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

Science and Engineering (Mathematical and Physical Sciences)

# Title of Project : Sensitive Search for New Physics Law with Precision Measurement of Muon Anomalous Magnetic Moment

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Research Area : Experimental Particle and Nuclear Physics
Keyword : Particle Physics, Fundamental Physics, Precision Measurements, Symmetries

## 【Purpose and Background of the Research】

While the discovery of the higgs particle represented a major step forward in particle physics, there still remain many profound problems in the standard model of particle physics. In particular, the origin of particle/anti-particle asymmetry (CP violation) is unexplained by the model. It would be necessary to find a new physics law beyond the standard model in approaching to more complete picture of the matter in the universe.

Muon is of the rare cases where physics beyond the standard model is indicated. Its anomalous magnetic moment ($g$-2) has been measured down to 0.54 ppm at Brookhaven National Laboratory (BNL) to find a significant discrepancy from the standard model by more than three standard deviations. While one possible candidate to explain the discrepancy is a contribution of super-symmetric particles, it should be noted that the direct observable in the measurement at BNL was a quadratic sum of precessions originated in $g$-2 and electric dipole moment (EDM). The spin precession in the presence of the static magnetic and electric field can be described as follows.

$$\vec{\omega} = -\frac{e}{m}\left[\left(\frac{g_\mu - 2}{2}\right)\vec{B} + \left(\frac{\mu\mathrm{EDM}}{2}\right)\vec{\beta}\times\vec{B}\right] = \vec{\omega}_{g-2} + \vec{\omega}_{\mathrm{EDM}} \quad (1)$$

In another word, $g$-2 produces in-orbit plane precession and EDM does out-of plane rotation. In the BNL measurement, the EDM part was neglected in claiming the discrepancy form the standard model. We have developed a novel technique to measure both $g$-2 and EDM simultaneously, which is to be realized by the proposed experiment.

## 【Research Methods】

In the proposed experiment, we produce ultra-cold muon beam to be accelerated to 300 MeV/$c$ to be injected into a super-precision magnet of 3 T, where the precession vector of the muon is going to be precisely measured. As a prerequisite of the measurement, we are also going to measure the hyper-fine splitting of muonium (Mu), the bound state of $\mu^+$ and electron. The ultra cold muon is produced by laser-ionization of the thermal Mu atoms evaporated into a vacuum region at room temperature. Mu is produced by stopping the surface muon beam on a silica aerogel target in the experimental hall. The “stopping” and “thermal diffusion” is essential in ultra-cold muon technique. The ultra-cold muon beam can be realized only by the high intensity surface muon, which can be obtained only by the high intensity proton driver such as J-PARC.

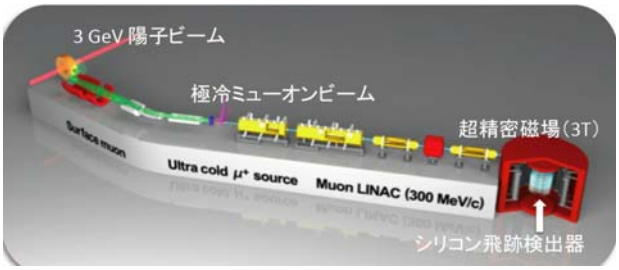


Figure: schematic view of the experiment

## 【Expected Research Achievements and Scientific Significance】

The $g$-2 and EDM have been proving significant constraints on the BSM. The results of the experiment will further constrain the nature of the BSM; if the discrepancy is established, the separation of $g$-2 (=CP-even) and EDM (= CP-odd) will contribute strongly to shape the BSM.

## 【Publications Relevant to the Project】


- ”A novel precision measurement of muon g-2 and EDM at J-PARC”, N. Saito for J-PARC g-2/EDM Collaboration; AIP Conf.Proc. 1467 (2012) 45-56
- “Enhancement of muonium emission rate from silica aerogel with a laser ablated surface” G.A. Beer, et al; PTEP 2014 (2014) 091C01


【Term of Project】 FY2015-2019

【Budget Allocation】 155,700 Thousand Yen

## 【Homepage Address and Other Contact Information】

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