BRINK-AXEL HYPOTHESIS IN THE PYGMY DIPOLE RESONANCE REGION

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Abstract:
The gamma strength functions are fundamental properties of atomic nuclei as they govern the formation and decay of excited nuclei. They are also inputs for calculations of radiative neutron capture cross-sections which play a central role in astrophysics models of nucleosynthesis and stellar evolution. The astrophysics simulations require the knowledge of nuclear structure ingredients for about 5000 nuclids therefore they rely on theoretical predictions of nuclear structure observables, including the gamma strength functions.

While all electromagnetic multipoles can contribute to the strength function, usually the electric dipole (E1) transitions dominate. Above the particle threshold, the E1 strength function is governed by the isovector giant dipole resonance (GDR) but at lower energies the situation is more complex : in nuclei with neutron excess one observes an enhancement of the strength called pygmy dipole resonance interpreted as an excitation of the neutron skin over the N=Z core. As the pygmy mode is located near particle threshold, its impact on astrophysical reactions rates and resulting abundounces of the r-process have been studied [1].

The Brink-Axel hypothesis states in its primary primary version that the cross section of the GDR is independent on the structure of the state on which it is built. As in the stellar environements one deals with with finite temperatures, the validity of Brink-Axel hypothesis for excited states becomes crucial. In a recent experiment [2] a deviation from this hypothesis was noted in the decay of ^{208}Pb to different final states in the PDR region. Other existing experimental evidence and theoretical calculations remain inconclusive about the regions of validity of the Brink-Axel hypothesis.

Currently, the only theoretical approach which can describe coherently photoabsorption and gamma decay of excited states is the Configuration Interaction. In this internship, we are going to use this approach to study the evolution of the PDR with temperature in light nuclei, where such calculations are easily feasible. We are going to check the validity of the Brink-Axel hypothesis for selected cases and propose a microscopic explanation of the observed behavior of the PDR evolution.

This work can be continued as a PhD project, extending the subject to further calculations of interest for the r-process simulations which are carried out in collaboration with Université Libre de Bruxèlles.

[1] S. Goriely, E. Khan, M. Samyn, Nucl. Phys. A739, 331 (2004).
[2] B. Wasilewska et al. , Acta Phys. Pol. 50, 469 (2019).
[3] K. Sieja, Phys. Rev. Lett. 119, 052502 (2017).