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Measuring the neutron lifetime using a magneto-gravitational trap for ultracold neurons

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Recent measurements of the neutron lifetime have individually reported uncertainties of about 1 s but disagree by as much 7 s, resulting in a shift of about 6.5 sigma in the accepted value over recent years. Measurements based on the decay in flight of cold neutron beams appear to yield longer lifetimes than those based on counting surviving ultracold neutrons after storage in material-walled traps. The present storage experiments are challenged by the existence of multiple neutron loss mechanisms in the trap that act with characteristic times similar to the neutron lifetime of 880.1 (1.1) s, such as absorption or upscatter of the neutrons on the material trap walls and escape of unbound neutrons from quasi-stable orbits within the trap. Also, the efficiency of detection of the surviving trapped neutrons can vary with time due to evolution of neutron population into different regions of phase space within the trap. Therefore, a new experiment, UCNt, is now being developed at Los Alamos National Lab to eliminate these systematic effects by storing the ultracold neutrons in an asymmetric magneto-gravitational trap, in which the neutrons: 1) never interact with a material surface during their storage time in the trap; 2) rapidly populate all of the energetically accessible phase space; and 3) are detected rapidly at the end of the storage time by a novel in-trap integrating activation detector. The trap consists of a bowl-shaped Halbach array of neodymium-iron permanent magnets capable of repelling neutrons with a kinetic energy of up to 50 neV and is closed on the top by gravity. The neutron detector consists of an absorbing vanadium foil which is lowered into the trap from above to collect the surviving neutrons, then withdrawn to an ex situ activation counter. We will present results of the first neutron storage measurement in the trap and results from commissioning the vanadium activation detector, along with our plans to investigate systematic effects in the experiment with the immediate goal of reaching sufficient precision to resolve the difference between the beam and bottle experiments.

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