Breaking and restoring symmetries within the nuclear energy density functional framework

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Symmetries are essential features of quantal systems as they characterize their energetics and provide transition matrix elements of operators with specific selection rules. However, certain emergent phenomena relate to the spontaneous breaking of those symmetries [1]. In nuclear systems, such spontaneously-broken symmetries (i) relate to specific features of the inter-particle interactions, (ii) characterize internal correlations and (ii) leave clear fingerprints in the excitation spectrum of the system. In finite systems though, quantum fluctuations cannot be ignored such that the concept of spontaneous symmetry breaking is only an intermediate description that arises within certain approximations. Eventually, symmetries must be restored to achieve a complete description of the system.

We presently discuss the breaking and restoration of symmetries within the frame of the nuclear energy density functional (EDF) method [2]. In this context, we focus on key differences between wave-function- and energy-functional-based methods. Such differences underline pathologies that have recently been identified in EDF-based calculations [3, 4, 5] and for which cures have been proposed [6, 7, 8]. Building on the work of Ref. [7] and taking angular-momentum as an example, we will discuss new potential constraints on the underlying energy density functional that could make the restoration of broken symmetries better formulated within EDF-based methods [9].

References

[1] C. Yannouleas, U. Landman, Rep. Prog. Phys. 70 (2007) 2067 and references therein
[2] M. Bender, P.-H. Heenen, P.-G. Reinhard, Rev. Mod. Phys. 75 (2003) 121 and references therein
[3] D. Almehed, S. Frauendorf, F. Donau, Phys. Rev. C63 (2001) 044311
[4] M. Anguiano, J. L. Egido, L. M. Robledo, Nucl. Phys. A696 (2001) 467
[5] J. Dobaczewski, W. Nazarewicz, P. G. Reinhard, M. V. Stoitsov, Phys. Rev. C 76 (2007) 054315
[6] D. Lacroix, T. Duguet, M. Bender, Phys. Rev. C 79 (2009) 044318
[7] M. Bender, T. Duguet, D. Lacroix, Phys. Rev. C 79 (2009) 044319
[8] T. Duguet, M. Bender, K. Bennaceur, D. Lacroix, T. Lesinski, Phys. Rev. C 79 (2009) 044320
[9] T. Duguet, J. Sadoudi, J. Phys. G: Nucl. Part. Phys. 37 (2010) 064009