STUDY OF EXOTIC NUCLEI THROUGH CONVERSION ELECTRON SPECTROSCOPY

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The knowledge of spin and parity of excited levels in exotic nuclei revealed exciting phenomena appearing only in nuclei with extreme N/Z ratios. Excited levels in nuclei are mainly depopulated by competitive processes between gamma-emission and internal electron conversion. The spin and parity of the initial and final state for a given Z and gamma energy could be deduced by knowing the ratio between the emitted conversion electrons and gamma particles. By measuring the internal conversion coefficient α_k or the ratio α_k/α_L we can extract the multipolarity of the transition. This paper will present preliminary results concerning the evolution of $g_{9/2}$ orbital with increasing number of neutrons in the vicinity of N=40 nuclei.

1. Introduction

In the last decades a lot of effort was spent to understand the behavior of nuclear matter in extreme conditions. New technologies were discovered and used to produce and study new isotopes that revealed completely new and unexpected phenomena. One major role in understanding these new phenomena is played by the knowledge of structure of low-lying excited states in nuclei far from beta-stability valley. In particular the nuclear structure and decay properties of neutron-rich nuclei in the vicinity of the magic nucleus ^{68}Ni have been intensively investigated over the last decade [1]. The comparison between shell-model calculations using different nucleon-nucleon interaction with the existing experimental results has shown the importance of tensor force effects in understanding the structure of nuclei around Z~28 and N>40. The importance of the monopole term of the tensor force was pointed out by Otsuka et al.[2,3] in understanding the evolution of the nuclear structure in this region of the nuclear chart. The lowering of the $\pi 1f_{5/2}$ orbital was predicted, while the energy of the $\pi 1f_{7/2}$ increases when the neutrons start filling the $g_{9/2}$ orbital. The same theoretical estimation predicted the cross over between $\pi 2p_{3/2}$ and $\pi 1f_{5/2}$ around N=45, given the repulsive character of the tensor force. This was experimentally proven by Flanagan and Mane using laser spectroscopy techniques for copper and gallium isotopic chains [4, 5].

2. Experimental Set-up

In order to investigate the shell evolution near ^{68}Ni towards the doubly magic ^{78}Ni , neutron-rich nuclei were produced by the fragmentation reaction of a primary beam of ^{86}Kr at the incident energy of 60.4MeV/A on a Be target. The cocktail beam was separated in flight using the LISE2000 spectrometer by means of the energy loss and magnetic rigidity. Isotope identification was performed by combined measurements of the energy loss, magnetic rigidity and Time-of-Flight (TOF) in an event-by-event basis. At the focal plane, the ions were implanted in a 75 μm kapton foil inclined at 70^0. Behind this foil a position sensitive Si detector was used in order to reject the events associated with the fragments that were not stopped in the foil. Two high-purity Ge detectors and a LEPS surrounded the implantation set-up in a very compact geometry. In the lower part of the foil a nitrogen cooled SiLi detector was placed to detect internal conversion electrons In this paper we present the preliminary results regarding the nuclear structure of ^{75}Cu.

3. Results

The gamma delayed spectrum obtained after the implantation of ^{75}Cu is presented in figure 1. We can observe the existence of two delayed gamma rays (62.2(4) and 66.5(4) keV) that come from an isomer state decay in ^{75}Cu.

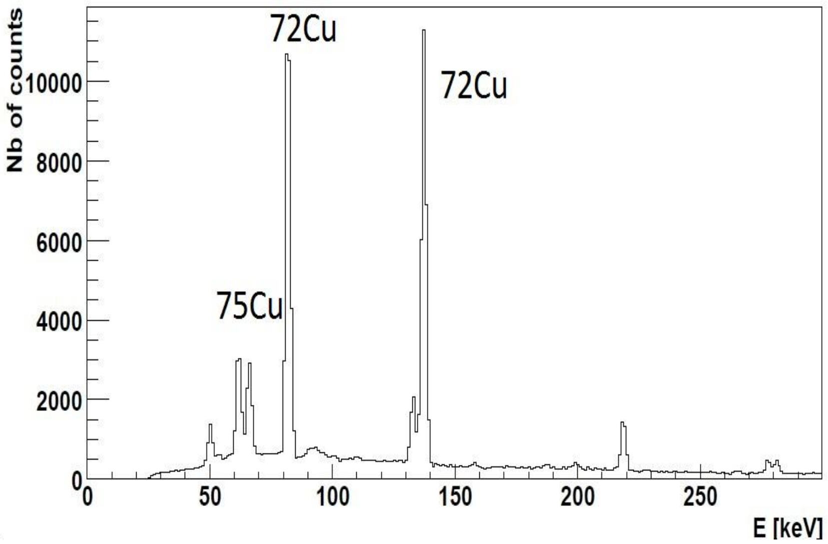

Figure 1. Preliminary gamma spectrum obtained shortly after the implantation of the ^{75}Cu nucleus in the kapton foil.

