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New Precise Measurement of Muonium Hyperfine Structure at J-PARC

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Muonium atom is the bound state of a positive muon and an electron. MuSEUM (Muonium Spectroscopy Experiment Using Microwave) collaboration is an international research group for precise determination of the ground-state hyperfine transition frequency of muonium. Since muonium is purely leptonic and free from the finite-size effect of proton, measurement of its hyperfine structure is a good probe for the stringent test of bound-state QED(Quantum Electrodynamics). MuSEUM experiment also determines the muon mass precisely, which is an input parameter for the muon g-2 experiments proposed both at J-PARC and Fermilab. MuSEUM is hence able to make a great contribution to the search for new physics beyond the standard model through the g-2 experiments. It is also suggested [1] that the experiment is sensitive for CPT and Lorentz violation, by utilising the sidereal rotation of the earth. The final goal of MuSEUM is the ten-fold improvement of the current experimental value of the hyperfine transition frequency of muonium[2].

In the experiment, a muon pulse beam is injected into a krypton gas chamber, where muons form muonium by capturing electrons from the gas atom. Then the muon decays with an asymmetric positron emission which favours the direction of magnetic moment of the muon, upstream of the beam axis. Muon spin flip induced by applied field enhances the number of positron detected by downstream positron counters, hence hyperfine transition is observed.

Recently, MuSEUM have tried the hyperfine resonance search and obtained the first resonance signal at the zero magnetic field. By utilizing three layers of magnetic shield made of permalloy, the field was suppressed less than 100 nT. Detector system including beam profile monitors and decay positron counters worked properly. In the presentation, we discuss the resonance search as well as the future prospects based on the recent progress.

[1]R. Bluhm, et al., PRL84. 1098 (2000)
[2]W. Liu. et al., PRL82 711(1999)

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