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Pygmy dipole resonances in deformed nuclei

It is well established that the study of the low lying dipole states, the so called Pygmy Dipole Resonance (PDR), can be fruitful done by using an isoscalar probe in addition to the conventional isovector one due to the fact that their transition densities show a strong mixing of their isoscalar and isovector components. The combined use of real and virtual phonons and experiments employing ($\alpha, \alpha\gamma$) as well as (^{17}O, ^{17}O' γ), for the investigation of the PDR states has unveiled a new feature of these states: the splitting of the PDR. Namely, the energy region of these low-lying dipole states can be separated in two parts: the lower part is excited by both the isoscalar and isovector interactions while the high energy part is populated only by the electromagnetic probes.

In deformed nuclei the Giant Dipole Resonance (GDR) peak is separated in two parts. Each of them corresponds to an out-of-phase oscillation of neutron against protons along the symmetry and its perpendicular axes. A common picture of the PDR consider that this mode can be generated by an out-of-phase oscillation of the neutron excess against a proton plus neutron core. If this were true then the same mechanism leading to the splitting of the GDR should be valid also for the low lying dipole states, therefore producing a separation of the pygmy dipole peak in two bumps.

A strong isoscalar-isovector mixing at the nuclear surface is found for the transition densities calculated within a simple macroscopic model. These results are corroborated by some microscopic calculations.

The macroscopic model is designed for nuclei with neutron excess. It consists in a deformed core surrounded by a deformed skin formed by the neutron excess. An out of phase oscillation of the skin against the core is allowed and the corresponding transition densities are constructed. This simple model shows that a suitable way to investigate the pygmy states in deformed prolate nuclei is through the use of isoscalar probes. Measurement of the pygmy excitations along an isotope chain with increasing deformation may give new perspectives about these novel excitation modes.

Primary author: LANZA, Edoardo G.

Presenter: LANZA, Edoardo G.

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