New neutron-deficient isotopes from ^{78}Kr fragmentation

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The most fundamental property of a nuclear species is its stability or instability with respect to the strong interaction, i.e. whether or not it is particle stable. On the proton-rich side of the valley of stability, if an isotope is sufficiently unbound, it may decay by one- or two-proton emission, the first being the decay mode for odd-Z (proton number) nuclei, whereas the second decay mode occurs for even-Z nuclei. Therefore, reaching the limits of stability allows one not only to test mass models predicting these limits, but also to search for new and exotic decay modes.

Thus two-proton (2p) radioactivity with half-lives of the order of milli-seconds was first observed in the region of iron-nickel-zinc with the known 2p emitters ^{45}Fe, ^{48}Ni, and ^{54}Zn[1]. Just above this region, ^{59}Ge, ^{63}Se, and ^{67}Kr were predicted to be possible new 2p emitters (see e.g.[2]).

In a recent experiment at the BigRIPS separator[3] at the RIKEN Nishina Center, we fragmented a primary ^{78}Kr beam at 345 MeV/A with an intensity of up to 250 pnA on a beryllium target (thickness 4975 μm). The BigRIPS separator was used to separate the isotopes of interest and to detect and identify them by means of the ΔE-ToF-Bρ method. After removal of scattered and incomplete events by means of cuts with beam-line detectors, clean identification spectra could be produced and three new isotopes, ^{63}Se, ^{67}Kr, and ^{68}Kr, were identified for the first time. In addition, ^{59}Ge was also observed, an isotope which was only very recently identified in an experiment at MSU and unreported at the time of the present experiment[4].

Figure 1 shows the identification plot from the present experiment. The three new isotopes and ^{59}Ge are indicated. The observed production rates exceed rates at other facilities by at least two orders of magnitude. The present experiment thus allowed us to determine the production cross sections for the nuclei transmitted close to the central beam trajectory where the uncertainties due to the momentum distribution of the fragments and the separator transmission are minimal. Figure 2 presents these cross sections and compares them to predictions of EPAX3, an empirical parametrization of fragmentation cross sections[5]. Clearly, EPAX3 overestimates the experimental cross sections a lot.

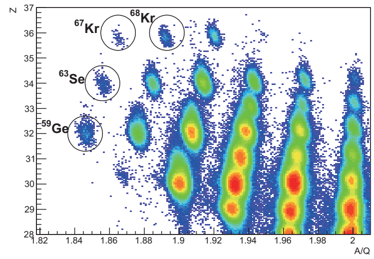

Fig. 1. Identification plot for isotopes produced in a recent BigRIPS experiment using ^{78}Kr fragmentation. New isotopes and possible 2p emitters are indicated in the figure.

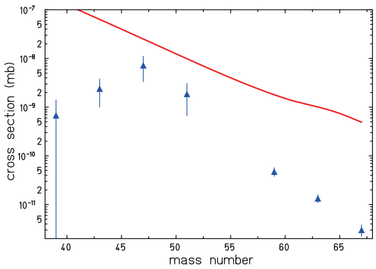

Fig. 2. Comparison of experimentally determined production cross sections for ^{78}Kr fragments with EPAX3 predictions.

The experimental data for the decay of these nuclei are presently under analysis. In particular, the question of whether some of them decay by 2p radioactivity is of prime interest.

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