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Muonium Atom Interferometry for High-precision Studies of Symmetries and Interactions

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Muonium, a hydrogen-like atom consisting of a positive muon and an electron, is a purely leptonic system. Since it contains no composite nucleons, theoretical calculations of its energy levels are free from finite-size effects, making precision spectroscopy of muonium a powerful tool for testing the Standard Model. However, the sensitivity of new physics searches using muonium spectroscopy is often limited by the uncertainty in the muon mass. A new, high-precision determination of the muon mass, independent of muonium spectroscopy, would therefore be highly beneficial for new physics searches. We propose a novel method to measure the muon mass using muonium atom interferometry. In this experiment, the muon mass will be determined by inducing transitions in muonium atoms with a series of laser pulses and quantifying the phase shift between atomic wave packets caused by the associated photon recoils. Realizing this interferometer requires a high-brightness, low-velocity muonium beam. We are currently developing an apparatus for a multi-stage cooling scheme for muons, which combines a solid rare-gas moderator with laser ionization of muonium, to produce such a beam. In this presentation, we will report on the project's overview and the current status of the experimental apparatus and simulations.

Primary author: KANDA, Sohtaro (KEK)

Presenter: KANDA, Sohtaro (KEK)

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