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Neutrinoless double beta decay in the relativistic framework

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The neutrinoless double beta decay is of fundamental importance for particle physics, nuclear physics, and cosmology. Nuclear matrix element, which encodes the impact of the nuclear structure on the decay half-life, is crucial to interpreting the experimental limits and even more potential future discoveries. However, current knowledge of the nuclear matrix element is not satisfactory due to the unknown short-range contributions to the transition operator [1] and also the complicated nuclear many-body wavefunctions [2].

For the transition operator, we have developed a relativistic framework based on a manifestly Lorentz-invariant chiral Lagrangian [3]. We show that the neutrinoless double-beta decay transition amplitude can be renormalized at leading order without any unknown short-range operators [4]. This enables a model-free determination of the neutrinoless double beta decay operator in nuclear-structure calculations. It also defines a stringent benchmark for the previous estimation of the unknown short-range contributions in the nonrelativistic framework.

For the nuclear many-body wavefunctions, we have established the relativistic configuration-interaction density functional theory [5,6], a novel framework which combines the advantages of nuclear shell model and relativistic density functional theory. It allows a fully microscopic and self-consistent treatment of nuclear triaxiality within a full model space. It provides the first investigation for the triaxial effects on the nuclear matrix elements for both two-neutrino and neutrinoless double beta decays in 76Ge [7]. The triaxiality enhances the nuclear matrix element of the neutrinoless double beta decay significantly by a factor around two.

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