Feasibility study of ^{199}Pt Q-moment measurement using in-gas-jet laser ionization spectroscopy at KISS

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KEK Isotope Separation System (KISS)[1)] has been developed to study nuclei in the region of neutron magic number $N = 126$. We investigated the nuclear structure of ^{199}Pt and Ir isotopes by measuring their hyperfine structures (HFSs) through the in-gas-cell laser ionization technique.[2)] In the measurement, we obtained precise values of magnetic dipole moments $\mu = +0.75(8)\ \mu_{\rm N}$ and $\mu = -0.57(5)\ \mu_{\rm N}$ for ^{199g}Pt and ^{199m}Pt, respectively. However the errors of electric quadrupole moments were quite large, $Q_g = +1.7(17)$ b and $Q_m = +3.5(21)$ b. To improve the spectral resolution, we developed an in-gas-jet laser ionization spectroscopy technique at KISS. In the laser system, a diode laser (TOPTICA, DLC DL Pro HP, 450 nm) is used for the seed laser of a pulsed dye-amplifier (Sirah), which creates UV light ($\lambda_1 = 225$ nm) for the excitation to the state $5d^8 6s6p\ ^5{\rm F}_2$. A Nd:YAG laser (EdgeWave) is used to pump the dye amplifier and for ionization as the second step ($\lambda_2 = 355$ nm). Compared to in-gas-cell ionization, we improved the resolution from 12.5(5) GHz to 0.6(1) GHz in the full width of the half maximum owing to the low density and temperature conditions of the gas jet.[3)] From this result, we are expecting to obtain a much more precise value of electromagnetic moments and isotope shift for ^{199}Pt through the in-gas-jet laser ionization spectroscopy technique.

The feasibility of ^{199}Pt HFS measurement through the in-gas-jet laser ionization spectroscopy was investigated by the Monte Carlo simulation. Based on the HFS spread and present resolution of 0.6 GHz by the in-gas-jet method, we determined the measurement step $\Delta\nu_1 = 0.27$ GHz. From the yield of $^{199g+m}$Pt, we determined the measurement time of 10 min for each data point, which corresponds to a measurement of 20 h. A Voigt function with Gaussian width $\Gamma_{\rm G} = 316(27)$ MHz and Lorentzian width $\Gamma_{\rm L} = 110(76)$ MHz, which were determined from the off-line measurement of ^{196}Pt ($I^\pi = 0^+$), was used in a response function of the resonance peak. Relative intensities between each resonance peak were computed via the Racah coefficient. We assumed the unknown electric quadrupole hyperfine coupling constant of the atomic excited state of ^{199g}Pt to be 1 GHz.

Figure 1 shows the simulated hyperfine splitting spectrum of $^{199g+m}$Pt. The vertical axis indicates the expected β-ray events detected by MSPGC[4)] during the 10 min beam accumulation. The total β-ray events were evaluated to be 4915 counts. Figure 2 shows the simulated HFS spectrum of ^{199m}Pt nuclei obtained by gating on a 392 keV γ-ray. Total γ-ray events detected by the four super clover Ge detectors were evaluated to be 3941 counts. In the analysis, the spectra in Figs. 1 and 2 were simultaneously fitted using the common parameters (electromagnetic hyperfine coupling constants) for ^{199i}Pt ($i = g,\ m$). The reduced chi-square of fitting was 1.13. In the simulation, we assumed $\mu_g = +0.75\ \mu_{\rm N}$ and $Q_g = +1.7$ b, and $\mu_m = -0.57\ \mu_{\rm N}$ and $Q_m = +3.5$ b for ^{199g}Pt and ^{199m}Pt respectively. The evaluated electromagnetic moments from the fitting were $\mu_g = +0.7434(58)\ \mu_{\rm N}$, $Q_g = +1.75(10)$ b, $\mu_m = -0.5740(49)\ \mu_{\rm N}$, and $Q_m = +3.42(10)$ b. From the simulation, we confirmed that the 20 h measurement is enough to achieve precise values of electromagnetic moments for ^{199}Pt.

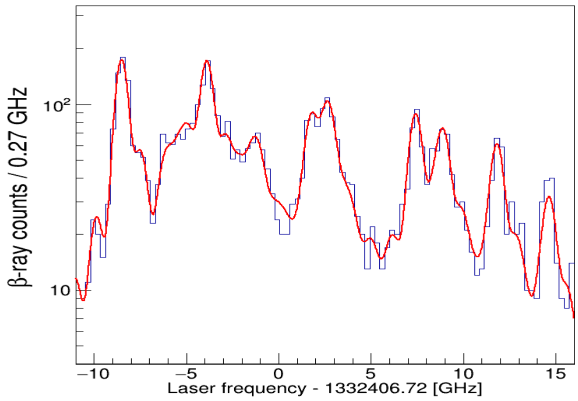

Fig. 1. Simulated HFS spectrum of $^{199g+m}$Pt. Red line indicates the simultaneous fitting function.

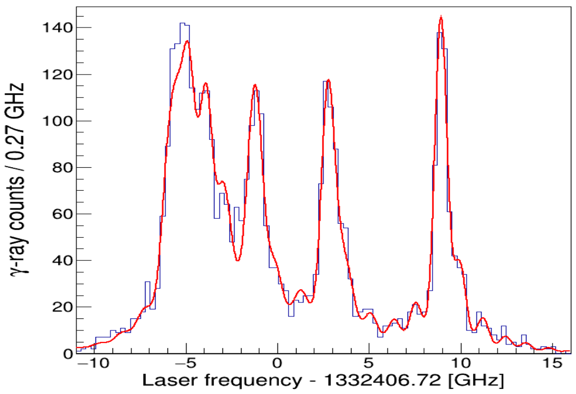

Fig. 2. Simulated HFS spectrum of ^{199m}Pt obtained by gating on 392-keV γ-ray.

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