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New Precision Measurement of Muonium Hyperfine Structure

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Muonium is the bound state of a positive muon and an electron. MuSEUM (Muonium Spectroscopy Experiment Using Microwave) is a new precise measurement of muonium hyperfine structure (MuHFS) at J-PARC (Japan Proton Accelerator Research Complex). MuSEUM determines the MuHFS and muon magnetic moment with a ten times better precision than the precursor experiments at Los Alamos Meson Physics Facility (LAMPF) [1].

There are three major motivations for this new measurement.

1. Contribution to the search for BSM physics via muon g-2. Muon anomalous magnetic moment, a_μ, is known for the 3σ tension between the experimental value at BNL and the theoretical value from the standard model[2]. Two new experimental projects to measure muon g-2 more precisely (100 ppb) are ongoing at J-PARC and Fermilab using a muon storage ring. To extract a_μ, these storage ring experiments need an input parameter, μ_μ/μ_p, which can be precisely determined by the MUHFS spectroscopy. MuSEUM determine the parameter with a precision of 10 ppb, a factor of twelve improvement from the precursor experiment at LAMPF, without assuming the bound-state QED is correct.
2. Test of the bound-state QED. Muonium is a purely leptonic system and theoretical calculation of its hyperfine structure is more precise than that of hydrogen. Although free-QED theory is well verified by the electron g-2 experiment[3], for the bound-state situation theorists need to employ different theoretical approach from free QED, so testing its validity is worthwhile.
3. Test of Lorentz invariance. If the Lorentz symmetry is broken, the hyperfine structure is shifted. This causes the sidereal oscillation of MuHFS due to the earth's rotation[4]. By analysing the change of MuHFS in one sidereal day, MuSEUM can test the Lorentz invariance.

Recently, we have succeeded in measuring the MuHFS at J-PARC. This is the first measurement of MuHFS using intense pulsed muon beam, thus this is a promising result for the improvement of the statistics, which was the most dominant source of the uncertainty in the precursor experiments at LAMPF. We are currently working on the measurement at very weak field, which has different sources of systematic uncertainties from precursor experiments at high field (at 1.7T). We also plan a measurement at high field and development of magnetometer using proton NMR in pure water is in progress. The test measurement revealed that the precision of the magnetometer already surpassed the precision of the one used in the LAMPF experiment. A new muon beam line (called H-Line) with ten times more muon intensity is under construction and will be ready for use in a few years.

In this presentation, we report the recent results of the measurement at very weak field and R&D for the high field measurement.

[1] W. Liu, *et al.*, PRL 82 711, (1999)
[2] G. W. Bennett, *et al.*, PRD 73 072003 (2006)
[3] D. Hanneke, S. Fogwell, G. Gabrielse, PRL 100 120801, (2008)
[4] A. H. Gomes, V. A. Kostelecky, A. J. Vargas, PRD 90 076009 (2014)

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