LEMING: Towards the measurement of the gravitational acceleration of muonium atoms

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Muonium (Mu = $\mu^+ + e^-$) is a purely leptonic, two-body exotic atom amenable to laser spectroscopy, which provides precision measurements of fundamental constants (m_μ, μ_μ), and tests of bound state QED. It also provides a unique probe to test the weak equivalence principle on elementary antimatter of the second generation using a system without large contributions to the mass from the strong interaction.

In the newly approved LEMING experiment at the Paul Scherrer institute we aim to measure the free fall of Mu, and pave the way for improved laser spectroscopy measurements. Both experimental goals rely on a novel, cold vacuum muonium source instead of using state-of-the-art thermal sources. We have demonstrated the working principle of a novel Mu source based on muonium conversion of conventional muon beams in thin a layer of superfluid helium, that provided nearly ~ 20 % conversion efficiency to a ~ 30 mrad angular divergence. Such an Mu beam may be amenable to atom interferometry measurements that provide a $\sim 1\%$ precision on the gravitational acceleration of Mu, and has the potential to improve the fractional precision of Mu 1S-2S measurements by more than an order of magnitude, assuming the MuMass excitation scheme.

In this talk, new measurements on the first observation of Mu emitted from superfluid helium and an initial characterization of the novel Mu source are presented. Prospects of this newly developed atomic Mu beam from superfluid helium in the context of future gravity and spectroscopy experiments will be discussed.