RELATIVE FUSION–EVAPORATION YIELDS IN THE VICINITY OF ^{100}Sn*

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Results of a measurement of relative yields of nuclei populated in heavy ion induced fusion-evaporation reactions in the region of ^{100}Sn are presented. Yields for altogether 18 products of the ^{58}Ni(^{50}Cr, $xpy\alpha zn$) reaction, were determined at 5 beam energies, basing on intensities of γ rays feeding ground states of respective nuclei.

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1. Introduction

During the last decade, many experimental and theoretical investigations have been devoted to studying exotic, very neutron deficient nuclei in the vicinity of the $N = Z = 50$ doubly-magic shell closure. Excited states of nuclei in this region are usually investigated in heavy ion induced fusion-evaporation reactions, in which the total cross-section is fragmented into many exit residue channels, corresponding to various combination of protons, neutrons and α-particles emitted from the compound nucleus. Information on yields of nuclei produced in such reactions is both scarce and much needed — as it is essential for planning experiments aiming at observation of more and more neutron deficient nuclei. These yields are in general poorly reproduced (or predicted) by available statistical fusion-evaporation codes, which also indicates that physical processes governing the evaporation of particles from a compound nucleus in the proximity of the proton drip line are not well understood. In this work we report on preliminary results of the measurement of relative evaporation cross section for nuclei produced in one of the typical reactions used to study very neutron deficient nuclei in the region.

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2. Experiment

The experiment was performed at the Tandem Accelerator Laboratory in Risø, Denmark with the NORDBALL detector array [1,2]. Beam of ^{58}Ni was hitting a thin (0.25 mg/cm^2) ^{50}Cr target, leading to the compound nucleus ^{108}Te. Data were collected at five beam energies: 201, 216, 231, 246 and 261 MeV. The target was backed by 23 mg/cm^2 of ^{197}Au. The backing was thick enough to stop the recoil nuclei produced in the reaction. The thin target used assured that the reaction energy was well defined, the energy loss of beam particles traversing the total thickness of the target was about 6 MeV (similar at each of the 5 bombarding energies). In this experiment NORDBALL was equipped with 15 Ge Compton suppressed spectrometers, a Neutron Wall [3] consisting of 11 liquid scintillator neutron detectors, a Silicon Ball [4] consisting of 21 silicon ΔE detectors for the identification of charged particles and 30 BaF_2 scintillators for γ-ray multiplicity filtering. Events were accepted by the data acquisition system if at least one Compton suppressed γ-ray was detected in the Ge detectors and one γ-ray in the BaF_2 array.

3. Data analysis and results

Many different final nuclei are simultaneously produced in the reaction which was studied in the present experiment. In optimal conditions, production yields of these nuclei could be determined from intensities of γ-ray transitions feeding respective ground states, measured in a single γ-ray spectrum, unbiased by any other experimental conditions, such as the trigger requirement. Such a simple procedure was however not possible in the present case. First, the hardware trigger condition mentioned above had to be used. Moreover, intensities of γ-ray lines belonging to specific nuclei could not be precisely determined in single γ-ray spectra, due to the very large number of γ-ray lines present in such spectra.

Intensities of γ-ray transitions feeding the ground states were thus determined from intensities of $\gamma\gamma$-coincidence peaks. In case of even nuclei the $2^+ \to 0^+$, $4^+ \to 2^+$ γ-ray coincidence peaks were used. For odd nuclei, attempts were made to properly estimate the intensities of all transitions feeding the ground states, also using the coincidence data. Note that in this analysis, data from the Silicon Ball and the Neutron Wall were not used. This was due to the fact that efficiencies for the detection of particles are not known a priori and bear a complicated dependence on the beam energy and particular reaction channel, making the estimation of the production yield difficult and uncertain.

