High precision spectroscopy of the 1s–2s transition in muonium with new slow muon and muonium production schemes

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Existing muon beams are of insufficient quality to allow laser spectroscopy with *continuous-wave* laser beams, a prerequisite for ultra-high resolution. In the case of the muonium 1s–2s transition, a fine and intense atomic beam of muonium atoms is required in order to achieve a 10^{-12} precision by *cw* laser spectroscopy. Such a measurement determines the muon mass with a precision of 2×10^{-9} and in conjunction with a remeasurement at PSI of the hyperfine structure interval in muonium at the 3×10^{-9} level, would result in a test of QED with a a factor of 30 increase in precision. It would set a new challenge to QED calculations in a system with no contribution from internal structure.

The incentive of reopening a research field which reached its summit 8 years ago is a new technique of slow muon production presented in Phys. Rev. Lett. 97, 194801 (2006). It is based on the compression and extraction of μ^+'s stopping in a helium gas target. The simplified version of the method that will be presented should allow a reasonably intense μ^+ beam to be focused and stop onto a thin target of less than $100\,\mu$ radius. The experiment considered here should be one of the important motivations for the development of technique.

Next to the muon beam development, the achievement of the aimed precision in the spectroscopy experiment calls for an optimized muonium production scheme. An new concept for vacuum emission of muonium will be presented that should lead to a muonium beam with a quality that compares favorably with existing cold H–beam sources. Under these conditions 1s–2s spectroscopy and muonium ionization can be achieved with cw laser beams with a final precision limited only by the statistical error resulting from the finite muon lifetime.