Nuclear spectroscopy of ^{196,197,198}Ir isotopes

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For improving the accuracy of theoretical β-decay half-lives ($T_{1/2}$) for the r-process nuclei relevant to the 3rd peak in the r-abundances, a systematic experimental study of nuclear structures around $N = 126$ is required. We performed half-life measurements of ^{196,197,198}Ir ($Z = 77$, $N = 119$, 120, 121) at KISS[1] to extract the refractory elements of the neutron-rich nuclei produced by the multi-nucleon transfer reaction ^{136}Xe + ^{198}Pt.[2] We also measured their hyperfine structure (HFS) to estimate the wave-function from the nuclear electromagnetic moment, spin, and quadrupole deformation parameter.

The extracted ions from KISS are implanted on an aluminized Mylar tape, and then β-rays emitted from the unstable nuclei are detected by the multi-segmented proportional gas-counter.[3] For the half-life measurement, growth and decay curves were measured when the time sequence of the KISS beam on/off = 1.5/4 $T_{1/2}$. After the confirmation of the half-lives and the extraction yields, the HFS spectra of the extracted nuclei were measured by counting the β-rays as a function of the excitation laser wavelength.

The typical time spectrum of the β-decay of ^{198}Ir is shown in Fig. 1. The fitting curve, which consists of one parent nucleus and a constant background, is shown by the red line. The half-lives of ^{196,197,198}Ir were evaluated to be 51(4) s, 6.1(4) min, and 8.9(4) s, respectively. These values are in good agreement with the values in a literature,[4], *i.e.*, 52(1) s, 5.8(5) min, and 8(1) s. The yields of more than 5 pps were high enough to perform the HFS measurements.

The magnetic dipole moment μ and the isotope shift of ^{196,197,198}Ir were deduced from the fittings of the measured HFS spectra. The μ values of odd-A Ir and Au ($Z = 79$) isotopes of $I^\pi = 3/2^+$[5] are shown in Fig. 2. The evaluated μ value of ^{197}Ir shows a similar systematic trend in gold isotopes. The μ values of ^{197}Ir and ^{199}Au are about two times larger than the values of the lighter odd-A isotopes, which are close to the Schmidt value 0.12 of the πd3/2 orbit. A larger μ suggests a larger deformation of ^{197}Ir and ^{199}Au.

The HFS also yields the nuclear mean-square charge radius and the quadrupole deformation parameters $|\beta_2|$, as shown in Fig. 3. The variations of $|\beta_2|$ at $A = 196$–198 seem to be consistent with the trend of the theoretical values given by the FRDM model[6] which predicts the shape transition from a prolate to an oblate shape between $A = 196$ and 197. Further study of the nuclear structures of $^{196–198}$Ir isotopes is in progress for the publication.

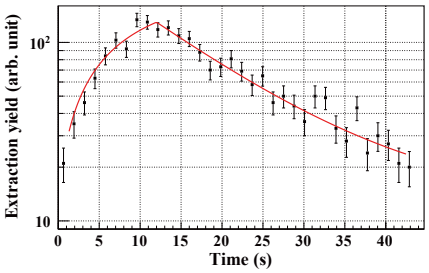

Fig. 1. Measured growth and decay time spectra for ^{198}Ir. The solid line indicates the best fitting curve to the experimental data.

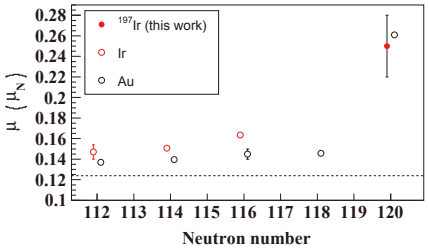

Fig. 2. Magnetic dipole moments of odd-A Ir and Au isotopes of $I^\pi = 3/2^+$.[5] The broken line indicates the Schmidt value 0.12 of the πd3/2 orbit.

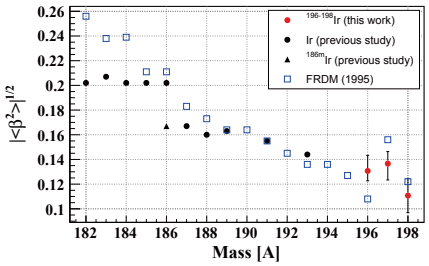

Fig. 3. The experimental β_2 values of iridium isotopes are compared with the theoretical values. The measured $|\beta_2|$ values of the isotopes $A \leq 193$ were taken from Ref. 7).

References

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