DIPOLE EXCITATIONS OF NUCLEI : THEORETICAL MODELS AND APPLICATIONS

RESPONSABLE: KAMILA SIEJA
IPHC 23 RUE DU LOESS, 67037 STRASBOURG
TEL : 03 88 10 61 67 ; E-MAIL : KAMILA.SIEJA@IPHC.CNRS.FR

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 (PDR) 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 aboundances of the r-process have been studied [1].
In recent years the Configuration Interaction approach was developed to study the radiative decay and photoresponse of nuclei [2,3]. In particular, the electric dipole response of light nuclei was studied in the PDR region, showing interesting effects of the redistribution of the PDR strengths on excited states of nuclei which may have consequences in the modeling of strength distributions used in calculations of reactions of astrophysical interest. However, due to the exponential increase of basis dimensions in the CI method, studying dipole response in heavier-mass nuclei becomes quickly impossible.
In this PhD project we will thus develop theoretical approaches and effective numerical algorithmes to tackle the problem of the dipole response of atomic nuclei. In particular, we will implement the possibility of such calculations to the recently-proposed Discrete Non-Orthogonal Shell Model approach [4] which bypasses the CI size problem by replacing the CI basis with a different family of states. Applications of the new method will be done to study PDR (E1) and scissors modes (M1) in various parts of the nuclear chart, currently inaccessible to standard diagonalization approaches.

[1] S. Goriely, E. Khan, M. Samyn, Nucl. Phys. A739, 331 (2004).
[2] K. Sieja, Phys. Rev. Lett. 119, 052502 (2017).
[3] K. Sieja, submitted (2023).
[4] D. D. Dao and F. Nowacki, Phys. Rev. C105 (2022) 054314.