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The 1S0 channel in nucleon-nucleon nuclear Effective Field Theory

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A longstanding problem has been to obtain nuclear forces from the underlying theory of QCD. In addition to allowing a derivation of nuclear structure, a first principles approach should provide insight into the nature of the virtual state present in the 1S0 nucleon-nucleon channel, which is very near threshold and thus has an anomalously large, negative scattering length. This fact, which is of relevance for nucleosynthesis and the abundance of the chemical elements in our Universe, is presumed to be caused by fine-tuned cancellations, whose origin remains unknown up to now. QCD at the energies of relevance for nuclear physics is described by Chiral Effective Field Theory, which captures the most general dynamics among nucleons and pions allowed by the symmetries of QCD. We present a systematic study of the different power countings that arise for the most important 1S0 effective range parameters in the context of a toy model consisting of the Yukawa part of one-pion exchange, for a range of pion masses that includes the physical case. We also discuss the more realistic situation in which additional short-range interactions play a significant role.

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