In the Figure 2 we present the same spectrum obtained by the SiLi detector. As it can be observed the electron spectrum is showing much lower statistics than the Ge spectrum and this preliminary result does not allow us to make a final statement concerning the transition multipolarities on the basis of the electron/gamma emission ratio.
Despite that the gamma spectrum revealed precious information. The ^{75}Cu was previously studied by Daugas *et al.*[6].

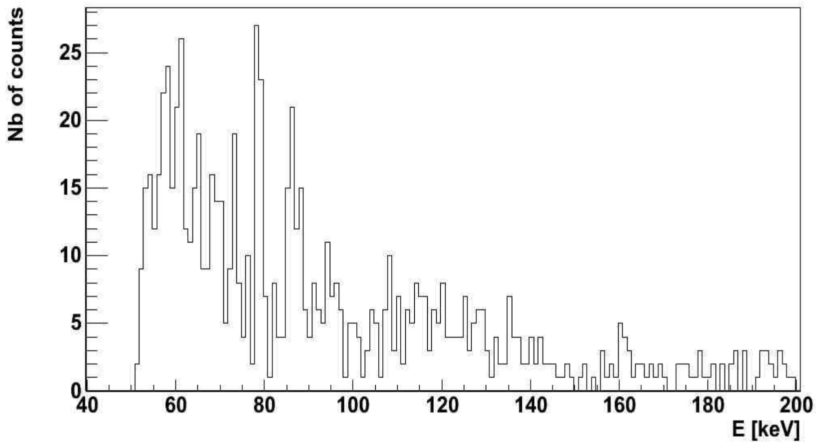

Figure 2. Preliminary electron spectrum obtained shortly after the implantation of the ^{75}Cu nucleus in the kapton foil.

In the previous experiment the two gamma lines were being placed in coincidence due to the lifetime spectra of the two observed transitions and γ-γ coincidences studies were not possible due to low statistics. In the present experiment due to higher statistics it was possible to construct γ-γ coincidence matrix. The obtained spectra does not show any trace of coincidence between the two gamma rays.

By measuring the lifetimes associated to the two observed transition we obtained 310(8) ns for the 61.7(2) keV line and 149(6) ns for the 66.0(2) keV, respectively. From fitting the decay of low-lying isomeric state with a sum of double-exponential function convoluted with a Gaussian function (representing the detector response function), it has been proven that this transition is populated mainly from the decay of the isomeric state above. These lifetimes translate into the following reduced transition probabilities (assuming pure transitions multipolarity) : B(M1)=1.0(4)10^{-4} W.u, B(E2)=32(11) W.u for the 66.0(2) keV transition, and B(M1)=2.43(4)10^{-4}W.u, B(E2)=221(1) W.u for the 61.7(2) keV transition, respectively.

The known spin and parity of the ground state and given the low energy state systematics for the odd copper isotopic chain give rise to two possible scenario for this two low-lying states observed (scenario A and scenario B, figure 2).

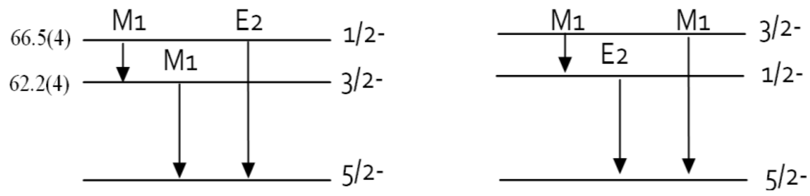

Figure 3: Proposed experimental spin assignment scenario A (left) and B (right)

The analysis of the experiment is ongoing as well the shell model calculations that will allow a clear assignation of the spin and parity for low lying levels in ^{75}Cu

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