« STRUCTURE OF VERY NEUTRON RICH NUCLEI: ^{10}HE AND ^{52}AR»

DESCRIPTION OF THE SUBJECT

Exploring neutron rich nuclei allowed discovering new unexpected phenomena. The most emblematic example is the observation of a halo of neutrons with anomalously high density far from the core. Nuclear matter allows also the formation of neutron skins at the nucleus periphery in nuclei with very exotic neutron over proton ratios. These observations are closely linked to the search for the limit of nuclear existence, *ie* the dripline. From the structure point of view, it was discovered that magic numbers may evolve and even disappear due to correlations, and new ones may appear far from stability as N=16 for Oxygen.

The study of exotic nuclei produced at very low intensity via fragmentation at several hundreds of MeV/u calls for the use of a thick target to increase luminosity. Usually, the use of such target is limited by the degradation in energy resolution induced by the uncertainty on vertex position. The MINOS device [1], a thick liquid hydrogen target coupled to a vertex tracker (Fig. 1) recently developed at IRFU (2012-2013), allows to measure, for the first time, vertex position inside the target.

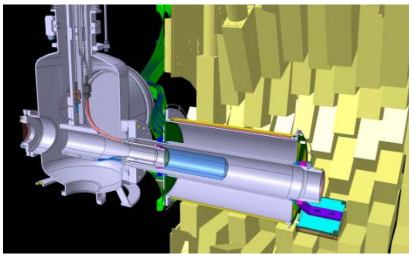

Figure 1: View of the MINOS system (target and tracker) coupled to a gamma array.

The thesis will focus on the study of very exotic nuclei (even beyond the dripline) that are expected to be magic. The first one is the halo nucleus ^{10}He, with Z=2 and N=8. Its unbound nature is well established [2] but different experiments yield different excitation spectra. The second one is ^{52}Ar with N=34 neutrons, which is claimed to be a new magic number in the region of ^{54}Ca [3]. The three-body force or the tensor term of the nuclear interaction could explain this controversial subshell closure.

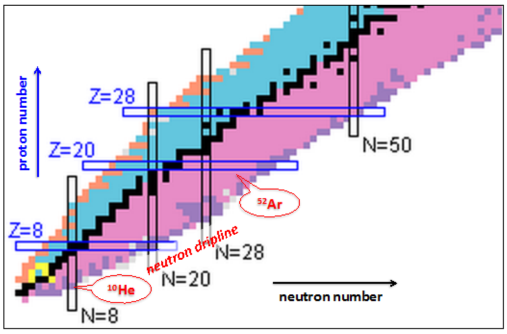

Figure 2: Nuclides chart, with the nuclei of interest for this thesis.

[1] A. Obertelli *et al.*, Eur. Phys. J. A **50**, 8 (2014).
[2] A.A.Korsheninnikov *et al.*, Phys. Lett. B **326**, 31 (1994).
[3] D. Steppenbeck *et al.*, Nature **502**, 207 (2013).

DESCRIPTION OF LABORATORY/GROUP/ADVISOR

Nuclear structure group at SPhN is composed of 12 researchers working on exotic nuclei, deformed nuclei, superheavy nuclei and theory. This thesis will lead to a close collaboration with most of them and in particular the experimentalist working on MINOS and the theorists. The framework of the thesis will be MINOS and SEASTAR collaborations. MINOS is composed of physicists and engineers from CEA and foreign collaborators, mainly from Japan. MINOS was financed by the ERC (European Research Council) on 2010-2015 periods. Its exploitation in Japan is governed by an agreement between CEA and RIKEN. SEASTAR is a collaboration focussed on gamma spectroscopy of exotic nuclei composed of more that 100 physicist worldwide. An application for a scholarship for a long stay in Japan can be envisaged depending on candidate's interest and experiments schedule.

The thesis will be directed by A. Corsi (CEA contact person) and A. Obertelli (thesis advisor).

WORK PLAN

The thesis will focus on the analysis of data taken with MINOS coupled to SAMURAI spectrometer at RIKEN, in Japan. SAMURAI large acceptance spectrometer allows measuring simultaneously many reaction channels. An experiment was performed in 2014 to study the structure of ^{11}Li, ^{14}Be and ^{17}B nuclei, with a two-neutron halo. Part of data has still to be analysed, namely the reaction channel ^{11}Li(p,2p) populating the unbound excited states of ^{10}He. This high-statistic measurement should bring additional information in the debate on the spectroscopy of this extremely neutron rich nucleus. A second experiment with the goal of studying the spectroscopy of ^{52}Ar and neighbouring nuclei is foreseen in Fall 2016 at the SAMURAI spectrometer. The candidate will first take in charge the analysis of data of ^{11}Li(p,2p)^{10}He reaction from 2014 experiment. This will give him a strong background on data analysis that will be an asset for the follow up of the thesis, which will consist in performing and analysing the experiment on ^{52}Ar region foreseen for 2016. In both cases, data analysis will be followed by interpretation of the results in collaboration with theorist of nuclear structure and reaction mechanism.

The candidate will also participate to other experiment using MINOS at RIKEN and, depending on its agenda and scientific project, join other experiment of the group related to exotic nuclei

TRAINING AND REQUIRED SKILLS

The candidate will have the opportunity to work with the world best devices for nuclear physics: RIKEN accelerator facility and MINOS device, unique in its kind. The proposed work is very exhaustive since it includes the preparation of an experiment, data analysis and interpretation. The experimental part will have a very important place since MINOS is developed at IRFU. The candidate will develop a unique expertise in testing and operating the cryogenic target and the tracker. A close collaboration with theorists working on nuclear structure (*ab initio* theories) and reaction mechanisms will offer the candidate the opportunity to develop his knowledge in theory.

COLLABORATIONS

The framework of the thesis is an international (mainly French and Japanese) collaboration. Theoretical interpretation will be done in collaboration with the best experts in the field. Working with the MINOS device the candidate will gain an important technical expertise thanks to the close collaboration with engineers and technicians from CEA.

CONTACTS

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