Recent developments in mean-field theories

Michael Bender

Université Bordeaux 1; CNRS/IN2P3; Centre d'Études Nucléaires de Bordeaux Gradignan, UMR5797, Chemin du Solarium, BP120, 33175 Gradignan, France

At present, methods based on self-consistent mean-field approaches are the only nuclear structure models that can be applied to all nuclei throughout the chart of nuclei except for the very lightest ones using a universal effective interaction, usually provided by an energy density functional [1]. This presentation will motivate why and when it is advantageous, even necessary, to go beyond the self-consistent mean field, and how to achieve this in a systematic manner by adding dynamical long-range correlations to existing mean-field methods through the restoration of symmetries and configuration mixing in the framework of the Generator Coordinate Method (see [2] and references therein for a summary of ideas), which has the promise of leading to a numerically tractable universal and consistent framework to calculate ground states and excited states of any nucleus and the transitions between them. The current state-of-the-art will be illustrated by results for nuclei exhibiting shape coexistence[3-5] and the systematics of masses of even-even nuclei [6]. An outlook will sketch necessary developments currently underway to turn this promising method into a tool with high predictive power for all nuclei as (i) the construction and parameterization of effective energy density functionals with significantly improved single-particle spectra as compared to the currently available ones (see Refs. [5,7]), (ii) the use of a richer variational space [8] than what was used in the past and (iii) the set-up of a consistent framework for configuration mixing when using an effective energy density functional that does not correspond to a many-body Hamiltonian, as the prescriptions commonly used are prone to unexpected inconsistencies that were overlooked so far [9,10].

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