [1-2]. Nonlinear effects in the wave-particle interaction process play essential roles in the rapid loss process through the pitch angle scattering of relativistic electrons in the magnetosphere. The efficient pitch angle scattering due to the nonlinear effects deforms the distribution of electrons in the velocity phase space in the time scale of plasma wave enhancement.

PCUBE is a 5-year project (2023-2027) to investigate the rapid loss process of radiation belt electrons by plasma waves by (1) developing a radiation belt model fully incorporating rapid loss, (2) measuring the radiation belt loss process by originally developed instruments onboard a CubeSat, and (3) analyzing spacecraft data measured in terrestrial and Jovian magnetospheres.

Our project tries to confirm a hypothesis that the efficient loss of radiation belt electrons occurs along the plasma duct, which concentrates plasma waves along a specific field line where the plasma density is enhanced from those of the surroundings [3]. To investigate the relationship between the plasma duct and the rapid loss process of radiation belt electrons, we need to observe the relativistic electron precipitation and the plasma density structure simultaneously in the Earth's upper atmosphere. We develop a high-energy electron detector and a plasma density probe for a CubeSat. The electron detector uses the avalanche photo-diode, which we employed in the energetic electron detector onboard the Arase satellite. The developed detector covers a wide energy range from tens to millions of electron volts. By measuring the energy dependence of precipitating electrons into the Earth, we clarify the roles of electromagnetic waves in the radiation belt loss process. We also develop the plasma density probe by miniaturizing those used in conventional sounding rocket experiments. We will install the originally developed probes into the CubeSat "IMPACT" developed by Kanazawa University to measure the loss of radiation belt electrons inside the plasma duct.

Because radiation belt electrons cause satellite anomalies and radiation exposure in space, our project reveals the fundamental physics of the rapid loss of radiation belts, developing the theoretical basis to control the radiation belts. Our project reveals the fundamental physics of the rapid loss of radiation belts, developing the theoretical basis to control the radiation belts.

References

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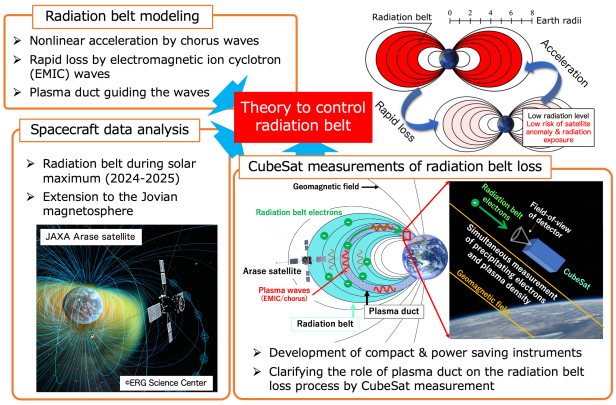

Figure 1. Schematic of probing, controlling, and understanding the radiation belt environments