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Non-relativistic expansion: A potential bridge to connect the relativistic and non-relativistic density functional theories

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Since the 1970s, the density functional theory (DFT) in both the non-relativistic and relativistic frameworks has achieved great successes in describing and understanding the ground-state and excited-state properties of thousands of nuclei in a microscopic and self-consistent way. However, the connection between these two frameworks remains unclear. The non-relativistic expansion is regarded to be the potential bridge. By working out the analytic expression of the $1/M^4$ order in the conventional similarity renormalization group (SRG) method, the convergence of this method is verified. As a step further, the reconstituted SRG method with a much faster speed of convergence is proposed by using the resummation technique [1]. The origin of the difference between the results obtained with the Foldy-Wouthuysen (FW) transformation and the SRG method is further explored [2]. Inspired by the reconstituted SRG method, the reconstituted FW transformation is developed. Different to the reconstituted SRG method, since only finite steps of unitary transformations are performed, both the single-particle vector and scalar densities can be easily calculated in the reconstituted FW transformations. In addition, the relativistic corrections to the single-particle vector and scalar densities are considered in the reconstituted FW transformations. As a result, the so-called picture-change error is further eliminated [3]. The reconstituted SRG method and FW transformation pave a promising way for the connection between the relativistic and non-relativistic DFTs.

References

[1] Y. Guo and H. Liang, Phys. Rev. C **99**, 054324 (2019)

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Field of your work

Theoretical nuclear physics

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