In-gas-cell laser ionization spectroscopy of Os isotopes using MRTOF-MS at KISS

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We developed the KEK Isotope Separation System (KISS)[1] to study the nuclear properties of neutron-rich isotopes with neutron numbers around $N = 126$. To study the nuclear structures at KISS, we measured the hyperfine structure (HFS) of ^{194}Os ($I^\pi = 0^+$, $T_{1/2} = 6.0$ y) and ^{196}Os ($I^\pi = 0^+$, $T_{1/2} = 34.9$ m) to determine the change in charge radius using the in-gas-cell laser ionization spectroscopy technique[2] assisted by the multi-reflection time-of-flight mass spectrograph (MRTOF-MS). The MRTOF-MS installed at KISS can successfully identify isotopes from mass-dependent time-of-flight (TOF) spectra.[3]

We measured the HFS of short-lived ($T_{1/2} \sim 30$ min) isotopes by detecting the β- and γ-rays at KISS, and it is difficult to measure the HFS of isotopes with $T_{1/2} > 1$ h by detecting the decay radiations in a limited beam time. However, we can efficiently measure the HFS of these isotopes through ion counting using the MRTOF-MS without waiting for the radiation decays. Here, we report the HFS measurement of ^{194}Os using the MRTOF-MS.

The ^{194}Os isotopes were produced in multi-nucleon transfer reactions by using a stable ^{136}Xe beam (50 pnA) with an energy of approximately 10 MeV/nucleon impinging on a ^{198}Pt target (12.5 mg/cm^2, enriched to 91% with about 3% each of ^{194,195,196}Pt). Singly charged isotopes, produced by the in-gas-cell laser ionization technique, with an energy of 20 keV were extracted from the KISS gas cell for the HFS measurements. The extracted isotopes were injected into a helium gas cell for thermalization. Doubly charged ions were primarily produced by the charge exchange reaction with helium atoms in the stopping process, and they were extracted from the helium gas cell. Subsequently, the bunched isotopes were injected into the MRTOF-MS for particle identification. The details of the MRTOF-MS system are reported in Ref. 3).

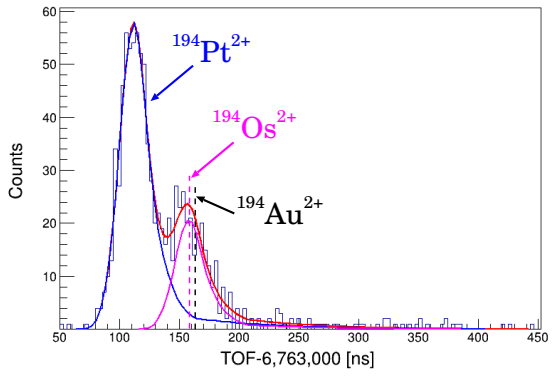

Fig. 1. Measured TOF spectrum of ^{194}Os^{2+}.

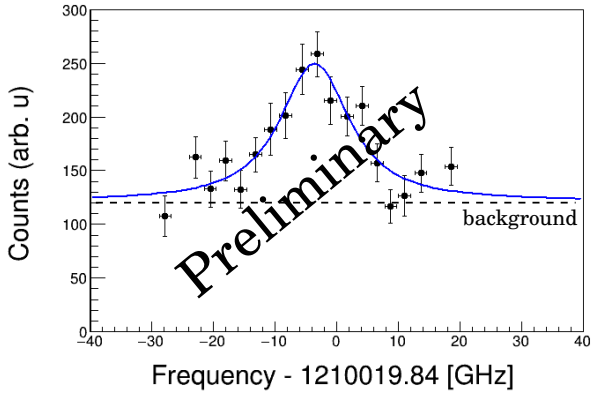

Fig. 2. Measured HFS spectrum of ^{194}Os ($I^\pi = 0^+$). Horizontal uncertainty estimated from the accuracy of a wavemeter.

Figure 1 shows the TOF spectrum of ^{194}Os^{2+} measured using the MRTOF-MS at KISS. We can clearly identify the ^{194}Os^{2+} isotope with a contaminant peak of ^{194}Pt^{2+} ions, which were emitted through elastic events from the production target and transported to the MRTOF-MS as survived ions. By fitting the TOF spectrum, we can deduce the number of ions extracted from the KISS gas cell. The HFS spectrum, as shown in Fig. 2, was obtained by measuring the number of laser-ionized ^{194}Os isotopes as a function of the laser wavelength. There appears one resonance peak stemming from one atomic transition of ^{194}Os due to $I^\pi = 0^+$. The constant background (dashed line) in Fig. 2 indicates the contaminant at the ^{194}Os^{2+} peak, which corresponds to ^{194}Au^{2+} transported as survived ions. The expected TOF peak position of ^{194}Au^{2+} indicated by the black dotted line in Fig. 1 deviates by about 4 ns from the ^{194}Os^{2+} peak. To evaluate the extraction yields of ^{194}Os^{2+} accurately, we fit the spectrum by omitting the ^{194}Au^{2+} peak because of the closeness of the peak positions. However, we could clearly deduce the resonance peak of ^{194}Os and the amount of ^{194}Au as the constant background, as shown in Fig. 2. From the peak position, we can determine the isotope shift value of ^{194}Os to deduce the change in the charge radius and discuss the nuclear deformation. Further analysis is in progress.

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References

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3) J. Y. Moon *et al.*, in this report.