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Single atom tagging and the quest for Majorana Neutrinos[1]

GIORGIO GRATTA, Physics Dept, Stanford University

Elementary spin 1/2 particles (fermions) are generally described by a 4-component Dirac wavefunction. However Nature only needs to work this way for charged particles, where particles and antiparticles are distinguished by the charge state. A simpler 2-component Majorana wavefunction can be used to describe *neutral* spin 1/2 particles, in which case the particle-antiparticle and spin symmetries are related to each other. And indeed, Majorana particles have recently emerged in the condensed matter of topological materials. Within the Standard Model of elementary particle physics the neutrino is the only possible candidate for a Majorana particle. Dirac and Majorana behavior is only discernable for particles of finite mass, since in the massless case two of the Dirac states are impossible to reach. The recent discovery of finite neutrino masses has opened the question of whether neutrinos are elementary Majorana particles. In the affirmative case a new nuclear decay, the neutrinoless double-beta decay, is possible, albeit with a half-life that becomes infinite as the mass goes to zero. Present searches for neutrinoless double-beta decay have given negative results, with 90% CL half-lives in excess of 10^{25}yrs. The next generation of experiments will use tons of a specific isotope and search for a few nuclear decays in years of data. The challenge is, of course, to distinguish such decays from the unavoidable background due to trace amounts of natural radioactivity. In the nEXO project we will use tons of the isotope ^{136}Xe , liquefied, in a Time Projection Chamber. In addition to more conventional (and essential) methods to suppress backgrounds, the nEXO collaboration is developing several techniques to recover and spectroscopically identify single atoms of the decay daughter, ^{136}Ba, of the double-beta decay of ^{136}Xe. These techniques can take advantage of ultrasensitive detection methods of atomic physics for a second phase of the nEXO program, with goals of improving the sensitivity to half-lives above 10^{28}yrs, corresponding to neutrino masses well below 10meV. I will describe the general status of the field and the R&D in progress to detect a few atoms of Ba produced in a year in tons of Xe.

[1]On behalf of the nEXO collaboration