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New Measurements of Muonic Helium Atom Hyperfine Structure at J-PARC MUSE

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Measurements of the muonic helium atom hyperfine structure (HFS) is a sensitive tool to test three-body atomic system, bound-state quantum electrodynamics (QED) theory, and determine fundamental constants of the negative muon magnetic moment and mass. The world most intense pulsed negative muon beam at J-PARC MUSE gives an opportunity to improve previous measurements and to test further CPT invariance through the comparison of the magnetic moments and masses of positive and negative muons (second generation leptons).
Muonic helium is a hydrogen-like atom composed of a helium atom with one of its electrons replaced by a negative muon. Its ground-state HFS, resulting from the interaction of the remaining electron and the negative muon magnetic moment, is very similar to that of muonium (a bound state of a positive muon and an electron) but inverted. New precise measurements of the muonium ground-state HFS interval using a microwave magnetic resonance technique are now in progress at J-PARC by the MuSEUM collaboration. The same technique as with muonium can be used to precisely measure the muonic helium HFS interval and the negative muon magnetic moment and mass. So, it is a timely opportunity to take advantage of the technical developments and experience gained by Museum to perform new precision measurements of muonic helium HFS [1].
Already, test measurements at D-line are in progress utilizing MuSEUM apparatus at zero field. Muonic helium HFS were measured at different helium pressures to determine the pressure shift using methane as an electron donor. The obtained results have already better accuracy than previous measurements [2,3]. Muonium HFS was also measured to investigate the isotopic effect on the pressure shift. Futhermore, a new experimental approach to improve HFS measurement accuracy is also being investigated by repolarizing muonic helium atoms using a spin exchange optical pumping (SEOP) technique [4,5].
An overview of the different aspects of these new muonic helium HFS measurements and the latest results will be presented.

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