Chiral effective potential with delta degrees of freedom

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The forces between nucleons based on chiral effective field theory have been studied in great detail over the last decade. Most calculations are based on the effective chiral Lagrangian formulated in terms of the asymptotically observed ground state fields, the pions and nucleons chirally coupled to external sources. The excitation of baryon and meson resonances is encoded in the low-energy constants of the pion-nucleon interaction beyond leading order. Such a framework provides an accurate representation of the nucleon-nucleon (NN) phase shifts if extended to a sufficiently high order. Still, it can be argued that the explicit inclusion of the delta, the most important resonance in nuclear physics, allows one to resum a certain class of important contributions and thus leads to an improved convergence as compared to the delta-less theory, provided a proper power counting scheme such as the small scale expansion [1] is employed.

I will present our complete analysis of two and three nucleon forces with explicit Δ degrees of freedom at next-to-next-to-leading order including isospin breaking effects $[2-4]$. The appearing low-energy constants are determined from a fit to pion-nucleon threshold parameters at next-to-leading order. We find an improved convergence for most peripheral NN phases compared to the theory with pions and nucleons only. This work paves the way to a systematic analysis of nuclear forces based on a theory with explicit deltas.

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