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Neutron Trapping using a Magneto-Gravitational Trap[1]

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Eighty years after Chadwick discovered the neutron, physicists today still cannot agree on how long the neutron lives. Measurements of the neutron lifetime have achieved the 0.1% level of precision ($\sim$ 1 s). However, results from several recent experiments are up to 7 s lower than the (pre-2010) particle data group (PDG) value. Experiments using the trap technique yield lifetime results lower than those using the beam technique. The PDG urges the community to resolve this discrepancy, now 6.5 sigma. Measuring the absolute neutron lifetime is difficult because of several limitations: the low energy of the neutron decay products, the inability to track slow neutrons, and the fact that the neutron lifetime is long (880.1 $\pm$ 1.1 s). Slow neutrons are susceptible to many loss mechanisms other than beta-decay, such as upscattering and absorption on material surfaces. Often, these interactions act on time scales comparable to the neutron beta-decay, making the extraction of the beta-decay lifetime particularly challenging. We will revisit this measurement by trapping ultracold neutrons (UCN) in a hybrid magnetic-gravitational trap. The trap consists of a Halbach array of permanent magnets, which can levitate UCN up to 50 neV. These neutrons are also confined vertically up to 0.5 m by gravity. Such a trap minimizes the chance of neutron interactions with material walls. In addition, the open-top geometry allows room to implement novel schemes to detect neutrons and decay particles in-situ. The UCNτ experiment aims to reduce the uncertainty of the neutron lifetime measurement to below 1 second. In this talk, I will report results of our first attempt to trap UCN in 2013 and discuss plans to quantify systematic effects.

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