Study of ^{252}Cf fission fragments with MRTOF-MS: mass measurement of neutron-rich cerium isotope ^{155}Ce

S. Kimura,[*1,*2] M. Wada,[*1] H. Haba,[*2] T. Niwase,[*3] M. Rosenbusch,[*2] and P. Schury[*1]
for the SHE-Mass Collaboration

Spontaneous fission of heavy nuclei can produce radioisotopes with a kinetic energy of approximately 1 MeV/nucleon. This feature is very useful for evaluating the gas cell's performance. We have continued the studies of the multi-reflection time-of-flight mass spectrograph (MRTOF-MS) system with a ^{252}Cf source, aiming to improve the system efficiency and measure the masses of the neutron-rich nuclides fed by spontaneous fission. Our efforts have been presented in previous reports.[1,2] The radioactivity of the present source is 9.25 MBq, and more than 250 isotopes have been confirmed in the time-of-flight (TOF) spectra till date. The mass resolving power of the MRTOF-MS reaches $R_m > 500{,}000$; thus, the mass measurements were achieved with a relative precision better than 10^{-7} in most of the cases. As a highlight in these measurements, here we briefly report the new mass measurement of ^{155}Ce.

In the TOF spectra of the ions of mass-to-charge ratio $(A/q) = 75.5$, a small peak close to the predicted positions of ^{155}Ce^{2+} was obtained. If the relative intensity and position of certain two peaks remain constant when the number of laps is varied, we can infer that those peaks are isobaric. In the MRTOF-MS measurement, the TOF ratio ρ represents the relative peak position. For the $A/q = 75.5$ case, the measurements were performed with 602 and 604 laps. The results presented in Fig. 1 show a similar intensity ratio to the others and also returned similar ρ-values with respect to the mass reference ^{155}Pm^{2+}; the observed chi-square value of two measurements, $\rho^2_{602} = 1.00013423(28)$ and $\rho^2_{604} = 1.00013413(26)$, was $\chi^2_{\rm obs} = 0.061$ and was sufficiently small to the 95% confidence level of $\chi^2_{95\%} = 3.84$. Thus, we conclude that these peaks were ^{155}Ce and experimentally determine its mass for the first time; ME(^{155}Ce) $= -47576(31)$ keV. Figure 2 shows the comparison with the theoretical predictions regarding the ^{155}Ce mass excess. No theoretical prediction reproduces the measured value; the differences, ME$_{\rm THEORY}$-ME$_{\rm EXP}$, were negative for all cases. Thus, the ground state of ^{155}Ce is less bound than all the predictions listed in Fig. 2.

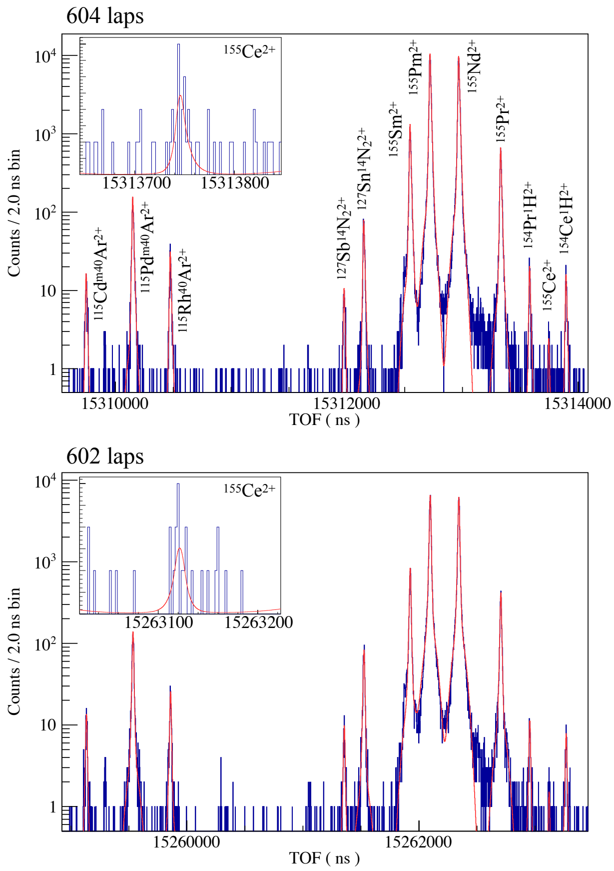

Fig. 1. TOF spectra of $A/q = 77.5$ series. Red lines show the fit results with the phenomenological fitting function. The enlarged spectra around the predicted positions of ^{155}Ce are indicated in the top-left panels.

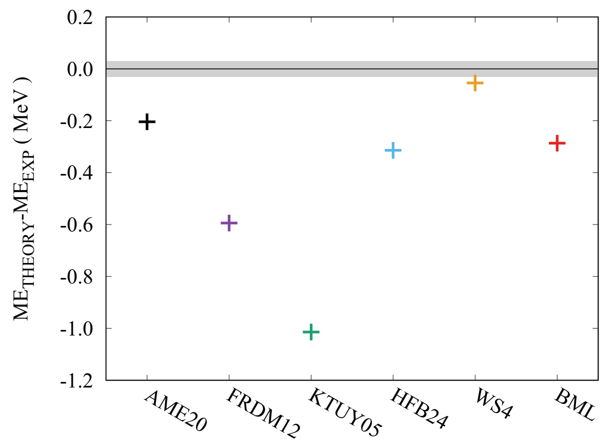

Fig. 2. Comparison of the theoretical predictions regarding the ^{155}Ce mass excess. The grey-colored band indicates the uncertainty ($\pm 1\sigma$) of the measured value.

References
1) S. Kimura *et al.*, RIKEN Accel. Prog. Rep. **53**, 52 (2019).
2) S. Kimura *et al.*, RIKEN Accel. Prog. Rep. **55**, 8 (2022).

*1 Wako Nuclear Science Center (WNSC), IPNS, KEK
*2 RIKEN Nishina Center
*3 Department of Physics, Kyushu University

DOI:10.34448/RIKEN.APR.57-175