LEMING - towards muonium interferometry

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The LEMING experiment aims to measure the gravitational free fall of muonium (Mu = $\mu^+ + e^-$), a purely leptonic, exotic atom. The experiment will be a unique probe to test the weak equivalence principle on elementary, second-generation antimatter using a system without large contributions to the mass from the strong interaction.

This talk will discuss the feasibility of making such a measurement to an error of approximately 1%. The experiment will employ atom interferometry using a three-grating interferometer, which relies on a novel, cold vacuum muonium source with a narrow energy and transverse momentum distribution. We have demonstrated the working principle of such a novel source based on muonium conversion of conventional muon beams in a thin layer of superfluid helium, which provided approximately 8% conversion efficiency to an atomic beam with 25 mrad angular divergence. Besides having the potential to improve the precision of Mu 1S-2S spectroscopy, this beam paves the way towards Mu interferometry.

A far-field, aperture near-field interferometer, based on the Talbot pattern, is being designed for this purpose, where the vertical phase of the interferogram encodes the gravitational acceleration of the atoms, which will be sampled by scanning the third (masking) grating. The main challenges include strict control over vibrational, displacement, and alignment constraints of a sub-nanometer measurement, while allowing for simultaneous X-ray calibration measurement.