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Development of the magnetic field mapping method for the precise spectroscopy of the muonium hyperfine splitting with 1.7 T magnetic field

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Muonium is a hydrogen-like atom formed by a positive muon and an electron. The measurement of muonium hyperfine structure (MuHFS) at ground state is a good probe to test the theory of the bound state quantum electrodynamics (QED). Moreover, from the MuHFS measurement with high magnetic field, the muon-to-proton magnetic moment ratio and mass ratio are also derived. As the muon-to-proton magnetic moment ratio is an important input parameter for the muon anomalous magnetic moment ($g-2$), the precision of the MuHFS measurement is also important for the ($g-2$) measurement, which is known for about 3 standard deviation (3σ) discrepancy between the standard model prediction and the experimental value [1] [2]. The current value of MuHFS was measured in 1.7 T magnetic field with a precision of 120 ppb and μμ/μp, mμ/mp were in 12 ppb [3]. However, the biggest uncertainty in the previous measurement was caused by the statistics and the second was systematical uncertainty caused by the magnetic field inhomogeneity. MuSEUM (Muonium Spectroscopy Experiment Using Microwave) collaboration is planning to improve this precision by a factor of 10 by using the intense pulsed muon beam at J-PARC MLF and suppressing the magnetic field inhomogeneity. To suppress the systematic uncertainty caused by the magnetic field inhomogeneity, we are developing the magnetic field mapping method to scan the magnetic field in the muonium production region with a high precision.

[1] K. Hagiwara et al., Journal of Physics G, 38 (2011).

[2] G.W. Bennett et al., Phys. Rev.D73 072003 (2006).

[3] W. Liu et al., Physical Review Letter 82 4 (1999).

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