Higher-order terms in the nuclear-energy-density functional

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One of the current projects at the Department of Physics in the University of Jyväskylä is to explore more general forms of the Skyrme energy-density functional (EDF). The aim is to find new phenomenological terms which are sensitive to experimental data.

In this context we have extended the Skyrme functional by including terms which contain higher orders of derivatives allowing for a better description of finite range effects. This was done by employing an expansion in derivatives in a spherical-tensor formalism [1] motivated by ideas of the density-matrix expansion. The resulting functionals have different number of free parameters depending on the order in derivatives and assumed symmetries, see Fig. 1. The usual Skyrme EDF is obtained as a second order expansion while we keep terms up to sixth order.

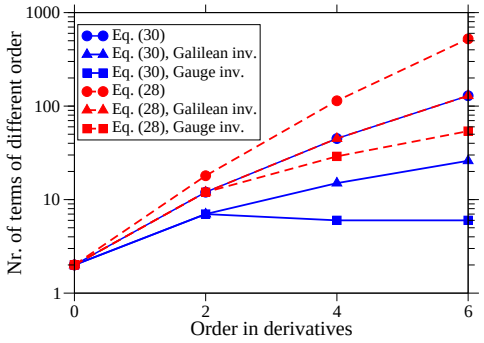

FIG. 1: Numbers of terms in the EDF with density dependent and density independent coupling cosntants, Eqs. (28) and (30) of [1], respectively, plotted in logarithmic scale as a function of the order in derivatives (Figure taken from [1]).

Using the notation introduced in reference [1], the self-consistent mean-field equations as well as the linear-response equations are derived straightforwardly in a systematic way. A spherical code working in the harmonic-oscillator basis is being constructed and will be used to consider the effect of the new terms on single-particle levels in spherical nuclei.

We are also calculating the contributions to infinite nuclear matter in order to put constraints on free parameters in the functional. The conditions for the continuity equation (in the time dependent case) to be preserved are also investigated.

[1] B. G. Carlsson, J. Dobaczewski, and M. Kortelainen, Phys. Rev. C **78**, 044326 (2008)