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Double-beta decay half-life of 96Zr –nuclear physics meets geochemistry

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Double-beta (\beta\beta) decay measurements are a class of nuclear studies with the objective of detecting the neutrinoless (0\nu) decay variants. Detection of a 0\nu\beta\beta decay would prove the neutrino to be massive and to be its own anti-particle (i.e., a Majorana particle). A key parameter in the detection of the 0\nu\beta\beta decay is the energy, or Q-value, of the decay.

^{96}Zr is of particular interest as a double-beta decay candidate. A geochemical measurement of its \beta\beta decay half-life by measuring an isotopic anomaly of the ^{96}Mo daughter in ancient zircon samples yielded a value of 0.94(32)x10^{19} yr [1]. More recently, the NEMO collaboration measured the half-life directly to be 2.4(3)x10^{19} yr [2], twice as long as the geochemical measurement. As the geochemical result could be contaminated by a sequence of two single \beta-decays, the first being a 4-fold unique forbidden \beta-decay of ^{96}Zr to the 44 keV J^{\pi}=5^+ excited state in ^{96}Nb, followed by the 23 h \beta-decay of ^{96}Nb to ^{96}Mo, further study is mandated. Depending on the Q-value for the first decay, the estimated half-life could be of the same order as the one for the \beta\beta-decay [3]. However, the key parameter is the Q-value for the single \beta-decay, which enters in leading order as Q^{13} into the phase-space factor of the decay.

Such a study is being carried out at the TRIUMF TITAN experiment and at the University of Calgary Isotope Science Lab. At TITAN we are measuring the Q-values for the ^{96}Zr to ^{96}Mo \beta\beta-decay and for the ^{96}Zr to ^{96}Nb single \beta-decay, with the goal of reaching a precision near 0.1 keV. At the UCalgary ISL, we are repeating the measurement of the ^{96}Mo isotopic anomaly using modern equipment and techniques. Combined, these measurements will remove a long-standing discrepancy of the two independent ^{96}Zr \beta\beta-decay half-life measurements.

[1] M. E. Wieser and J. R. De Laeter, Phys. Rev. C 64, 024308 (2001).

[2] NEMO-3 Collaboration, Nucl. Phys. A 847, 168-179 (2010).

[3] J. Suhonen, Univ. Jyväskylä, private communication.

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