Cold muonium atoms for future atomic physics and gravity experiments

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We are investigating methods to create a novel muonium (Mu) source, based on $\mu^+ \rightarrow \mathrm{Mu}$ conversion near to the surface of superfluid helium (SFHe). This source would have the potential of providing high brightness atomic beams for next generation Mu experiments, *e.g.* to increase precision of present Mu spectroscopy results [1, 2]. We are also investigating the feasibility of using such sources for measuring the gravitational interaction of Mu. The positive muon (μ^+) which is dominating the Mu mass is not only an elementary antiparticle, but a second-generation lepton too. This makes a gravity experiment highly motivated [3], and complementary to gravitational studies of antihydrogen [4, 5, 6] and positronium [7].

State-of-the-art Mu sources (like silica aerogel, mesoporous SiO_2) emit Mu atoms with a large (thermal) energy distribution, and wide ($\sim \cos\theta$) angular distribution. Cooling of these porous samples below 100 K results in rapidly declining numbers of vacuum-emitted muonium due to decreased mobility, and atoms sticking to the pore walls [8]. The advantage of using superfluid helium for Mu production at $T < 0.3$ K temperatures is the expected large chemical potential ($E/k_B \sim 270$ K) of the atom. This implies that in the vicinity of the surface, Mu would be ejected with relatively high (~ 6 mm/μs) velocities from the bulk to near-vacuum even at the lowest temperatures, while transverse momentum would remain low due to the cold media [9]. In this talk, methods and challenges to create such SFHe Mu sources, the present status, and the feasibility of an antimatter gravity experiment will be discussed.

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