Nuclear spectroscopy of multi-nucleon transfer reaction products in the ^{136}Xe and ^{198}Pt system

Y. Hirayama,[*1] M. Mukai,[*2,*3] Y.X. Watanabe,[*1] Y. Kakiguchi,[*1] P. Schury,[*1] M. Oyaizu,[*1] H. Miyatake,[*1] M. Wada,[*1,*2] M. Ahmed,[*1,*3] S. Kimura,[*2,*3] J.Y. Moon,[*4] J.H. Park,[*4] H. Ishiyama,[*4] S.C. Jeong,[*4] S. Kanaya,[*5] H. Muhammad,[*5] A. Odahara,[*5] T. Shimoda,[*5] S. Suzuki,[*5] and H. Tsuru[*5]

We have developed the KEK Isotope Separation System (KISS)[1)] to study the β-decay properties of neutron-rich isotopes with neutron numbers around $N = 126$ for astrophysics research[2)]. We extracted elastic events of ^{198}Pt and unstable nuclei of ^{199,201}Pt and ^{196,197,198}Ir produced in the ^{136}Xe beam and ^{198}Pt target system[3)]. We successfully measured the lifetime of these unstable nuclei, and measured the hyperfine structure (HFS) of ^{199}Pt and ^{196,197}Ir in order to determine the magnetic dipole moment and the change in the charge radius by using the in-gas-cell laser ionization spectroscopy technique.

We performed nuclear spectroscopy using the ^{136}Xe beam with an energy of 10.75 MeV/nucleon and a maximum intensity of 100 pnA. We introduced a doughnut-shaped gas cell with the ^{198}Pt rotating target system in order to increase the extraction yield not only by increasing the ^{136}Xe primary beam intensity but also by reducing the argon-gas plasma density in the gas cell. The ^{136}Xe beam was directed onto the ^{198}Pt rotating target placed in front of the gas cell, and was stopped at a tungsten beam dump without entering the gas cell. As a result, we successfully extracted the laser ionized $^{199}Pt^{+}$ with a one order of magnitude higher yield than that with a primary beam intensity of 20 pnA.

Figure 1 shows a typical β-decay curve of ^{197}Ir. The half-life time was evaluated from the fit to the spectrum where the decays of the parent nucleus ^{197}Ir and daughter nucleus ^{197}Pt and a constant background were taken into account. The half-life times measured in this experiment are listed in Table 1. The measured half-life times $t_{1/2}$ were in good agreement with the reported values.

Figure 2 shows the measured HFS of ^{199}Pt obtained by detecting β-rays. We found that not only ^{199g}Pt but also ^{199m}Pt were laser-ionized, from γ-ray measurement. This indicated that the measured HFS consists of the HFS of ^{199g}Pt and ^{199m}Pt. In order to identify each HFS, we plan to measure the HFS by detecting γ-rays emitted from ^{199m}Pt, and then decompose the HFS of ^{199g}Pt. It is feasible to evaluate the magnetic dipole moment and the change in charge radius for ^{199g}Pt and ^{199m}Pt from the spectrum analysis.

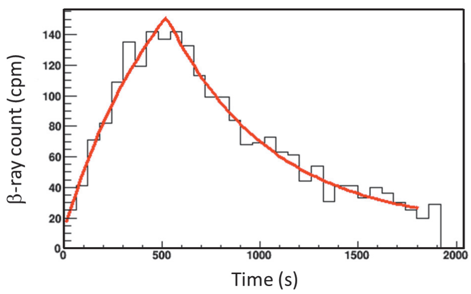

Fig. 1. Measured β-decay curve of ^{197}Ir. The red line indicates the best-fit result to evaluate the half-life time.

Table 1. Comparison between the present measured and reported half-life times of ^{199,201}Pt and ^{196,197,198}Ir.

Nuclide	Measured $t_{1/2}$	Reported $t_{1/2}$
^{199}Pt	31.3(1.5) min	30.8(2) min
^{201}Pt	1.9(5) min	2.5(1) min
^{196}Ir	52(5) s	52(1) s
^{197}Ir	6.1(4) min	5.8(5) min
^{198}Ir	10(1) s	8(1) s

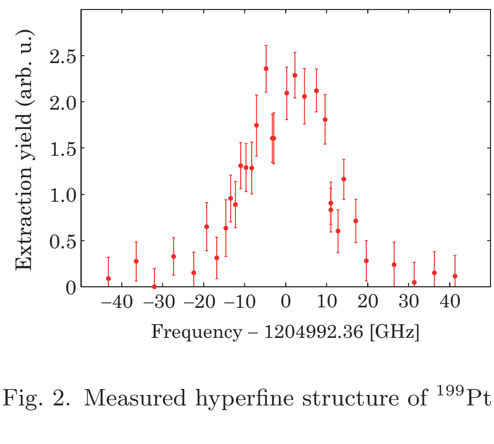

Fig. 2. Measured hyperfine structure of ^{199}Pt.

*1 Wako Nuclear Science Center (WNSC), Institute of Particle and Nuclear Studies (IPNS), High Energy Accelerator Research Organization (KEK)
*2 RIKEN Nishina Center
*3 Department of Physics, University of Tsukuba
*4 Institute for Basic Science, Rare Isotope Science Project
*5 Department of Physics, Osaka University

References

1) Y. Hirayama et al., Nucl. Instr. Meth. **B353**, 4 (2015).
2) S.C. Jeong et al.: KEK Report 2010-2.
3) Y.X. Watanabe et al., Phys. Rev. Lett. **115**, 172503 (2015).