2015 European Nuclear Physics Conference
European Physical Society · university of groningen · kvi - center for advanced radiation technology
Groningen · 31 August - 4 September 2015 · www.EuNCP2015.org

Contribution ID: **199** Type: **Oral**

Evolution of low-energy nuclear collective excitations

Thursday, 3 September 2015 12:00 (30 minutes)

Low-energy collective excitations reflect the underlying effective nuclear interactions and shell structure of single-nucleon orbitals. The evolution of collective states characterizes a variety of interesting structure phenomena across the nuclide chart: clustering in light nuclei, modification of shell structures and occurrence of deformations in closed-shell nuclei far from stability, location of the drip-line in neutron-rich nuclei, shape coexistence and shape transitions in medium-heavy and heavy nuclei, low-energy resonances and the formation of neutron skin, octupole correlations, subshell closures in deformed superheavy nuclei, etc. An accurate modeling of low-energy collective excitations presents a challenge and crucial test for any theoretical approach. The microscopic self-consistent mean-field method that uses effective interactions or universal energy density functionals, provides a complete and detailed description of ground-state properties and collective excitations, from relatively light systems to superheavy nuclei, and from the valley of beta-stability to the particle drip-lines. Based on this framework, structure models have been developed that go beyond the static mean-field approximation and include collective correlations related to restoration of broken symmetries and fluctuations of collective variables. These models have become standard tools for nuclear structure calculations, able to describe and explain a wealth of new data from radioactive-beam facilities, the exciting phenomenology of nuclear astrophysics, and provide microscopic predictions for low-energy nuclear phenomena.

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Session Classification: Plenary VIII