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Lattice QCD Calculation of Electroweak Box Contributions to Superaligned Nuclear and Neutron Beta Decays

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We present the first lattice QCD calculation of the universal axial γW -box contribution $square_{\gamma W}^{VA}$ to both superaligned nuclear and neutron beta decays.

This contribution emerges as a significant component within the theoretical uncertainties surrounding the extraction of $|V_{ud}|$ from superaligned decays.

Our calculation is conducted using two domain wall fermion ensembles at the physical pion mass.

To construct the nucleon 4-point correlation functions, we employ the random sparsening field technique. Furthermore, we incorporate long-distance contributions to the hadronic function using the infinite-volume reconstruction method.

Upon performing the continuum extrapolation, we arrive at

$square_{\gamma W}^{VA} = 3.65(8)_{\text{lat}}(1)_{\text{PT}} \times 10^{-3}$. Consequently, this yields a slightly higher value of $|V_{ud}| = 0.97386(11)_{\text{exp.}}(9)_{\text{RC}}(27)_{\text{NS}}$, reducing the previous 2.1σ tension with the CKM unitarity to 1.8σ .

Additionally, we calculate the vector γW -box contribution to the axial charge g_A , denoted as $square_{\gamma W}^{VV}$, and explore its potential implications.

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