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

Science and Engineering (Mathematical and Physical Sciences)

Title of Project : Research on the Acceleration and Propagation of Cosmic Rays by High-precision Direct Observation

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Research Project Number : 26220708　Researcher Number : 90167536
Research Area : Particle, Nuclear, Cosmic ray, Astrophysics
Keyword : Cosmic ray (experiment)

【Purpose and Background of the Research】

Astroparticle physics is comprised of the following two aspects: One is the particle and nuclear physics aspect needed to study the processes of particle creation, and the other is the astrophysics one to study the processes of particle acceleration and transportation. Since the energy spectra and the composition of the cosmic rays are determined by these two processes, it is crucial for correct understanding of the cosmic rays to resolve the effects of both processes with a direct observation at high altitude without atmospheric effects. Therefore, several observations using balloons and satellites have been carried out worldwide.

From recent observations, new findings at high particle energies have been reported, including (1) an excess of the positron to electron ratio as well as the combined electron and positron flux, and (2) a hardening of the energy spectrum of protons and helium. These are considered to indicate the existence of unknown nearby sources and transportation process and/or of Dark Matter, which is one of the most important unresolved issues in astrophysics. Nevertheless, we need more detailed observation to get a conclusion, since the so far obtained data is not fully consistent, and its statistics are not also not yet sufficient at higher energies. We will get new insights into the origin of the cosmic rays by tackling these outstanding questions, discerning nearby astrophysical sources from Dark Matter annihilation or decay with a high precision observation at the ISS.

【Research Methods】

We will carry out an observation of the electron cosmic rays in the TeV region, and of the protons and heavy nuclei up to the Knee region (~3×10^{15} eV) with the CALorimetric Electron Telescope (CALET) aboard the JEM-EF of the ISS. CALET consists of the following components: CHarge Detector (CHD), IMaging Calorimeter (IMC), and Total AbSorption Calorimeter (TASC). Different kinds of particles produce specific shower signatures inside the detector, allowing for distinction of particularly gamma-rays, electrons and protons. The species, energy and arrival direction of the incident particles are determined by analyzing the combined signal from all detector components.

CALET will be brought to the ISS aboard the Japanese HTV-5 unmanned supply spacecraft, for 5-year observation. The onboard data will be transferred in real time to the CALET operations center at Waseda University (WCOC) via the Tsukuba Space Center. We will contribute successful completion of the research goals by running mission operations and data analysis at the WCOC.

【Expected Research Achievements and Scientific Significance】

The magnet spectrometers used in PAMELA and AMS are not well suited to observe electrons in the TeV region, though they are capable of distinguishing positrons from electrons. Previous calorimeters, such as ATIC, CREAM and Fermi-LAT, are not optimized for the detection of high energy electrons, and their capabilities become significantly worse in the TeV region. The unique feature of CALET is its thick (30 r.l.), fully active calorimeter that allows observation well into the TeV energy region with excellent energy resolution, coupled with a fine imaging upper calorimeter. As a result, CALET has the capability to identify nearby sources and to search for Dark Matter, even with a mass exceeding 1TeV. More- over, it is possible to observe the energy spectra of protons and heavy nuclei at energies in 10 GeV-1000 TeV and the B/C ratio up to several TeV/n. From these, finally the exact parameters governing the acceleration and transportation of cosmic rays will be revealed.

【Publications Relevant to the Project】

・S.Torii, “Observing Cosmic Rays in Space”, BUTSURI, 67, pp.821-827 (2014) (in Japanese).
・S.Torii, “Calorimetric Electron Telescope mission: Search for dark matter and nearby sources”, NIM. A630, pp.55-57 (2011).

【Term of Project】

FY2014-2018

【Budget Allocation】

130,000 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.crlab.wise.sci.waseda.ac.jp