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Unitarity of the CKM mass-mixing matrix as a test of the Standard Model: status and future prospects

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The Cabibbo-Kobayashi-Maskawa (CKM) matrix parameterizes the rotation between the weak and mass eigenstates of the quark families. If the Standard Model of electroweak interactions is complete, then unitarity requires that the sum of the square of the top row of elements is unity, *i.e.* $V_{ud}^2 + V_{us}^2 + V_{ub}^2 = 1$. Currently, this test fails at the $2.4\,\sigma$ level, a provocative discrepancy which may be an indication of new physics not contained within the Standard Model framework. By far the largest element, V_{ud}, is known from measurements of the comparative half-lives, or ft-values, of the nine precisely measured $0^+ \rightarrow 0^+$ superallowed β^+ decays. The 2^{nd} largest, V_{us}, is measured from kaon decays. Recently, the values of both of these elements as adopted by the Particle Data Group have been called into question; it remains to be seen whether unitarity will be satisfied in the end or if the discrepancy is even more pronounced. Within the nuclear physics community, many groups around the world have research programs aimed at improving the measurement of V_{ud}. Some are extending the number of cases of precisely measured superallowed decays; others are testing the theoretical corrections needed to extract V_{ud} from the $0^+ \rightarrow 0^+$ decays. The neutron represents another exciting opportunity to measure V_{ud} because the theoretical corrections are simpler to calculate in this three-quark system. I will review the physics behind the CKM matrix and discuss some of the experiments in progress which will improve the precision of the unitarity test. As examples, I will discuss the UCNA experiment using ultra-cold neutrons and an experiment involving ^{32}Ar as a test of the theoretical corrections applied to the superallowed β decays.