Exploration of neutron-rich Zinc isotopes at new experimental station LeRIBSS at the HRIBF, Oak Ridge

Very neutron-rich nuclei offer the only laboratory access to matter dominated by neutrons. The outer layer of those short-lived species consists of a neutron skin, which dramatically impacts their structure, reactions, and decays. In particular, beta and beta-delayed neutron (βn) decays are important factors determining the creation of elements in the universe. Indeed, the distribution of elements in the stellar ashes remaining after a supernova explosion, a possible site for the rapid-neutron capture process (r-process), is shaped by these decays. To fully explain the element's distribution, essential data are needed for the regions of nuclei, where the r-process path approaches magic neutron numbers, e.g., N=50 around ^{80}Zn, N=82 around ^{130}Cd, and N=126 around ^{195}Tm.

At the Holifield Radioactive Ion Beam Facility (HRIBF), we produce very neutron-rich nuclei using proton-induced fission of ^{238}U. We have recently extended the range of elements available for β-decay studies at the HRIBF by constructing the Low-energy Radioactive Ion Beam Spectroscopy Station (LeRIBSS). At LeRIBSS, we can study β-decays of positive and negative ions extracted directly from the target-ion source system. Positive-ion beams, which include now zinc and cadmium isotopes, have excellent ion-optical properties that help to purify the activity samples. During the commissioning of LeRIBSS, we have performed decay studies of ^{79}Zn, ^{80}Zn, the classical "r-process waiting-point" magic nucleus, and ^{81}Zn, the most neutron-rich among known zinc isotopes.

The mass resolving power of the HRIBF radioactive beam injector magnet was high enough to purify the ^{81}Zn activity despite the fact that the intensity of the neighboring nucleus ^{81}Ga was five orders of magnitude larger. This enhanced sensitivity allowed us to identify for the first time higher energy levels, up to ~ 2 MeV, in the magic nucleus ^{81}Ga.. Our data provide unique information on the proton orbits above the ^{78}Ni core along the N=50 magic neutron number.

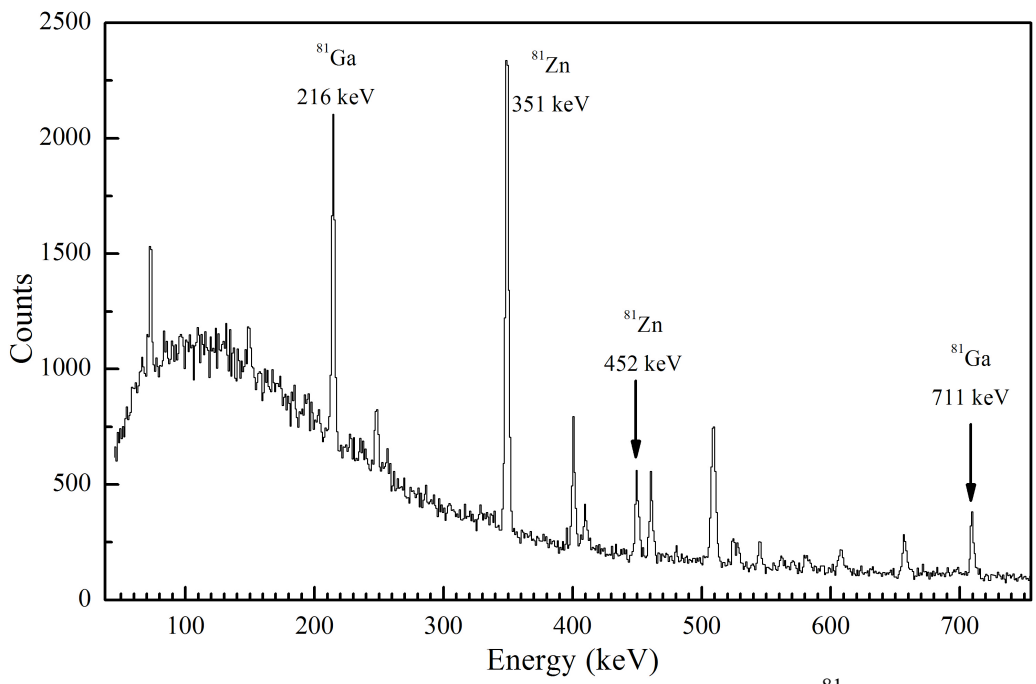

Fig. 1. The energy spectrum of γ-radiation following the decay of ^{81}Zn measured at LeRIBSS. The ^{81}Ga activity was produced in the studied samples only as a decay product of ^{81}Zn..