

## The Neutron Lifetime

F. E. Wietfeldt  
Tulane University  
New Orleans, Louisiana USA

The neutron is a key building block of ordinary matter, more than half of the Earth's mass is contributed by neutrons, but when freed from the confines of a stable atom a neutron decays into a proton, an electron, and an antineutrino with a lifetime of about 15 minutes. Free neutron decay is the prototype semileptonic weak interaction and simplest nuclear beta decay. There are no complications from nuclear structure, and the decay energy is small compared to the nucleon mass so recoil-order corrections enter below the 0.1% level, so neutron decay is an attractive system for precise low energy weak interaction measurements. The neutron lifetime establishes the time scale and temperature of nucleon "freeze out" shortly after the Big Bang, which sets the neutron to proton ratio during the era of primordial nucleosynthesis and thence the light element abundances, and constrains the effective number of light neutrinos. The neutron lifetime has been the subject of more than 20 major experiments since the 1950's. Two main methods, the neutron beam method and the ultracold neutron storage method, have reached the  $10^{-3}$  precision level in recent years but unfortunately now disagree by 10 seconds (5 standard deviations). This "neutron lifetime discrepancy", has been widely discussed, reported in the general media, and has motivated a number of hypothetical exotic physics solutions. I will review the physics of the neutron lifetime, past and current experiments, and describe the new next-generation beam experiment BL3 that will run at the NIST Center for Neutron Research starting in 2027.