

High precision measurement of muonium hyperfine structure

Toya Tanaka^{a,b} on behalf of the MuSEUM collaboration

^a Graduate School of Arts and Sciences, University of Tokyo, ^b RIKEN

Muonium is a hydrogen-like atom formed by a positive muon and an electron. Its 1S state hyperfine structure is evaluated with high precision both by theoretical calculations and experimental results. Therefore, muonium is suitable for a stringent test of the bound state QED of hydrogen-like atoms. MuSEUM (Muonium Spectroscopy Experiment Using Microwave) collaboration aims to measure the muonium hyperfine structure with high precision.

The Muonium hyperfine structure can be measured in two methods. One is to measure the spin transition frequency $\Delta\nu_{\text{HFS}}$ in extremely low magnetic field (ZF). And the another way is to measure the spin transition frequencies $\Delta\nu_{12}$ and $\Delta\nu_{34}$ of the split states by the Zeeman effect in high magnetic field (HF). In the HF measurement, the muon-to-proton magnetic moment ratio (μ_{μ}/μ_{p}) and muon-to-electron mass ratio (m_{μ}/m_{e}) can be derived by $\Delta\nu_{12}$ and $\Delta\nu_{34}$. (Figure 1)

The previous research of MuHFS was performed at the former LAMPF (Los Alamos Meson Physics Facility) with 300 ppb in ZF [1] and 12ppb in HF [2]. Also μ_{μ}/μ_{p} and m_{μ}/m_{e} are measured at HF MuHFS measurement with 120ppb [2]. Also μ_{μ}/μ_{p} is a important parameter to determine the precision of the muon anomalous magnetic moment (a_{μ}) measurement. a_{μ} is one of the physical properties which the experimental result differs from the theoretical calculation [3]. Therefore, MuHFS measurement is essential for the precision of a_{μ} . MuSEUM collaboration aims to measure both ZF and HF measurement and improve the precision by a factor of 10.

Previous measurements were constrained by statistical uncertainty. This problem is cleared by utilizing the intense pulsed muon beam at J-PARC MLF (Material and Life Science Experimental Facility) MUSE (Muon Science Establishment). MuSEUM collaboration is currently measuring MuHFS in ZF with our upgraded experimental system, and in parallel we are also developing the magnetic field mapping system for the future HF measurement. In this presentation I would like to introduce about the developments of the MuSEUM experiment and report the experimental status.

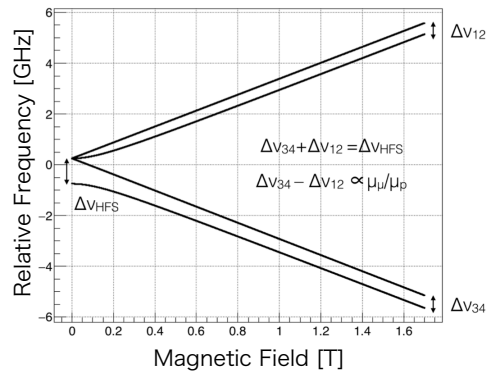


Figure 1: Breit Labi diagram of muonium

[1] D. E. Casperson, *et al.*, Physics Letters 59 B 4 (1975).

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

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