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Nucleon-nucleon interaction in manifestly Lorentz-invariant chiral effective field theory

We propose a systematic approach to study the nucleon-nucleon interaction by applying time-ordered perturbation theory (TOPT) to covariant chiral effective field theory. Diagrammatic rules of TOPT, for the first time, are worked out for particles with non-zero spin and interactions involving time derivatives. They can be applied to derive chiral potentials at any chiral order. The effective potential, as a sum of two-nucleon irreducible time-ordered diagrams, and the scattering equation (Kadyshevsky equation) are obtained within the same framework. According to the Weinberg power counting, at leading order, we find that NN potential is perturbatively renormalizable, and the corresponding integral equation has unique solutions in all partial waves. Through evaluating the two-pion exchange contribution at the one-loop level, we formulate the NN interaction up to NNLO. A good description of phase shifts and the deuteron properties is achieved by treating the full NNLO potential non-perturbatively.

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