APR17-2016-000403

Abstract for an Invited Paper
for the APR17 Meeting of
the American Physical Society

Local chiral potentials with Δ-intermediate states and the structure of light nuclei

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We present a fully local nucleon-nucleon potential in chiral effective field theory (χEFT) retaining pions, nucleons and Δ-isobars as explicit degrees of freedom, and use it in hypersperical-harmonics and quantum Monte Carlo calculations of ground and excited states of ^{3}H, ^{3}He, ^{4}He, ^{6}He, and ^{6}Li nuclei. The calculation of the potential is carried out by including one- and two-pion-exchange contributions up to next-to-next-to-leading order (N2LO) and contact interactions up to next-to-next-to-next-to-leading order (N3LO). The low-energy constants multiplying these contact interactions are fitted to the 2013 Granada database in two different ranges of laboratory energies, either 0–125 MeV or 0–200 MeV, and to the deuteron binding energy and nn singlet scattering length. Fits to these data are performed for three models characterized by long- and short-range cutoffs, $R_{\rm L}$ and $R_{\rm S}$ respectively, ranging from $(R_{\rm L}, R_{\rm S}) = (1.2, 0.8)$ fm down to $(0.8, 0.6)$ fm. The long-range (short-range) cutoff regularizes the one- and two-pion exchange (contact) part of the potential.