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

Broad Section B

Title of Project : Search for rare muon decay with highest sensitivity to unravel grand unification of elementary particle

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Keyword : Grand Unified Theory, Supersymmetry, rare muon decay, charged lepton flavor violation

【Purpose and Background of the Research】

It is widely believed that the three fundamental forces are unified in the early universe. The grand unification has not, however, been experimentally proved. The lepton flavor violating decay $\mu \to e\gamma$ would happen with a branching ratio of 10^{-11}-10^{-14} in the grand unified theory, while it is strongly suppressed in the standard model of particle physics. A discovery of $\mu \to e\gamma$ will, therefore, be unambiguous evidence of the grand unified theory. The project proposed here is to carry out the MEG II experiment to search for $\mu \to e\gamma$ with a branching ratio sensitivity down to 5×10^{-14} using the world's highest muon beam at the Paul Scherrer Institute and innovative detectors. In addition, it is also planned to carry out detector R&D for a new $\mu \to e\gamma$ search experiment with 30 times better sensitivity compared to MEG II. It will enhance the chance of discovery and would even enable precise measurements of $\mu \to e\gamma$ after a possible discovery in MEG II to pin down the underlying grand unified theory.

【Research Methods】

The MEG II experiment with ten times higher sensitivity compared to the previous MEG experiment was proposed in 2012 (Fig.1). The detector construction has been finished and the commissioning of the detectors is now in progress. Following the full engineering run, the physics data taking is expected to be started in 2022. Our group will be responsible for the stable operation and data-taking on the liquid xenon detector and the positron timing counter as well as the physics analysis. Since the sensitivity is expected to surpass the MEG sensitivity with the initial data for a few months, it would be possible to find an indication of $\mu \to e\gamma$ during this project. The sensitivity is expected to reach 5×10^{-14} by the end of the project period, which is high enough to severely test the SUSY-GUT with a good chance of discovery.

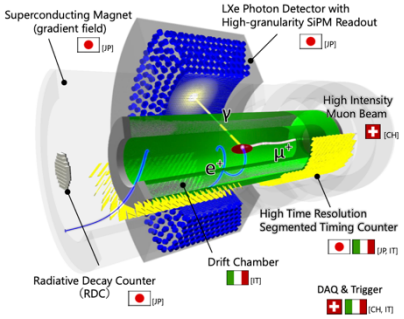

Figure 1 Apparatus of MEG II experiment

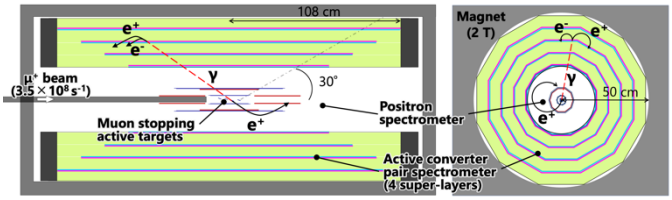

Figure 2 Conceptual view of new $\mu \to e\gamma$ experiment

The new $\mu \to e\gamma$ experiment proposed in this project is expected to achieve 30 times higher sensitivity compared to MEG II, based on a completely new experimental design with innovative detectors including a photon pair spectrometer with an active converter and a positron detector composed of an ultra-thin silicon sensor tracker, a RPC-based timing counter and an active target.

【Expected Research Achievements and Scientific Significance】

The MEG II will be the first charged lepton flavor violation experiment to have a sufficient sensitivity to test the grand unification with a good chance of discovery. It is expected to open a new research area with the charged lepton flavor violation. Furthermore, the ``measurements '' of $\mu \to e\gamma$ such as the absolute branching ratio and the angular distribution with the new experiment proposed by this project with much higher sensitivity after the possible discovery of $\mu \to e\gamma$ in MEG II would reveal the details of the SUSY-GUT. In addition, the new apparatus would provide a possibility of a concurrent search for $\mu \to eee$, to test the SUSY-GUT even more severely.

【Publications Relevant to the Project】

- “The design of the MEG II experiment”, T. Iwamoto, T. Mori, H. Nishiguchi, W. Ootani, et.al., Eur. Phys. J., C78, 380(2018)
- “Search for the lepton flavour violating decay $\mu \to e\gamma$with the full dataset of the MEG experiment”, T. Iwamoto, T. Mori, H. Nishiguchi, W. Ootani, et.al., Eur. Phys. J., C76, 434(2016)

【Homepage Address and Other Contact Information】

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