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Atomic nucleus at the edge of stability

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Loosely bound nuclei are currently the focus of interest in low-energy nuclear physics. The deeper understanding of their properties, provided by the open-shell model for quantum systems, changes the understanding of many phenomena and opens new horizons for spectroscopic studies of nuclei from the drop lines to the β-stability valley, as well as for states near and above the particle emission threshold [1,2]. Systematic studies in this broad region of masses and excitation energies will extend and complete our knowledge of atomic nuclei at the edge of stability.

In this lecture I will discuss recent progress in the description of nuclear states using the shell model for open quantum systems. In particular, I will present selected applications of the real energy continuum shell model, the so-called shell model embedded in the continuum, and the complex energy continuum shell model, the so-called Gamow shell model in the coupled channel basis. The most important generic properties of open quantum systems will be illustrated by examples of (i) the near-threshold collectivity and clustering, (ii) chameleon features of the resonances, (iii) the low-energy reactions of astrophysical importance, (iv) the modification of electromagnetic transitions by the coupling to decay channels, (v) the change of effective NN interactions and shell occupancy in weakly bound/unbound states, (vi) the exceptional point singularities in the scattering continuum and their consequences in the nuclear spectroscopy and reactions. Based on these examples, I will argue that near-threshold nuclear states constitute a new quantum regime of atomic nucleus with unique, universal properties.

[1] N. Michel, M. Płoszajczak, *Gamow Shell Model - The Unified Theory of Nuclear Structure and Reactions*, Lecture Notes in Physics **983** (Springer, Cham, 2021).

[2] N. Michel, W. Nazarewicz, M. Płoszajczak and T. Vertse, J. Phys. G: Nucl. Part. Phys., **36** (2008) 013101.