18aD2-1

Generation of relativistic electrons in geospace: the ERG project
ジオスペースにおける相対論的電子加速：ERG衛星プロジェクト

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Relativistic electrons in the radiation belts are highly variable associated with geomagneic disturbances. Mechamisms to generate relativistic electrons have been considered; the betatron accelerations via the radial transport by MHD waves, and the cyclotron-resonance with the whistler mode waves. In order to elucidiate the acceleration mechanisms, the geospace exploration project ERG: Exploration of energization and Radiation in Geospace is now ongoing. The ERG satellite will launch in 2016, and the newly developed anlyzer to directly detect wave-particle interactions is installed. In this presentation, we will review the generation mechanisms for relativistic electrons and present the overview of the ERG project.

1. Introduction

The energetic electrons are trapped in the terrestrial magnetic field, and they form the radiation belts (Van Allen belts). MeV electrons in the radiation belts are the highest energy particle population in the geospace. The electron radiation belts consist of two belts; the inner belt and the outer belt. During the space storms, the outer belt electron decreases clearly in their main phase, and then recovers and sometimes increases over the pre-storm level. These variations indicate that the electron acceleration processes take place during the space storm.

As the electron acceleration mechanisms, two different theories have been proposed. One is the betatron acceleration. In this process, since the first adiabatic invariant (the magnetic moment) of electrons is always conserved, the electron energy increases when electrons move to the Earthward. It is expected that the drift-resonance with the MHD fast mode waves drive the radial transport of the relativistic electrons. After the discovery of the radiation belts in the end of 1950s, this idea has been believed as the primary acceleration mechanism in the outer belt. On the other hand, new idea has been proposed in 1990s. The cyclotron resonance with the whistler mode waves can cause accelerations of MeV electrons. Especially, the chorus waves that are non-linear whistler mode waves with the frequency drift can cause the rapid acceleration of the MeV electros.

In order to understand which process is the primary process to generate relativistic electrons during the space storms and to understand the elementary process of electron accelerations, the direct measurements for plasma/particles as well as fields/waves inside the radiation belts are essential.

2. The ERG project

Exploration of energization and Radiation in Geospace (ERG) is the project to understand the generation mechanism of relativistic electrons and dynamical evolutions of space [1].

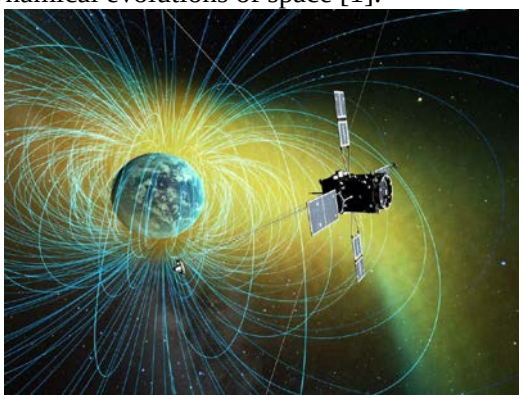

Fig.1. The ERG satellite
(image. Copyright ERG project)

The ERG satellite is a science satellite mission of ISAS/JAXA (**Figure 1**). The satellite will be launched around the declining phase of solar cycle 24 (2016). The nominal mission life is planned to be longer than one year. The satellite is designed to be Sun-oriented and spin-stabilized with rotation rate of 7.5 rpm. The designed apogee altitude is 4.5 Re (L~5.5 at equatorial plane), and the perigee altitude is ~300 km. The planned orbital inclination is 31 degrees.

The satellite can measure electrons from 12

eV to 20 MeV by 4 different sensors and ions from 10 eV/q to 180 keV/q with mass discriminations by 2 different sensors.

The satellite also measures fields and waves from DC to 10 MHz (electric fields) and 100 kHz (magnetic fields). Besides conventional frequency-spectrum observations, the satellite can measure waveform that is essential to understand the non-linear wave particle interactions.

To understand the energy exchange process between plasma/particles and waves through wave-particle interactions, the newly developed WPIA (wave-particle interaction analyzer) system is installed in the ERG satellite. Recently, an innovative method for direct measurement of the vector product of E and v has been proposed [2]. Based on this idea, WPIA directly calculates the relative phase at each event of particle detections by the onboard particle instruments. S-WPIA has the capability to identify the fraction in the phase space. The fraction corresponds to the electron hole that is theoretically expected [3]. Thus, WPIA will discriminate quantitatively which electrons contribute to chorus generation and which electrons are actually accelerated by chorus waves. This will be the first observation to unambiguously identify how energy conversion takes place via wave-particle interactions in space.

3. Summary

We briefly review the dynamics of the radiation belt electrons and the ERG project. Using the WPIA system, the ERG satellite can measure directly evidence the energy exchange between the particle and waves. The ERG project will shed on the lights on the acceleration mechanisms of relativistic electrons in space, which are the fundamental processes in the universe.

Acknowledgments

The ERG mission is a science satellite program of ISAS/JAXA.

References

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[2] Y. Katoh et al. : Ann. Geophys. **31** (2013) 503.

[3] Y. Omura: J. Geophys. Res. **113** (2008).