How to Classify Three-Body Forces – and Why

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To add 3-body forces when theory and data disagree is untenable when predictions are required. For the “pion-less” Effective Field Theory at momenta below the pion-mass, I provide a recipe to systematically estimate the typical size of 3-body forces in all partial waves and orders, including external currents [1]. It is based on the superficial degree of divergence of the 3-body diagrams which contain only two-body forces and the renormalisation-group argument that low-energy observables must be insensitive to details of short-distance dynamics. Naïve dimensional analysis must be amended as the asymptotic solution to the leading-order problem depends for large off-shell momenta crucially on the partial wave and spin-combination considered. The typical strength of most 3-body forces turns out weaker than expected, demoting many to high orders. As application, the cross section of \( nd \to t\gamma \) at thermal neutron energies bears no new 3-body force [2], besides those fixed by the triton binding energy and \( nd \) scattering length in the triton channel. It is calculated as

\[
[0.485(\text{LO}) + 0.011(\text{NLO}) + 0.007(\text{NNLO})] \text{ mb} = [0.503 \pm 0.003] \text{ mb},
\]

converges and compares well with experiment, \([0.509 \pm 0.015] \text{ mb}\). In contradistinction, potential models list a spread of \([0.49 \ldots 0.66] \text{ mb}\), depending on the 2-nucleon potential and inclusion of the \( \Delta (1232) \).


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