Contribution ID: **340** Type: **Invited Talk**

The LEMING experiment

Wednesday 19 October 2022 14:30 (30 minutes)

Despite the immense success of the Standard Model (SM), it is well known to be incomplete in describing Nature. Most obviously it is not incorporating gravity, and also falling short in explaining cosmological observations like the baryon asymmetry of the Universe, or the nature of dark matter and dark energy. Recent tensions concerning lepton universality are also persistent in the latest results of LHCb [1], or the muon g-2 experiment [2]. In this talk, we discuss exotic atomic systems like antiprotonic helium (ASACUSA experiment at CERN) and muonium (LEMING experiment at PSI) that gives us access to some of these beyond SM physics.

In our newly approved LEMING experiment at the Paul Scherrer institute we aspire to carry out next generation atomic physics and gravity experiments using muonium, which is an exotic atom consisting purely leptons, a muon and an electron (M = $\mu^+ + e^-$) [3]. The result of a M gravity measurement would be a direct test of the weak equivalence principle using elementary (anti)leptons from two families, in the absence of large binding energies from the strong interaction.

We started this challenging task by developing a novel cold atomic M beam in vacuum using muon conversion in superfluid helium. The basis of this new concept relied on the measured behavior of exotic atoms in SFHe, a recent laser spectroscopy result using antiprotonic helium at CERN [4]. Our new tantalizing measurements with the newly synthesized cold M beam production put us on a path for increased precision in 1S-2S laser spectroscopy of M, and may pave the way for a free fall experiment, that would be the first direct measurement of the gravitational interaction using (anti)leptons.

References

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[2] Muon g−2 Collaboration, Phys. Rev. Lett. 126, 141801 (2021)
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Session Classification: Session