β-decay spectroscopy of ^{187}Ta

M. Mukai,[*1] Y. Hirayama,[*2] Y. X. Watanabe,[*2] S. C. Jeong,[*2] H. Miyatake,[*2] S. Ishizawa,[*1,*2,*3] T. Niwase,[*1,*2,*4] M. Rosenbusch,[*2] P. Schury,[*2] M. Wada,[*2] H. Watanabe,[*1,*5] M. Brunet,[*6] F. G. Kondev,[*7] G. J. Lane,[*8] Yu. A. Litvinov,[*9] Zs. Podolyák,[*6] and P. M. Walker[*6]

The nuclear data of neutron-rich nuclei around $N = 126$, such as the nuclear mass, decay half-life, and decay scheme, are key for understanding the formation of the third peak around $A = 195$ through the r-process in explosive stellar environments, and the data are required to be investigated experimentally. Furthermore, the neutron-rich region around $Z = 75$ is not only a transition region of nuclear deformation, but also expected to contain high-energy long-lived isomers. Owing to the astrophysical and nuclear physics interests in this nuclear region, nuclear spectroscopy has been performed at the KEK Isotope Separation System (KISS) [1,2] installed in the Radioactive Isotope Beam Factory (RIBF), RIKEN.

The isomeric states of ^{187}Ta ($Z = 73$, $N = 114$) were first observed in the Experimental Storage Ring (ESR) at GSI.[3] In that study, the half-lives and excited energies were determined to be 2.3(6) min for the ground state (gs), 22(9) s for the first isomeric state (m1) at the excitation energy $E_x = 1789(13)$ keV, and >5 min for the second isomeric state (m2) at $E_x = 2935(14)$ keV.[3] We performed the β- and γ-decay spectroscopy of ^{187}Ta to investigate the nuclear structure of the ground and two isomeric states at KISS. They are predicted to have nuclear spins of $25/2^-$ and $41/2^+$ for the m1 and m2 states, respectively. The results of successful experiments on the m1 isomer were reported in Ref. 4). The present report describes the progress of the analysis investigating the unknown β-decays of $^{187\mathrm{gs,\,m1,\,m2}}$Ta.

$^{187\mathrm{gs,\,m1,\,m2}}$Ta were produced using multi-nucleon transfer reactions of a natural tungsten target (5 μm thick) and ^{136}Xe beam (7.2 MeV/nucleon, 50 particle-nA). The target-like fragments were thermalized and neutralized in a gas cell filled with purified Ar gas of $\sim$1 atm[2] and re-ionized element-selectively by using a laser resonance ionization technique[5] at the exit of the gas cell. Subsequently, the mass number was chosen by using a dipole magnet with a mass resolving power of $A/\Delta A \sim 900$. The mass-analyzed ions were transported to the decay station, which consists of a tape transport device, a multi-segmented proportional gas counter,[6] and four clover-type germanium detectors.

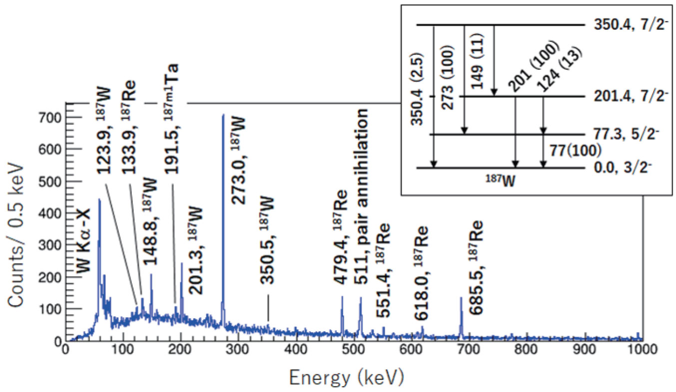

Fig. 1. Energy spectrum of γ-rays associated with the β-decay of ^{187}Ta and ^{187}W, as well as some of the internal transitions of $^{187\mathrm{m1}}$Ta. The labels indicate the energy (keV) and possible origin of the observed γ-rays. The inset shows a part of the low-energy level scheme in ^{187}W. The values in parentheses are the relative intensities of transitions.[7]

Figure 1 shows the γ-ray energy spectrum in coincidence with events of the gas counter telescope, which are sensitive to electron energies of >100 keV.[6] The measurement was performed with the time sequence of beam-on/off = 1800/1800 sec. We observed γ-rays originating from β-decays of ^{187}Ta as well as ^{187}W ($T_{1/2} = 24.0$ h), which is the daughter nucleus of ^{187}Ta, and from the internal decay of $^{187\mathrm{m1}}$Ta ($T_{1/2} = 7.3(9)$ sec)[4] emitting high-energy (>100 keV) conversion electrons. The γ-ray transitions were assigned not only through comparison with previously reported transition energies,[7] but also by checking the half-lives from the energy-gated time spectra for each gamma peak. Consequently, all of the observed γ-rays emitted from ^{187}W were identified (upper right scheme in Fig. 1). The observed γ-rays emitted from ^{187}Re agree with those measured in previous decay studies.

Further analysis to determine the decay branch from the three states of ^{187}Ta is ongoing.

*1 RIKEN Nishina Center
*2 Wako Nuclear Science Center (WNSC), Institute of Particle and Nuclear Studies (IPNS), High Energy Accelerator Research Organization (KEK)
*3 Graduate School of Science and Engineering, Yamagata University
*4 Department of Physics, Kyushu University
*5 International Research Center for Nuclei and Particles in the Cosmos, Beihang University
*6 Department of Physics, University of Surrey
*7 Physics Division, Argonne National Laboratory
*8 Department of Nuclear Physics, Australian National University
*9 GSI Helmholtzzentrum für Schwerionenforschung GmbH

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