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Systematic studies to produce heavy above-target nuclides in multinucleon transfer reactions

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Exotic nuclei are typically produced via projectile fragmentation or projectile fission at relativistic energies, or through complete fusion reactions at near-Coulomb barrier energies. These production methods, along with the available beam intensities, define the current boundaries of the chart of nuclides. However, theoretical predictions suggest that several thousand additional isotopes may exist on the neutron-rich side, including many along the astrophysical r-process path. Multi-nucleon transfer (MNT) reactions offer a promising pathway to access this largely unexplored territory.

In our recent studies published in ref [1], we investigated MNT reactions involving the systems 48Ca+208Pb, 50Ti+208Pb, and 40Ar+209Bi, focusing on the population of nuclei with proton numbers greater than that of the target. The target-like reaction products were separated in flight using the velocity filter SHELS of the Flerov Laboratory for Nuclear Reactions (FLNR), Dubna. Our goal was to examine transfer reactions for producing new heavy and superheavy nuclei and to assess the applicability of velocity filters for their investigation. We observed and studied about 40 different nuclides, resulting from the transfer of up to eight protons from the projectile to the target and moving in forward direction relative to the beam axis. We present cross-section systematics for isotopes of elements Z = (83 − 91) measured in our experiment and compare them with available data from transfer reactions with actinide targets which lead to isotopes up to Z = 103.

Our results will be discussed in the context of previous measurements, and we will present future prospects for employing MNT reactions to produce new heavy and superheavy isotopes [1–6]. In addition, the design of a new kinematic separator, the Separator for Transactinide Research (STAR), to be developed at FLNR, JINR (Dubna), will be introduced [6–7]. This project will be carried out alongside the modernization of the U400 cyclotron (U400R).

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