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Precision measurement of muonium hyperfine structure at J-PARC

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A hydrogen-like atom in which a positive muon (μ^+) and an electron are
bound is called muonium (Mu). The MuSEUM collaboration aims to determine
the muonium's hyperfine structure (MuHFS) with a precision of 1 ppb, a tenfold
improvement in precision compared to previous experimental results [1]. Since
muonium is a leptonic two-body system, high-precision comparison of
experimental and theoretical results is the most rigorous validation of bound- state quantum electrodynamics (QED). In the experiment, the MuHFS is
determined by microwave spectroscopy of the Zeeman-split sublevels in a high magnetic field. The muon-to-proton magnetic moment ratio is obtained simultaneously, which is necessary for the experimental determination of the
muon's anomalous magnetic moment. The experiment is proposed to be performed at J-PARC MLF MUSE, where the world-highest intense pulsed
muon beam is delivered. Since the proposal submission in 2011, we have been developing the apparatus and conducting pilot experiments in a near-zero
magnetic field [3]. We are working on high-precision NMR probes and a passive shimming method to obtain a uniform magnetic field in a superconducting
magnet to proceed to high-field experiments. In this contribution, the project overview, results of the zero-field experiments, and preparation status for a high-field experiment will be introduced.
\vspace{10pt}
[1] W. Liu, *et al.*, Phys. Rev. Lett. 82, 711 (1999).
[2] G. W. Bennet *et al.*, Phys. Rev. D 73, 072003 (2006). [3] S. Kanda *et al.*, Phys. Lett. B 815, 136154 (2021).

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