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First direct determination of the superallowed β-decay Q-EC-value for O-14 via Penning trap mass spectrometry at the LEBIT facility

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The conserved vector current (CVC) hypothesis asserts that the vector part of the weak interaction is independent of the nuclear interaction. This means that the vector coupling constant Gv is truly a constant and does not require renormalization. This constant, when combined with the purely leptonic muon decay constant GF determines the up-down matrix element Vud of the Cabibbo-Kobayashi-Maskawa (CKM) quark-mixing matrix. Measurements of the f t values of super-allowed $0+ \longrightarrow 0+$ transitions allow Gv to be determined. A precise determination of Vud has been, and continues to be, an important component of the test of the unitarity of the CKM quark-mixing matrix and the search for physics beyond the standard model. To determine an ft value, the decay half-life, the branching ratio for the $0+ \longrightarrow 0+$ transition, and the QEC values need to be known.

Low-Z, superallowed β-emitters like O-14 are particularly significant for setting limits on the existence of scalar currents. While the CVC hypothesis states that Ft should be the same for all superallowed $0+ \longrightarrow 0+$ β-decays, if there is a scalar interaction, an additional term approximately inversely proportional to QEC would be present in Ft. As QEC-values are smaller for lower-Z isotopes, these isotopes would be most sensitive to the presence of a scalar current, showing the largest deviation in Ft. To date, 14 Ft values are used to calculate the world average [1]. Of these 14 decays, only O-14 has not been measured in a Penning trap, despite multiple attempts at other facilities. At LEBIT [2] we have performed the first direct measurement of the ground state β-decay QEC value. This measurement provides an order of magnitude improvement in precision, and it no longer makes a significant contribution to the uncertainty of its associated Ft value. Together with future reductions in the uncertainties of the other major contributors, particularly the half life and branching ratio, more stringent limits will be placed on the existence of scalar currents in the electroweak interaction.

[1] J. C. Hardy and I. S. Towner, Phys. Rev. C 91, 025501 (2015).
[2] R. J. Ringle, S. Schwarz, and G. Bollen, Int. J. Mass Spectrom. 349-350, 87 (2013).

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