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Correlations beyond mean field based on covariant density functional theory*

Peter Ring[1,2]

[1]Physics Department, Technical University Munich, 85748 Garching, Germany
[2]School of Physics, Peking University, 100871 Beijing, China

Abstract

The concept of Density Functional Theory (DFT) is a mapping of the complicated quantum mechanical many-body problem to a one-body problem, which can be solved relatively easily. Correlations are taken into account by the violation of symmetries. In nuclear physics DFT provides a very successful and universal description of nuclei all over the periodic table. Covariant versions (CDFT) take into account full Lorentz invariance, a basic symmetry of QCD. It puts stringent restrictions on the number of parameters without loosing the good agreement with experimental data.

According to the Kohn-Hohenberg theorem, DFT is known to be exact for the description of ground state properties of systems in an external field, but for self-bound systems such as nuclei this fact is still under debate. On the other side nuclear density functional theory is based on phenomenological functionals and in practical applications it is evident that not all the correlations can be taken into account in this way and that there are many important nuclear phenomena, such as shape coexistence or the structure of nuclear spectra, cannot be described successfully on a pure mean field level.

Therefore there are a number of extensions of nuclear density functional theory which start from successful phenomenological nuclear density functionals and allow, without new parameters, the mixing of configurations and the description of excited states. We give an overview of such methods for covariant density functional theory and discuss a number of recent applications, such as quantum phase transitions, complex spectra in transitional nuclei, or neutrinoless double beta decay.

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