Precision Measurement of Muonium Hyperfine Structure at J-PARC

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The muonium atom is a bound state of a positive muon and an electron, and is one of the hydrogenlike atoms which consists purely of leptons. By measuring the muonium hyperfine structure, the muon mass and the magnetic moment ratio of the proton to the muon can be determined. These values are used to determine the experimental value of muon $g-2$, for which a discrepancy of 4.2σ between the Standard Model prediction and experimental values has been reported [1], and the importance of these measurements is increasing. We plan to measure the hyperfine structure of muonium with ten times higher precision than the previous experiment [2] by using high-intensity muon beam at J-PARC.

First, we developed a zero-field experiment and observed the resonance curve at the J-PARC MLF D-Line [3]. Experimental setup is shown in Fig. 1. We also established Rabi-oscillation spectroscopy, which reduces systematic uncertainty due to microwave power by directly determining resonance frequency from Rabi oscillations without microwave frequency sweep [4].

The high-field experiment will be performed with the same setup as the zero-field experiment except for the magnetic field and microwave cavity. The pure water NMR probe for high-precision magnetic field measurements has achieved an accuracy of 15 ppb with a single channel, and is being developed for multi-channel measurements over a wide area. The prototype module is shown in Fig. 2. A cylindrical microwave cavity has been completed, and a rectangular cavity is being designed and developed to allow greater freedom in resonance frequency selection. We will report on the status of the above developments.

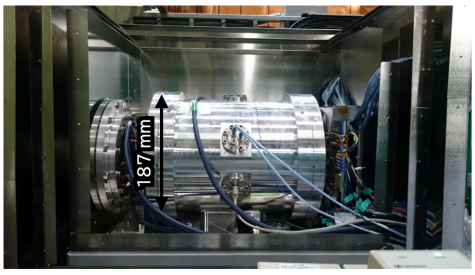

Figure 1: Setup of the zero-field experiment.

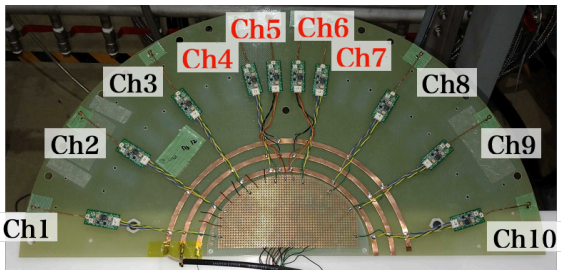

Figure 2: Prototype of multi-channel magnetic probes.

[1] B. Abi *et al.*, (The Muon g 2 Collaboration) Phys. Rev. Lett. **126**, 141801.
[2] W. Liu *et al.*, Phys. Rev. Lett. **82**, 711-714.
[3] S. Kanda *et al.*, Phys. Lett. B **815** 136154.
[4] S. Nishimura *et al.*, Phys Rev. A **104**, L020801.