Constraints on the nuclear energy density functional and new possible analytical forms

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Résumé

The theoretical tool of choice for the microscopic description of all medium- and heavy-mass nuclei is the Energy Density Functional (EDF) method. Such a method relies on the concept of spontaneous symmetry breaking and restoration. In that sense, it is intrinsically a two-step approach. However, the symmetry restoration procedure is only well-defined in the particular case where the energy functional derives from a pseudo-potential. Thereby and as it has been recently shown, existing parameterizations of the energy functional provides unphysical results. Such a problem as well as the lack of predictive power call for developing new families of functionals. The first part of the presented work is devoted to a study of the symmetry restoration problem and to the identification of properties that could constrain the analytic form of energy functionals that do not derive from a pseudo-potential. The second part deals with the construction of an energy functional that derives from a pseudo potential. The difficulties of such work are (i) the identification of the minimal complexity of the pseudo-potential necessary to obtain an energy functional that is flexible enough to provide high-quality EDF parameterizations, (ii) the tedious analytical derivation of the functional and of the associated one-body fields, (iii) the implementation of the latter in existing codes, and (iv) the development of an efficient fitting procedure. Eventually, it seems possible to generate a parameterization that strictly derives from a pseudo-potential and that provides as good results as state-of-the-art (quasi) bilinear functionals.

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