【Grant-in-Aid for Transformative Research Areas（Ｂ）】

Section II

Title of Project： Formation of the Multiscale Muon Imaging for Particles and Huge Structures

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【Purpose of the Research Project】

In this Research Area, we aim to establish "Multiscale Muon Imaging (MSMI)" to visualize a wide range of materials and objects ranging from attometer (10-18m) to kilometer (103m) by using subatomic muons. We exploit the fusion of different research methods of science and engineering, and open up next-generation fundamental technologies and disciplines that will contribute to a wide range of applications from basic research to social implementation.

We will explore new particle phenomena by real-time muon detection using gas detectors, and realize three-dimensional visualization of giant structures such as pyramids and volcanoes using nuclear emulsions. In addition, we will be the first in the world to realize the basis for scientific safety management of levees by applying the same visualization method. Furthermore, by exploring muon acceleration technology, we will establish the basis for a portable muon accelerator that can see through objects with high resolution in both time and space.

【Content of the Research Project】

Experts in particle physics, civil engineering, and accelerator science will collaborate to advance muon detection and muon acceleration technologies, and to expand the scope of visualization to revolutionize muon imaging for fundamental research, applied research, and future social implementation.

In this Research Area, we aim to discover new particle phenomena by measuring particle interactions generated by accelerators using gas detectors (Planned Research A01). We will observe cosmic rays penetrating through pyramids and volcanoes using nuclear emulsions, and aim for the world's first three-dimensional visualization of their interiors (Planned Research A02). In addition, we will develop the world's first scientific method for safety management of levees by using cosmic rays to visualize the inside of levees and water distribution there, which has not been possible in the past (Planned Research A03). Furthermore, we will establish a basis for seeing through any object with a portable muon accelerator by studying muon acceleration technology (Planned Research A04). While maintaining a balance between these planned research projects, the general team will monitor the latest progress of the research, and will pursue the possibility of fusion and expansion of visualization targets by setting the direction of each research project and proposing technical collaboration between the planned research projects, thereby creating the seeds for further research.

【Expected Research Achievements and Scientific Significance】

The realization of MSMI, which is the goal of this Research Area, will make it possible to visualize phenomena that have been longed for in various academic fields, and is expected to contribute to the development of basic research, the creation of new research fields, and the solution of social issues. In addition, the fusion of disciplines through this research will enable a comprehensive view of the original disciplines, and a breakthrough in each discipline can be expected at the same time.

The MSMI is expected to bring about a paradigm shift in a wide range of academic fields, including physics, archaeology, earth and planetary science, engineering, and mathematical science, in response to the issues set in planned researches. Specific examples of future impacts include the observation of huge active volcanoes such as Mt. Fuji, and the implementation of MSMI in the investigation of the aging of social infrastructure (bridges, dams, tunnels, etc.), which is becoming a serious social issue due to the emergence of climate change and severe national finances.

【Key Words】

Muon: A subatomic particle with properties similar to those of an electron, but with a mass 207 times that of an electron. With an energy of over 1 TeV (10^{12} electron volts), muons have such a high penetrating power that they can penetrate even 1 km of bedrock.

Muon imaging: A technology that uses muons to visualize the internal structure (density contrast) of objects. The penetration probability of a muon through a material depends on the product of the density of the material it passes through and the distance. Using this property of muons, the internal structure of thick objects that cannot be visualized with X-rays can be visualized nondestructively using the same principle as X-ray radiography.

【Term of Project】 FY2021-2023

【Budget Allocation】 105,000 Thousand Yen

【Homepage Address and Other Contact Information】

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