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Recent progress in global optimizations of covariant energy density functionals

Content

Covariant density functional theory (CDFT) describes the nucleus as a system of A nucleons (fermions) which interact via the exchange of different mesons. It is very successful in the description of phenomena related to nuclear structure, nuclear reactions and nuclear astrophysics [1]. However, at present absolute majority of covariant energy density functionals (CEDFs) are fitted to spherical nuclei. This does not permit the improvement of the global description of nuclear observables (for example, nuclear masses) and creates theoretical uncertainties.
Our group is working on the global improvement of covariant energy density functionals (CEDFs) towards more accurate description of binding energies, charge radii, deformations etc. across the nuclear chart. Some important steps in that directions will be discussed in this presentation. To overcome numerical problems connected with global fit of energy density functionals (EDFs), a new anchor-based optimization method has been proposed by us in [2]. In this approach, the optimization of the parameters of EDFs is carried out for a selected set of spherical anchor nuclei, the physical observables of which are modified by the correction function, which takes into account the global performance of EDFs. It is shown that the use of this approach leads to a substantial improvement in the global description of binding energies for several classes of covariant EDFs at moderate computational cost [2,3,4]. This allows for the first time to take into account infinite basis corrections to binding energies in the fermionic and mesonic (bosonic) sectors of CDFT [4]. For the first time total electron binding energies for atoms of superheavy elements have been calculated within atomic relativistic Hartree-Fock approach and the dependence of these energies on the neutron excess has been investigated across the nuclear chart [4,5]. In addition, it was shown that theoretical uncertainties in the calculations of the total electron binding energies are very small. This allows very accurate conversion of experimental atomic binding energies presented in Atomic Mass Evaluations into nuclear ones. The latter are used in global fits of CEDFs. The connection of the parameters of CEDFs defined via global fits of nuclear binding energies with nuclear matter properties generated by these functionals has been investigated. The remaining issues and in progress results will be discussed. A particular attention will be paid to implementation of beyond mean field effects into fitting protocol.

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