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Coulomb Energy Density Functionals for Nuclear Systems

Since the nuclear force is much stronger than the electromagnetic one, it mainly determines the properties of atomic nuclei. Nevertheless, in specific studies, it is important to evaluate the electromagnetic contribution to the properties of atomic nuclei. Since the electromagnetic force is well known in contrast to the nuclear force, its contribution to properties of atomic nuclei can be evaluated with high accuracy.

The Coulomb exchange and correlation energies in atomic nuclei are evaluated by using the energy density functionals widely applied for the electron systems [1]. Both the local density approximation (LDA) and generalized gradient approximation (GGA) functionals are investigated. We find that the correlation functionals of electron systems do not yield accurate results in atomic nuclei since the correlation energy is written in terms of the response function, which is also affected by the strong interaction as well as the Coulomb interaction in the nucleus.

Self-consistent calculations using the GGA exchange functional are also performed [2]. In most cases, the GGA exchange functional reproduces the exact-Fock Coulomb energy, if one of the GGA-functional coefficients is increased by $25\,\%$ than the original coefficient. This fact is remarkable since the numerical cost of GGA is $O\left(N^3\right)$, whereas the cost of exact Hartree-Fock approximation is $O\left(N^4\right)$ for the self-consistent calculations.

In this talk, future perspectives which are promising to achieve a better description and understanding of effects in which the Coulomb interaction plays important roles, such as the mass difference of mirror nuclei, the energy of the isobaric analog state, and the superallowed Fermi β decay are also given.

Reference

[1] T. Naito, R. Akashi, and H. Liang. Phys. Rev. C **97**, 044319 (2018).
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Primary authors: Mr NAITO, Tomoya (Department of Physics, The University of Tokyo/RIKEN Nishina Center); Dr AKASHI, Ryosuke (Department of Physics, The University of Tokyo); COLO', Gianluca (MI); Dr LIANG, Haozhao (RIKEN Nishina Center/Department of Physics, The University of Tokyo); Dr ROCA-MAZA, Xavier (Dipartimento di Fisica, Università degli Studi di Milano and INFN, Sezione di Milano)

Presenter: Mr NAITO, Tomoya (Department of Physics, The University of Tokyo/RIKEN Nishina Center)

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