Production of new neutron-rich nuclei in projectile fragmentation reactions

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One of the major challenges of nuclear physics is to enlarge the present limits of the chart of the nuclides and in particular toward the neutron-rich side reaching the r-process path in the medium- and heavy-mass regions. Promising results have been obtained during the last years in experiments investigating the properties of medium-mass neutron-rich nuclei close to the waiting point around N=82 [1] however, the waiting point around N=126 remains unexplored [2]. Indeed, fission has been successfully used to produce medium-mass neutron-rich isotopes [3] while the present limits of the chart of the nuclides in the heavy neutron-rich region still lie close to the stability. Few years ago, cold-fragmentation reactions induced by relativistic projectiles were proposed [4] as the possible reaction mechanism to populate the heavy neutron-rich side of the chart of nuclides and overcome the present limitations.

In this paper we report on several experiments performed with the FRS at GSI to explore the production of heavy and medium-mass neutron-rich nuclei. We used cold-fragmentation reactions induced by ^{238}U, ^{208}Pb and ^{136}Xe at 1 AGeV impinging a Be target. The isotopic identification was achieved by measuring both the atomic number and the mass-over-charge ratio of each nucleus by means of the measurements of the magnetic rigidities, time-of-flight and energy loss of each fragment passing through the FRS.

In these measurements we were able to identify for the first time more than 40 new neutron-rich isotopes approaching N=126 and N=82. Their production cross sections have been compared to calculations performed with the semi-empirical EPAX formula [5] and the more elaborated physical code COFRA [4].These data and model calculations are used to discuss the optimum reaction mechanisms to produce neutron-rich nuclei in future radioactive nuclear beam facilities. In particular we will concentrate in the expected production by using fission, fragmentation, or a two-step reaction scheme where fission products are fragmented to produce medium-mass neutron-rich nuclei.

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