In-gas-cell laser resonance ionization spectroscopy of ^{196,197,198}Ir†

M. Mukai,[*1,*2,*3] Y. Hirayama,[*3] Y. X. Watanabe,[*3] S. Schiffmann,[*4,*5] J. Ekman,[*6] M. Godefroid,[*5] P. Schury,[*3] Y. Kakiguchi,[*3] M. Oyaizu,[*3] M. Wada,[*3] S. C. Jeong,[*7] J. Y. Moon,[*7] J. H. Park,[*7] H. Ishiyama,[*1] S. Kimura,[*1] H. Ueno,[*1] M. Ahmed,[*2] A. Ozawa,[*2] H. Watanabe,[*8] S. Kanaya,[*9] and H. Miyatake[*3]

The experimentally measured nuclear quadrupole deformation parameters of mercury, gold, platinum, and iridium approach the value for the spherical shape with increasing neutron number.[1)] However, for iridium isotopes, the finite-range droplet model (FRDM)[2)] predicts a shape transition from prolate ($A \leqq 196$) to oblate ($A \geqq 197$) at $A = 197$. We have investigated the evolution of nuclear structure of iridium isotopes, $^{196\text{–}198}$Ir ($Z = 77$, $N = 119$–121), with in-gas-cell laser ionization spectroscopy as the first step of a systematic study of nuclear structures for nuclei around $N = 126$ at the KEK Isotope Separation System (KISS).[3)] In the present work, we report the magnetic dipole moments (μ), mean-square charge radii, and nuclear quadrupole deformation parameters (β_2), as determined from hyperfine structure (HFS) measurements.

Neutron-rich iridium isotopes were produced using multi-nucleon transfer reactions of a ^{198}Pt target (12.5 mg/cm^2) and ^{136}Xe beam (9.4 MeV/nucleon, 50 particle-nA).[4)] The target-like fragments were thermalized and neutralized in a gas cell filled with purified Ar gas of ∼1 atm[3)] and re-ionized element-selectively by using a laser resonance ionization technique at the exit of the gas cell. The excitation transition of $5d^76s^2\ {}^4F_{9/2} \rightarrow 9/2^\circ$ ($\lambda_1 = 247.587$ nm) was chosen for the spectroscopy, and the excitation laser was produced by a dye laser pumped by an excimer laser. The mass number was chosen using a dipole magnet with a mass resolving power of $A/\Delta A \sim 900$. The mass-analyzed ions were transported to a decay station, which consists of a tape transport device, a multi-segmented proportional gas counter, and four clover-type germanium detectors.

The extraction of each nucleus was confirmed through the measurement of β-decay half-life. The HFS spectra were measured by counting β-rays as a function of excitation laser frequency, as shown in Fig. 1. The measured spectra were fitted using the Voigt function for each transition between HFSs of ground and excited states to determine the μ and isotope shift values.

The μ value of ^{197}Ir ($I^\pi = 3/2^+$) was determined to be

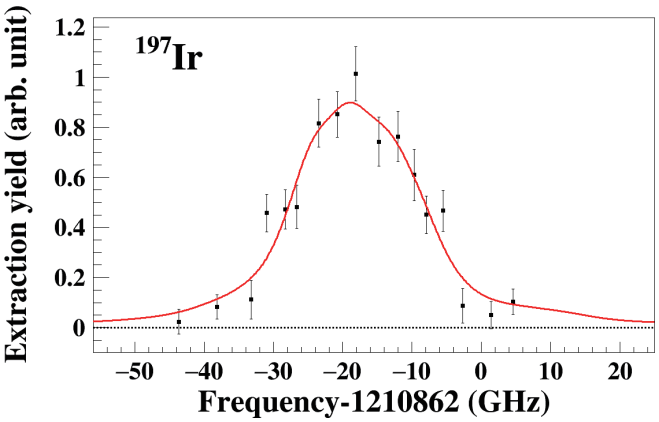

Fig. 1. Spectrum of ^{197}Ir ion counts as a function of the excitation laser frequency with the best fit (red solid line). The black dotted line indicates the fitted background level. The spectrum was measured at an argon gas pressure of 74 kPa.

$+0.27^{+0.10}_{-0.03}$ μ_N. In the case of the unknown spin nuclei ^{196}Ir ($I^\pi = (0^-)$) and ^{198}Ir, the results of chi-square fitting strongly indicate that their nuclear spin are $I > 0$ with fitted μ values of +(0.31–0.36) μ_N ($I = 1$–3) for ^{196}Ir and +(0.13–0.26) μ_N ($I = 1$–3) for ^{198}Ir.

The quadrupole deformation parameter was deduced from the measured isotope shifts while assuming an axial-deformed nuclear charge distribution and theoretical electronic factor of the excitation transition from large-scale atomic calculations.[5)] The deduced $|\beta_2|$ values were 0.06(2) and 0.07(2) for ^{197}Ir and ^{198}Ir, respectively.

The experimental μ values were compared with calculated μ values based on the strong coupling model.[6,7)] The comparison shows good agreement in the μ value for ^{197}Ir with the assumption of prolate deformation and suggests $I = 1^-$ or 2^- for ^{196}Ir and $I = 2^-$ for ^{198}Ir.

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*1 RIKEN Nishina Center
*2 Graduate School of Sciences and Technology, University of Tsukuba
*3 Wako Nuclear Science Center (WNSC), Institute of Particle and Nuclear Studies (IPNS), High Energy Accelerator Research Organization (KEK)
*4 Department of Physics, Lund University
*5 Spectroscopy, Quantum Chemistry and Atmospheric Remote Sensing (SQUARES), Université libre de Bruxelles
*6 Materials Science and Applied Mathematics, Malmö University
*7 Rare Isotope Science Project, Institute for Basic Science
*8 International Research Center for Nuclei and Particles in the Cosmos, Beihang University
*9 Department of Physics, Osaka University

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