High-accuracy mass measurements of neutron-rich argon isotopes and their impacts on the understanding of $N = 32$ subshell closure

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In the shell-model description, the evolution of the shell structure far away from stability has been a major focus of nuclear physics. Two-neutron separation energy measurements, as well as $E(2^+)$ measurements, are the primary methods used to explore the shell evolution of exotic nuclei with extreme neutron-to-proton asymmetry. Atomic mass measurements are continuously driven towards more exotic nuclei, from the first discovery of the vanishing of the $N = 20$ shell closure to the emergence of the new magic number $N = 32$ in calcium.[1)]

The localized magic behavior of the $N = 32$ shell closure has been examined extensively. In this region, sizable $E(2^+)$ are reported from Ca to Cr isotopes at $N = 32$ as well as a large empirical shell gap, although the latter does not show in V and Cr isotopes.

For isotopic chains below the proton magic number $Z = 20$, ISOLTRAP measured the masses of ^{52,53}K, revealing a persistence of the $N = 32$ shell gap, that is slightly lower than that of calcium.[2)] In Ar isotopes, a slight increase in $E(2^+)$ from ^{48}Ar to ^{50}Ar implies the existence of the $N = 32$ subshell gap.[3)] In contrast to Ar, a sizable increase occurs at the $N = 32$ relative to the $N = 30$ even-even neighbor in the Ca chain. However, shell-model calculations indicate that the sizes of the $N = 32, 34$ subshell gaps in Ar isotopes are similar to those in Ca isotopes regarding the effective single-particle energies (ESPEs).[3,4)] Hence, the evolution of the $N = 32$ subshell below $Z = 20$ towards more exotic nuclei, in particular, the structural properties in neutron-rich Ar isotopes, remains an open question.

Herein, we report high-accuracy mass measurements of ^{49,50}Ar produced in the projectile fragmentation of ^{70}Zn using the RIKEN-KEK Collaborative RI Stopper and MRTOF-based Analyzer and Spectroscopy System (CRISMASS@F11), which consists of an RF carpet helium gas catcher (RFGC) and multi-reflection time-of-flight mass spectrograph (ZD MRTOF-MS),[5)] located downstream of the ZeroDegree Spectrometer (ZDS) at RIBF.

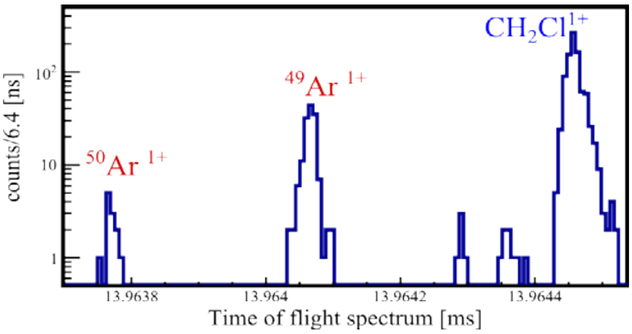

Fig. 1. Time-of-flight spectrum in this experiment; $m/q = 49, 50$ ions are included. ^{49,50}Ar indicated in red are the nuclei of interest.

The experiment was performed symbiotically during a nuclear charge-radius measurement. The RIs were stopped and extracted from the RFGC as ions and then prepared and transported via ion traps. Finally, the masses of exotic nuclei were analyzed using MRTOF mass spectrometry through time-of-flight measurement.

During this measurement, ZD MRTOF-MS operated with a mass resolving power of about 600 k. A corrected spectrum, as shown in Fig. 1, was obtained after eliminating the drift influence using $^{39}K^+$ ions and ions from a ^{248}Cm fission source to produce fission fragments with the same m/q values as the nuclei of interest as useful references for mass calibration.

The data are presently under review.

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DOI:10.34448/RIKEN.APR.58-228