Applications of ChPT currents to low-energy processes

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In the phenomenological potential picture, nuclear responses to external probes are given by one-body terms and exchange-current terms acting on nuclear wave functions that result from solving the Shroedinger equation governed by a potential; furthermore, the exchange currents are derived from one-boson exchange diagrams. This approach, to be referred to as the *standard nuclear physics approach* (SNPA), has been used extensively for describing nuclear electroweak processes. At the more fundamental level, however, one wishes to establish a link between SNPA and QCD. Chiral perturbation theory (ChPT) provides a useful framework to this end. In applying nuclear ChPT to a process that involves an external current, a transition operator $\mathcal{T}$ is obtained from irreducible diagrams that involve the relevant current. To preserve formal consistency, we must calculate the nuclear matrix element of $\mathcal{T}$ with the use of wave functions which are governed by the nuclear interactions that subsume irreducible diagrams up to the relevant order. This program, however, is not always easy to implement, and we often adopt wave functions obtained with the phenomenological potential. We have recently demonstrated [1] that the reliability of this hybrid approach can be significantly improved by renormalizing the relevant low-energy constants (LECs) to reproduce appropriate nuclear observables. We refer to this improved hybrid approach as EFT*.

In [1] we argued that the GT transition amplitudes involving the A=2,3 and 4 nuclei can be controlled simultaneously and systematically using EFT*. To the lowest meaningful order, the two-body currents for the GT transition involve only one unknown LEC (denoted by $\hat{d}_R$), and that, once $\hat{d}_R$ is determined from the tritium β-decay rate, we can make accurate preditions on the solar pp and hep fusion rates. EFT* can also be used to estimate the ν-d cross sections with high precision [2]. These cross sections are of great importance in interpreting the Sudbery Neutrino Observatory experiments.

References

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