Discovery of new isotope ^{241}U and systematical mass measurement of neutron-rich Pa-Pu nuclei with KISS-MRTOF system

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We previously operated the KEK Isotope Separation System (KISS)[1,2] for nuclear spectroscopy of neutron-rich nuclei around $N = 126$ and beyond. We explore neutron-rich uranium regions with a recently developed multi-reflection time-of-flight mass spectrograph (MRTOF-MS).[3] In this manuscript, we report the first systematic mass measurements of neutron-rich Pa-Pu isotopes produced as projectile-like fragments (PLF) via several multi-nucleon transfer (MNT) channels of the ^{238}U + ^{198}Pt reaction at the KISS facility.

The experimental setup of KISS facility is described elsewhere.[1,2] A rotating ^{198}Pt (enriched to 91.63%) target with a thickness of 12.5 mg/cm^2 was bombarded by a primary beam of ^{238}U (10.75 MeV/nucleon), which was provided by the RIKEN Ring Cyclotron with typical intensity of approximately 30 particle nA. The isotopes of interest were produced as PLFs in the MNT reactions, with their masses and velocities being close to those of the primary beam particle. Moreover, they were scattered around the grazing angle. The energy of reaction products were attenuated using a 40-μm Ti energy degrader to maximize the yield stopping in a doughnut-shaped gas cell filled with 65-kPa argon gas.

We successfully performed the high-precision direct mass measurement of 19 neutron-rich Pa-Pu nuclides (Fig. 1) and discovered a new uranium isotope ^{241}U.[4] Figure 2(a) shows the TOF spectrum at 1001 laps in the MRTOF with resonant laser wavelength for the new isotope ^{241}U. Figure 2(b) shows the TOF spectrum at 600 laps with resonant wavelength for ^{241}Np. The comparison of the spectra in Figs. 2(a) and (b) indicates the identification of the new isotope ^{241}U.

This study was demonstrated to explore the neutron-rich actinide region using MNT reaction via KISS and MRTOF setup. We plan to use further heavier/symmetric projectile and target combinations such as ^{238}U+^{238}U/^{248}Cm, which is promising for reaching more exotic nuclei to understand both astrophysically relevant processes and the evolution of nuclear structure at $N = 152$ and beyond.

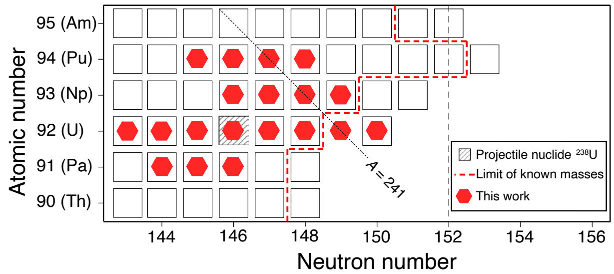

Fig. 1. Part of nuclear chart of the neutron-rich actinide region. Red dashed line indicates the mass known line, and red hexagon symbols denote the measured data in this work.

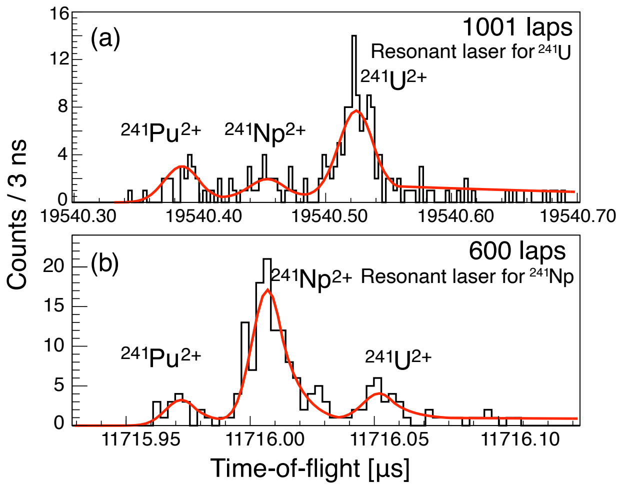

Fig. 2. TOF spectra with the solid red lines denoting the fitting curves. (a) $A/q = 120.5$ region after 1001 laps in the MRTOF-MS with resonant wavelength for the new isotope ^{241}U. (b) $A/q = 120.5$ region after 600 laps with resonance for ^{241}Np. The absolute TOF values were different between (a) and (b) owing to the difference in the number of laps.

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