Mutlinucleon transfer reaction studies using the velocity filter SHELS

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1. Introduction

Heavy ion fusion reactions have been successfully used to synthesis super heavy elements (SHE). The heaviest element produced up to now is element Z=118 and the production cross-section limit using conventional HI-fusion has been reached experimentally. Since these methods cannot be applied to reach neutron-rich super heavy nuclei due to the lack of sufficiently neutronrich projectile and target nuclei. New calculations [1] and recent experiments [2] suggest the use of Multi Nucleon Transfer (MNT) reactions as a promising pathway to the synthesis of new neutron-rich SHE with proton numbers up to about Z = 106. In this work, we present results from the analysis of experimental data on MNT reactions with the ^{50}Ti projectile incident on ^{208}Pb target. The experiment was performed at velocity filter SHELS of FLNR Dubna.

2. Experiment

The 242.8 MeV energy ^{50}Ti beam provided by the U400 cyclotron accelerator with an average intensity of 0.3×10^{12} projectiles/s impinged on a 500 μg/cm^2 ^{208}Pb thick target. The target foils were mounted on a rotating wheel. The velocity filter SHELS has been adjusted to separate the deepinelastic target-like reaction products with velocity 1.2 - 1.6 times the compound nucleus velocity (V_{CN}) from the primary beam and other reaction products. After separation by the SHELS, the evaporation residues (ER) were implanted into a double sided silicon strip detectors (DSSD). In combination with DSSD, it is also installed an advanced 5 Clover configuration for γ detection which will improve the gamma detection efficiency by a factor of 3 compared to earlier detectors. With faster data acquisition system of SHELS, it will be possible to access nuclides down to the halflife of 1 μs. Also, SHELS uses a more pixelated 100×100 mm^2 DSSD with 128 vertical and horizontal strips, covered by eight 500×600 mm^2 silicon tunnel detectors (700 μm thick) in the backward hemisphere. This will also be more advantageous for the clear identification of the populated nuclides, especially the ones which have no long αdecay chains.

3. Results

In the experiment at SHELS transfer products from the reaction ^{50}Ti (242.2 MeV) +^{208}Pb were investigated. The populated above target nuclides were separated based on their velocities. In the above target region most of the known isotopes are alpha emitters with short half-lives. This helps to identify the implanted decay products by following their decay chains.

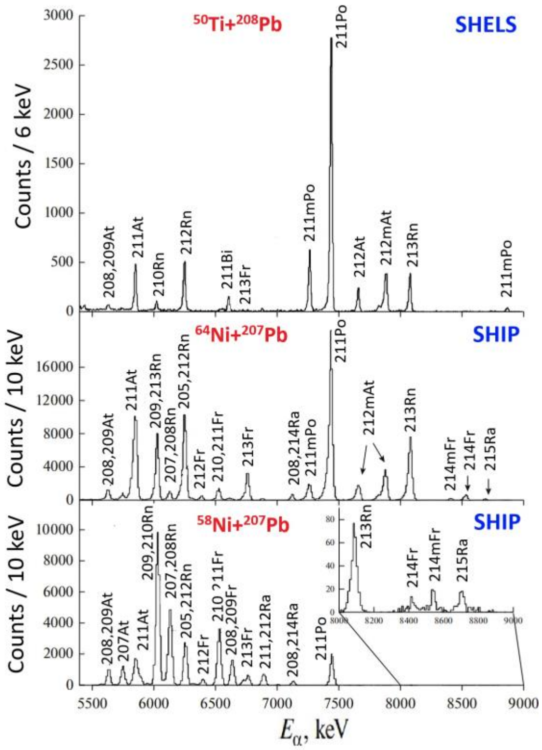

Fig. 1: The α-spectrum of the MNT products measured at SHELS from the reaction ^{50}Ti+^{208}Pb are compared which are measured at SHIP from the reactions ^{58,64}Ni+^{208}Pb [3]. The smaller intensity in case of ^{50}Ti+^{208}Pb is because of the about 20 times shorter irradiation time.

The α-spectrum of the transfer products measured at SHELS in the reaction ^{50}Ti+^{208}Pb is compared in Fig. 1 with the αspectra from ^{58,64}Ni+^{208}Pb reactions at SHIP [3]. The smaller intensity of the α-lines in case of ^{50}Ti+^{208}Pb reactions is because of about 20 times shorter irradiation time. Comparable transmission for transfer products using Pb targets was found at SHELS and SHIP. In addition, SHELS has more advanced clover detector, more pixelated DSSD and 10 times faster data acquisition system.

In the ^{50}Ti+^{208}Pb experiment, nearly 25 nuclei above the target were observed. The maximum transfer channels involving the transfer of 8 protons and 6 neutrons from the projectile to the target were identified. The cross-section as a function of mass number, total kinetic energies, excitation energy of the populated MNT products were investigated. The lowest total cross-section reached in this experiment is about 1 nb. The beam intensity in this experiment was limited to 0.05 pμA, though the U400 accelerator can deliver up to 1 pμA. Modernization of the U400 is planned in the coming years, which will allow the beam intensities up to 3 pμA. This increased intensity would enable the study of crosssections as low as 50 pb, facilitating the investigation of transfer channels involving more than 10 protons and several neutrons. The heaviest actinide targets, up to Es (99), can be used. According to model estimations, using the heaviest available actinide targets, combined with the sensitivity achieved in this experiment, opens the possibility to access several unknown neutron-rich nuclides. Additionally, a new project for a kinematic Separator for TransActinide Research (STAR) is planned at FLNR to study MNT reactions, alongside the modernization of the U400 cyclotron (U400R) will be advantageous [3, 4]. Unlike SHELS, STAR can be rotated with respect to the beam axis, making it ideal for studying MNT reactions that produce broad angular distributions of reaction products.

References

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