PhD position in experimental nuclear physics

Study of clustering using low-energy reactions induced by neutron-rich oxygen isotopes

Description: Correlations between nucleons are responsible for the formation of clusters in nuclei and in nuclear matter. The formation of clusters, especially of α particles, is essential for the understanding of fundamental nuclear processes such as the α radioactivity. They also play a key role in the description of the structure of light nuclei, in particular α-conjugated stable nuclei such as ^{12}C, or ^{16}O [1,2]. Clustering is also expected to manifest itself in dilute nuclear matter, such as the one produced in heavy-ion collisions during the expansion phase [3,4], or in low-density matter produced in the core-collapse supernovae and neutron star mergers. In the latter case, cluster formation can influence the production of r-process elements [5].
In ground state nuclei clusters are expected to be present at the nuclear surface where densities are below the α-cluster dissolution threshold (Mott density). Indeed, the pre-existence of α-clusters in nuclei was demonstrated in the 70s and 80s in proton-induced α-knockout reactions [6]. Since then, the possibility to investigate nuclei far from stability has opened up new opportunities, since the larger number of combinations of valence nucleons should increase the number of cluster configurations [7,8]. In the recent years, a number of experiments tried to identify those cluster configurations from the charged-particle decay of unbound states in neutron-rich light nuclei [9, 10, 11, 12, 13].

The aim of this thesis is to study α-clustering in neutron-rich oxygen isotopes in order to derive information on their structural properties but also on the evolution of the probability of α-clustering with the neutron skin thickness. To achieve this goal, we have submitted a proposal to the GANIL PAC (E889_23) in which we will carry out an experiment at GANIL using ^{16}O, ^{18}O, and exotic ^{20}O beams at 10.7 MeV/nucleon to populate unbound states via deep inelastic collisions. The charged-particle decay of the resonant states will be measured with the FAZIA and INDRA detectors to reconstruct the corresponding invariant masses.
Cluster configurations have been observed by charged-particle decaying unbound states in ^{18}O, $^{14}C\otimes\alpha$ [9] and in ^{20}O, $^{14}C\otimes{}^{6}He$ and $^{16}C\otimes\alpha$. However, α-branching ratios have only been obtained for ^{18}O [11, 12]. The excellent energy and isotopic resolution of the FAZIA detector together with its multi-hit capability will allow us to unambiguously identify the $^{14}C\otimes{}^{6}He$ and $^{16}C\otimes\alpha$ decays from ^{20}O, and accurately determine the corresponding α-branching ratios. Other resonant states decaying into two or more charged particles will also be measured.

The student will be involved in the following activities:
-participation in the campaign of measurement, using stable and radioactive beams, with the INDRA-FAZIA experimental device,
- analysis of the experiments using the KaliVeda analysis tools, especially regarding correlation observables;
- reduction of data performed with the coupling INDRA-FAZIA, including their analysis and interpretation.

Expected skills:
root software data analysis, ability to work in team

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