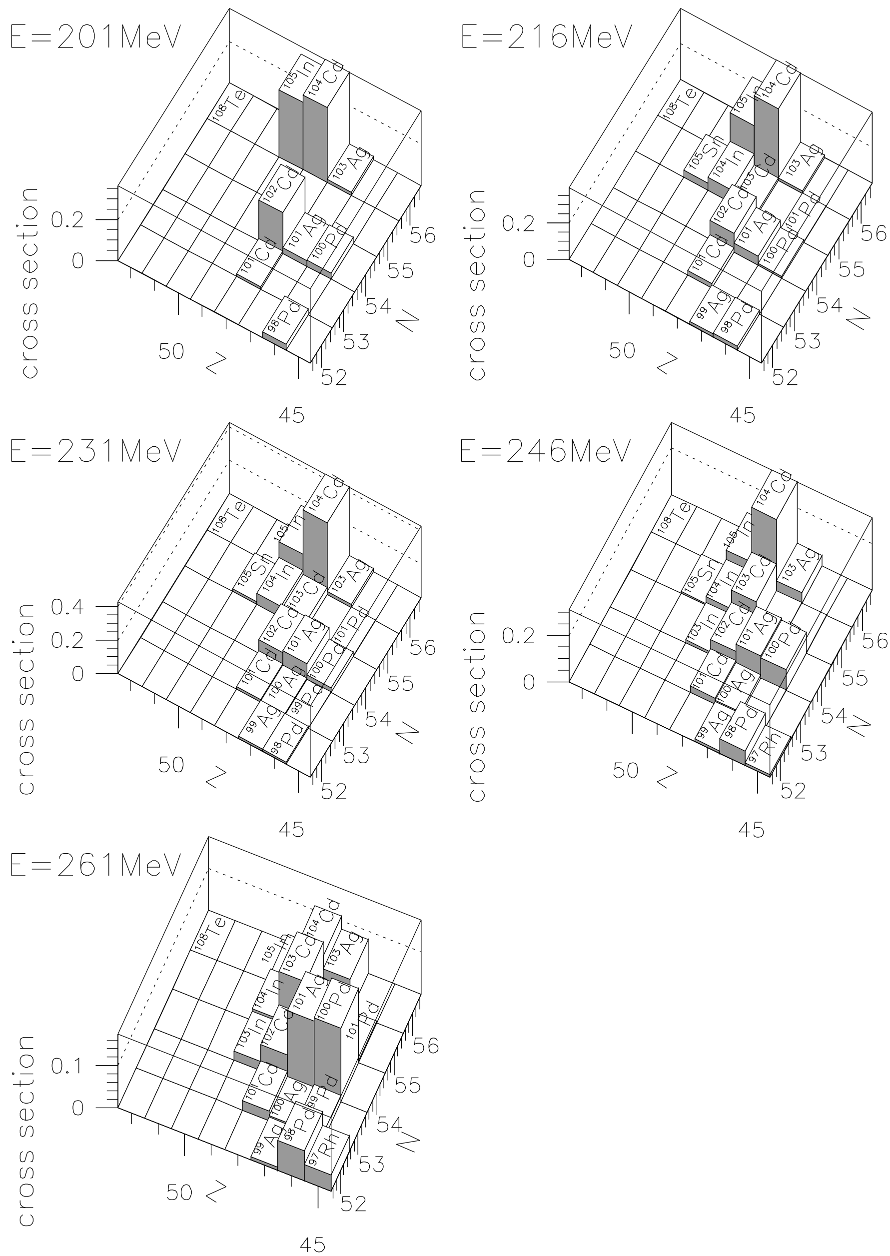

Fig. 1. Relative yields of nuclei produced by the emission of protons, α particles and neutrons from the compound nucleus ^{108}Te, determined at five ^{58}Ni beam energies (E). See also explanations in the text.

The yields determined as described above are affected by the effective (hardware plus software) trigger condition that at least one γ-ray was detected in the BaF_2 ball and two in the Ge detectors. The influence of this condition on the measured yields is different for nuclei produced with different average γ-ray multiplicities. This effect, which in some cases strongly changes the measured yields, is also studied using the present data and will be described in detail in the forthcoming publication. Results presented below are not corrected for differences in the γ-ray multiplicities.

Altogether 18 residual nuclei were identified in the experiment, with the relative yields ranging from 1–36% at 201MeV, 0.3–39% at 216MeV, 0.3–42% at 231MeV, 0.2–31% at 246MeV and 0.4–18% at 261MeV. The results are shown in Fig. 1. The dominating reaction channels are those in which only protons are emitted. Only for the two highest beam energies (246 and 261 MeV) the channels associated with the emission of a neutron or an alpha particle in addition to 3 or 4 protons become strong. Work on comparison of the measured yields with results of calculations using statistical fusion-evaporation codes is in progress.

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