Development of new superfluid helium-based muonium sources for the LEMING experiment

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The LEMING experiment aims to measure the gravitational acceleration of muonium (Mu = $\mu^+ + e^-$), a purely leptonic, exotic atom. Mu provides the only viable system to directly test the Weak Equivalence Principle on second generation anti-leptons. It also allows probing the coupling of gravity to the muon mass - a fundamental parameter of the Standard Model - without significant contributions from the strong interaction. The experiment utilizes an atom interferometer, which requires a novel coherent vacuum muonium source.

We have developed such a source by stopping a conventional muon beam in a superfluid helium (SFHe) target. Mu atoms are efficiently emitted from bulk SFHe as a beam with low angular divergence and a narrow velocity distribution. These properties continue to be investigated, particularly in the interest of developing an optimized vertical SFHe target. This new target employs a finely structured silicon grating, which traps SFHe within micron-sized trenches via capillary action. By directly generating a horizontal atomic beam, this novel microfluidic target removes the need for a beam reflector, significantly reducing decay losses caused by the short lifetime of the atoms ($\tau_{Mu} = 2.2\,\mu s$).

In this contribution, we present recent measurements demonstrating the emission of Mu from microfluidic targets of various sizes. We discuss the technical aspects of optimizing and integrating such a target into our current interferometer prototype. Additionally, an upgrade of the cryogenic detection system to silicon strip tracking detectors is presented.