One Nucleon Transfer Reactions Around ^{68}Ni at REX-ISOLDE

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Abstract. The newly built position sensitive Si detectors array of nearly 4π angular coverage which is going to be installed at the REX-ISOLDE facility at CERN is briefly presented. This setup will be combined with the Miniball detectors array, constituting a unique tool for the study of one-nucleon transfer reactions. The experimental study of d(^{66}Ni,p)^{67}Ni reaction will be proposed, as a starting point for a series of experiments aiming to the study of the single particle character of the levels of the odd mass neutron reach unstable Ni isotopes. In this contribution, the feasibility and sensitivity of the experiment is presented.

Keywords: direct transfer reactions, spectroscopic factors, radioactive ion beams, shell model
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INTRODUCTION

The magic numbers can be considered as the keystones for the modelling the nuclear structure. But recent studies suggest that by changing the number of neutrons with respect to the protons the size of shell gaps alters [1, 2]. Weakening of the spin-orbit force caused by the diffuse neutron matter [3], or the effect of tensor monopole neutron-proton interaction [4], are two possible causes for this effect. One interesting region of the nuclear chart is situated between ^{68}Ni and ^{78}Ni because of the closed proton shell (Z=28) and the closed neutron harmonic-oscillator sub-shell (N=40), where the $1g_{9/2}$ unique parity orbital plays a key role.

Up to now the collective properties of the neutron rich unstable isotopes of Ni, Zn and Cu at the N=40/50 mass region have been experimentally studied through the "safe" low energy Coulomb excitation [5, 6], through intermediate energy Coulomb excitation [7, 8] and β-decay studies [9, 10]. The experimental determination of the single particle character of the ground and first excited states of the odd-Ni isotopes will shed more light on the nuclear structure in this mass region.

EXPERIMENTAL SETUP

The REX-ISOLDE facility at CERN provides intensive and well-defined beams of unstable nuclei at energies up to 3A MeV. Furthermore, the newly built position sensitive Si detectors array of nearly 4π angular coverage combined with the Miniball detectors

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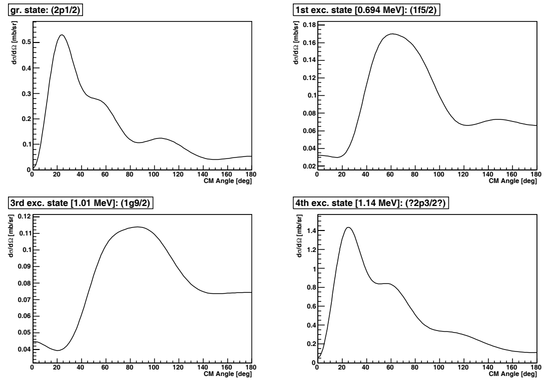

FIGURE 1. The differential cross section in CM system as obtained from DWBA calculations applying the code FRESCO [11]. The spin and parity of the forth excited state is assumed.

array, constitute a unique tool for the study of one-nucleon transfer reactions like the (d,p) one-neutron transfer reactions [12].

The position sensitive Si detector array will cover an extended angular range $8°<\theta_{lab}<75°$ and $105°<\theta_{lab}<172°$ which will allow the determination of the angular distribution of protons in a wide angular range and correspondingly the unambiguous assignment of spin and parity of the populated levels. The necessary particle identification at the forward angles will be performed by means of the double layer ΔE-E configuration. The barrel array will be installed in a scattering chamber surrounded by the Miniball detector array.

PHYSICAL CASE

The experimental study of d(^{66}Ni,p)^{67}Ni reaction will be proposed, using the ^{66}Ni radioactive ion beam from REX-ISOLDE [13], as a starting point for a series of experiments aiming to the study of the single particle character of the levels of the odd mass neutron rich unstable Ni isotopes. The objectives of this work are the unambiguous determination of spin and parities of the ground and first excited states of ^{67}Ni and of the corresponding relative spectroscopic factors (SF) that will be compared with those from large-scale shell model calculations.

The main issue of the study of the single particle character of the odd-even neutron rich Ni isotopes arises from the fact that some of the states are isomeric, mostly due to the occupation of the $1g_{9/2}$ orbital, a unique parity level in the fp shell. For that reason, the particle gamma coincidence technique can not always be implemented for the identification of the populated energy levels. That means that the overall resolution of the silicon array is of major importance and a thin CD_2target has to be used. Extended GEANT4 Monte-Carlo (MC) calculations have been performed where the full experimental setup was included. The simulated angular distribution of the protons has been obtained through DWBA calculations (Fig. 1). As can be seen in Fig. 2, four groups of

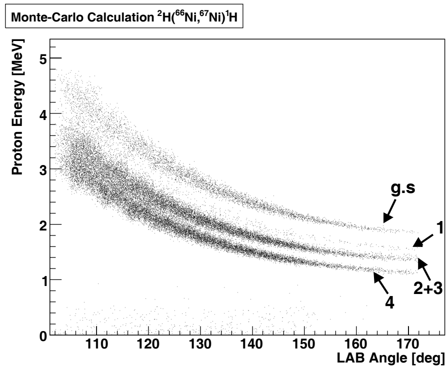

FIGURE 2. Results of the Monte-Carlo calculations. The different proton groups assigned to the population of the ground and the first four excited states of ^{67}Ni are indicated.

protons can be easily identified out of the five levels that were included to the MC calculations. The unresolved proton groups correspond to the second and third excitation levels at 1.0 and 1.14 MeV correspondingly.

CONCLUSIONS

As a starting point of the study of the single particle character around N=40 the d(^{66}Ni,p)^{67}Ni reaction will be proposed at REX-ISOLDE. The counting rate and the expected resolution of the newly build barrel configuration have been studied in the present work. In most cases, by using thin CD_2 target, the assignment of each proton group will be feasible even for the singles proton spectra. The simulations show that the unambiguous determination of the spin and parity as well as the determination of the relative SF 's of the populated levels is possible.

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