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Odd-mass Nb isotopes as a region of intertwined quantum phase transitions

Content

Structural changes induced by variation of parameters in the Hamiltonian, called quantum phase transitions (QPTs), are currently a topic of great interest in nuclear physics. In this field, most of the experimental and theoretical attention has been devoted to the evolution of structure with nucleon number, exhibiting two types of phase transitions. The first, denoted as Type I, is a shape-phase transition within a single configuration, *e.g.*, between spherical and deformed nuclei, as encountered in the neutron number 90 region [1]. The second, denoted as Type II, is a phase transition involving a crossing of different configurations, *e.g.*, of normal and intruder states, as encountered in nuclei near (sub-) shell closure [2]. If the mixing between the configurations is small, the Type II QPT can be accompanied by a distinguished Type I QPT within each configuration separately. Such a scenario, referred to as intertwined QPTs, was recently shown to occur in the $^{92-110}$Zr (Z=40) isotopes [3,4].

QPTs have been studied extensively in even-even nuclei, but far less in odd-even nuclei due to their complexity. For the latter, fully microscopic approaches, such as the large-scale shell model and beyond-mean-field methods, are computationally demanding and encounter difficulties. Alternative approaches involving particle-core coupling schemes, employing algebraic modeling and density functionals-based mean-field methods, have been proposed. So far these approaches were restricted to Type I QPTs in odd-mass nuclei without configuration mixing. In the present contribution, we present a general Bose-Fermi framework for studying spectral properties of QPTs and coexistence phenomena in odd-mass nuclei, in the presence of configuration mixing [5]. An application to the odd-mass $^{93-105}$Nb (Z=41) isotopes, discloses a Type I QPT (gradual evolution from spherical to deformed core shapes and transition from weak to strong coupling within the intruder configuration), superimposed on a Type II QPT (abrupt crossing of normal and intruder configurations). The pronounced presence of both types of QPTs demonstrates the occurrence of intertwined QPTs in odd-mass nuclei. Both quantum and classical aspects of this scenario will be considered. Work done in collaboration with N. Gavrielov (HU) and F. Iachello (Yale).

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