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HOBET: The SM as an Effective Theory and its Direct Matching to LQCD

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The configuration interaction shell model operates in a subset of the complete Hilbert space defined by projection operator P. Unless P is very large, an effective theory treatment is required. Historically, the renormalization into P has been done informally, by adding a few physically motivated operators with associated parameters to the matrix elements of a realistic or chiral potential. The parameters are then tuned to reproduce a selected set of observables. While this approach has some success in reproducing the excitation spectrum of nuclei, the contact with the wave function is lost. Also, even if the P space wave function were the projection of the full wave function, the evaluation of a bare operator $\left\langle f \left| P\hat{O}P \right| i \right\rangle$ between projections of initial and final states would miss longer and shorter range contributions from excluded states defined by Q=1-P and be scaled by the unknown and relatively small fraction of the wave function contained in P.

In this presentation, we describe the formal construction of the shell model as an effective theory along with answers for the renormalization of operators to account for contributions of parts of the wave function outside P and the wave function normalization. The underlying effective interaction can be expressed as an expansion whose LECs can be constrained by observables such as scattering phase shifts and binding energies, or the spectrum of two nucleons in a periodic volume as comes from LQCD calculations.

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