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Fine and Gross Spectral Features of New Modes of Nuclear Excitations

The emergence of low-energy dipole strength in nuclei with neutron excess, named pygmy dipole resonance, has triggered a great deal of experimental and theoretical effort.
Despite of many experimental and theoretical evidences for the close relationship between the pygmy dipole resonance and the neutron skin, there is currently no direct method to experimentally extract the neutron skin thickness from the pygmy dipole resonance. This could be related to the fact that at excitation energies below the neutron separation energy the pygmy resonances of dipole or higher multipolarity coexist with a variety of modes, such as the tail of giant resonances and multi-phonon excitations. The question that arises in this connection is how to differentiate the contributions of different origin to the low-energy photoabsorption spectra and in particular the pygmy dipole and giant dipole resonance modes which are supposed to have the largest impact to energy-weighted sum rules. For that purpose, we performed investigations in our theoretical approach which is based on highly advanced microscopic theory incorporating the energy-density functional and extended with multi-phonons quasiparticle-random-phase approximation. The obtained results could clearly separate pygmy resonance mode from other excitations. Of particular interest is the description as well of the fine structure of pygmy resonances. The relation of the latter to nuclear polarizability and symmetry energy and astrophysics is investigated.
Furthermore, energy-density-functional plus quasiparticle-phonon model (EDF+QPM) approach was implemented in first systematic studies of low-energy nuclear quadrupole response in neutron-rich Sn nuclei and it was able to predict a new mode of excitation named pygmy quadrupole resonance. The theoretical predictions within the EDF+QPM theory were further confirmed by independent measurements of low-energy quadrupole states with different probes which allow to identify the pygmy quadrupole resonance. The observed spectroscopic features of the pygmy quadrupole resonance are well described by the theory.

Primary author: Dr TSONEVA, Nadia (ELI-NP/IFIN-HH)

Presenter: Dr TSONEVA, Nadia (ELI-NP/IFIN-HH)

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