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Nuclear Beta Decays and CKM Unitarity

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Results from superallowed β decays between 0^+, $T = 1$ analog states yield the best value for V_{ud}, with a precision of $\pm$0.02%. World data now comprise 14 separate superallowed transitions having $\mathcal{F}t$ values known to 0.1% precision or better. These results, which cover a wide range of parent nuclei from ^{10}C to ^{74}Rb, constitute a very robust data set. Each transition's $\mathcal{F}t$ value depends on its half-life, Q-value and branching ratio. It also depends on small ($\sim$1%) transition-dependent theoretical corrections, of which the most sensitive accounts for isospin symmetry breaking. The validity of these corrections is confirmed by the excellent consistency among the 14 $\mathcal{F}t$-values, an expected consequence of CVC. Recent measurements, which compare pairs of mirror superallowed transitions, further support that validity. With CVC consistency established, the result now yields $V_{ud} = 0.97420(21)$, which makes this by far the most precisely known element of the CKM matrix. Together with V_{us} and V_{ub}, it leads to the most demanding test available of the unitarity of that matrix, with the sum of squares equaling 0.99962(49). Three other types of beta decay can be used to extract V_{ud}: the superallowed beta decay between $T = \frac{1}{2}$ mirror nuclei; and the beta decays of the neutron and pion. All three are hampered by experimental challenges that have limited their V_{ud} precision well short of that achieved with the superallowed $0^+ \rightarrow 0^+$ transitions. They are, however, statistically consistent with it.

E-mail

hardy@tamu.edu

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Primary author: Prof. HARDY, John C. (Texas A&M University)

Presenter: Prof. HARDY, John C. (Texas A&M University)

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