Progress of study of β-decay of neutron-rich nuclei with $Z \sim 60$

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Approximately half of the elements heavier than iron are formed by the rapid neutron-capture process (r-process). In the solar r-process abundance distribution, the region of rare-earth elements forms a peak around $A = 160$, which may have a different mechanism of formation compared with the other two distinct peaks at $A = 130$ and $A = 195$ relating to neutron-closed shells at $N = 82$ and $N = 126$, respectively[1]. β-decay half-lives of the elements always play an important role at both the cold and hot r-process paths and will be expected to constrain the conditions in understanding the r-process nucleosynthesis.

To study the rare-earth peak, a β-decay experiment with $Z \sim 60$ was performed at the RIBF facility in June 2013. This experiment was carried out using the in-flight fission of a 345 MeV/nucleon ^{238}U beam colliding with a Be target. The secondary beam, including a cocktail of highly neutron-rich isotopes, was implanted in the β-decay counting system WAS3ABi [2] (Wide-range Active Silicon-Strip Stopper Array for Beta and ion detection), which consists of a stack of five highly segmented DSSSDs (Double-Sided Silicon Strip Detectors). With the help of the high-purity germanium detectors (EURICA)[3], γ rays with a high production rate emitted from implanted radioactive isotopes or the daughters nuclei fed through the β decay can be measured. The β-decay half-lives could be determined by fitting the distribution of the time difference between the implantations in the WAS3ABi and the following β-decay events.

In this experiment, approximately 35 half-lives were measured, including approximately 25 new half-lives. Figure 1 displays some preliminary results of four decay curves obtained in this experiment. Daughter half-lives, granddaughter half-lives, as well as the constant background are taken into account by using the Likelihood fitting method. The β-decay half-lives can also be obtained by using β-delayed γ rays detected by the EURICA detector, which can eliminate the uncertainties from the daughter and granddaughter half-lives. Figure 2 shows the β-decay curve of ^{149}La gated the β-delayed γ rays.

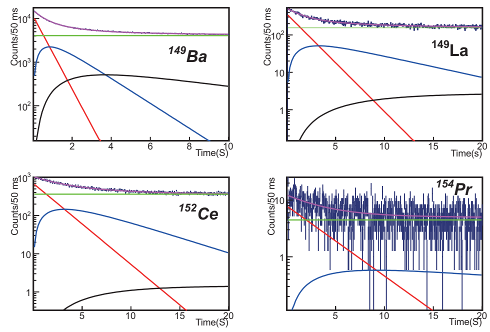

Fig. 1. Decay curves of four kinds of isotopes (^{149}Ba,^{149}La, ^{152}Ce, ^{154}Pr) are displayed. The red lines correspond to parent nuclei. The blue curves, black curves, and green lines correspond to the daughter nuclei, granddaughter nuclei, and a constant background.

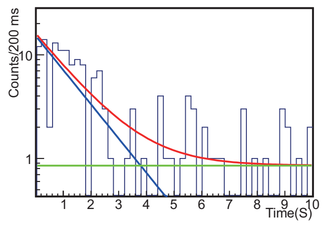

Fig. 2. ^{149}La decay curve obtained gating on the β-delayed γ-ray energy with 245.4keV.

In the latter phases of analysis, further new half-lives will be obtained. Simulation work of r-process will be performed by comparing the theoretical calculations with our experimental results.

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