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Discrepancy between experimental and theoretical β-decay rates resolved from first principles

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The dominant decay mode of atomic nuclei is β-decay, a process that changes a neutron into a proton (and vice versa). This decay offers a window to physics beyond the standard model, and is at the heart of microphysical processes in stellar explosions and element synthesis in the Universe. However, observed β-decay rates in nuclei have been found to be systematically smaller than for free neutrons: this 50-year old puzzle about the apparent quenching of the fundamental coupling constant by a factor of about 0.75 is without a first-principles theoretical explanation. This talk demonstrates that this quenching arises to a large extent from the coupling of the weak force to two nucleons as well as from strong correlations in the nucleus. State-of-the-art computations of β-decays, based on effective field theories of the strong and weak forces and powerful quantum many-body techniques, show that the quenching puzzle is solved from light- and medium-mass nuclei to ^{100}Sn. The results, published as [P. Gysbers, G. Hagen, J. D. Holt, G. R. Jansen, T. D. Morris, P. Navratil, T. Papenbrock. S. Quaglioni, A. Schwenk, S. R. Stroberg, and K. A. Wendt, Nature Physics 15, 428 (2019)], are consistent with experimental data and have implications for heavy element synthesis in neutron star mergers and predictions for the neutrino-less double-β-decay, where an analogous quenching puzzle is a source of uncertainty in extracting the neutrino mass scale.