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Mass measurments of fp-shell nuclei in the vicinity of proton dripline

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The two-proton radioactivity (2p decay), where two protons are simultaneously emitted during nuclear decay, was theoretically predicted over 60 years ago[1]. In the early 2000s, 2p decay was discovered in very proton-rich nuclei such as 45Fe and 48Ni [2, 3]. The en- ergy level structure and one- and two-proton separation energies (Sp, S2p) are essential to evaluate the two-proton emission probability of the 2p emitter penetrating through the Coulomb and centrifugal potentials. Since the level structure and mass difference among one- and two-proton removal nuclei are directly related to Sp and S2p, the systematic mea- surement of the masses of nuclei around the 2p emitter leads to a complete understanding of 2p decay.

We performed direct mass measurements of proton-rich Fe isotopes including 45Fe us- ing the TOF-Bρ tech-nique[4] at the SHARAQ beamline of RIBF. Proton-rich isotopes were produced by the fragmentation of the 78Kr primary beam at 345 MeV/nucleon in a 9Be target with a thickness of 2.2 g/cm2. The fragments were separated by the BigRIPS separator and transported to the OEDO beam line followed by the SHARAQ spectrometer. OEDO and SHARAQ were operated as a single spectrometer in the dispersion matching mode, which achieved a momentum resolution of 1/15,000. The time of flight (TOF) was measured by diamond detectors installed at the beginning and end of the beamline. Two multiwire drift chamber (MWDC) tracking detectors were also installed to correct the flight-pass length. To measure the Bρ value, a strip-readout parallel- plate avalanche counter (SR-PPAC) newly developed for measuring high-rate heavy-ion beams[5] was used at the intermediate focal plane. Gamma-ray detection systems were placed after the SHARAQ to identify isomers, which could shift the peak in the measured mass spectra.

Proton-rich Ti, Cr, Fe, and Ni isotopes were detected in the vicinity of the proton drip line. Masses of nine isotopes were newly determined for the first time in the present experiment. The separation energies deduced from the mass values exhibit the possible candidates of 2p decay in some proton-rich isotopes beyond the dripline.

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