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Precision laser spectroscopy of the ground state hyperfine splitting in muonic hydrogen

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The proton is a fundamental constituent of the world. However, its internal structure has not been fully understood because of the complicity and difficulties in both theory and experiment. In 2010, a significant discrepancy between two independent measurements of the proton charge radius was reported. This conflict is known as “proton radius puzzle”. Even though various interpretations have been proposed, no definitive solution to the problem has been found. One of the most straightforward and effective approaches to this puzzle is an investigation of the magnetic moment distribution in addition to the charge distribution. In the muonic hydrogen hyperfine splitting (HFS), there is a contribution from a finite volume effect of the proton. This contribution is described by the Zemach radius, which is defined as a convolution of the charge distribution with the magnetic moment distribution. In order to shed some light on the puzzle, we proposed a first direct measurement of the muonic hydrogen ground-state HFS for a determination of the proton Zemach radius in the highest precision. The goal of the experiment is a measurement of the muonic hydrogen HFS with 1 ppm of relative uncertainty and a determination of the proton Zemach radius with 1% of precision. We utilize a high-intensity pulsed muon beam, an intense mid-infrared laser, a nuclear spin polarized hydrogen target, and a segmented electron detector. In this presentation, an experimental overview and development progress in each sub-system are discussed.

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