In-gas-cell laser ionization spectroscopy of ^{191,192}Re at KISS

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Nuclear shape transitions from prolate to oblate deformation at neutron numbers $N = 116$–118 have been observed or predicted in the refractory elements with atomic numbers $Z = 72$–78.[1] For the Re ($Z = 75$) isotopic chain, the shape change in the ground state is predicted for $^{191-193}$Re isotopes ($N = 116$, 117, and 118)[2] with a subtle prolate-oblate competition in the ground state. Moreover, a recent β-decay study of ^{192}Re[3] suggested a change in the ground-state proton orbit from $[402]5/2^+$ to $[411]1/2^+$, and the expected nuclear spin-parity values of ^{191}Re$_{116}$ and ^{192}Re$_{117}$ are $1/2^+$ and 0^-, respectively.

To clarify the change in the proton orbit, which is strongly correlated to the nuclear shape transition, we performed in-gas-cell laser ionization spectroscopy of ^{191g}Re ($T_{1/2}$ = 9.8 min) and ^{192g}Re ($T_{1/2}$ = 15.1 s) at the KEK Isotope Separation System (KISS).[4] This study forms part of systematic laser spectroscopy studies[5] of refractory nuclei with neutron numbers approaching $N = 126$. Laser spectroscopy is a powerful tool for effectively investigating nuclear structure based on the nuclear spin, magnetic dipole moment $\mu_{\rm I}$, and isotope shifts $\Delta\nu$ deduced from the measured hyperfine structure (HFS) spectrum.

The ^{191g,192g}Re isotopes were produced through multi-nucleon transfer reactions by impinging a stable ^{136}Xe beam (30 particle nA) with an energy of approximately 10 MeV/nucleon on a ^{nat}Ir target (21 mg/cm^2). Singly charged ions were produced using the two-color two-step in-gas-cell laser ionization technique, λ_1 = 250.9741 nm and $\lambda_2 = 308$ nm. These ions were then extracted with an energy of 20 keV from the KISS gas cell for HFS measurements. The extracted ions were identified by detecting β-particles emitted from these nuclei, and their identities were confirmed based on the measured half-lives. Subsequently, the HFS spectra were measured.

Figure 1 shows the measured HFS spectra of ^{187g,191g,192g}Re. The HFS spectrum of ^{187g}Re ($I^\pi = 5/2^+$), emitted from a filament placed in the gas cell under identical experimental conditions to those of the HFS measurements for ^{191g,192g}Re, served as the laser response function for the in-gas-cell laser ionization spectroscopy of Re isotopes. The blue lines in Fig. 1

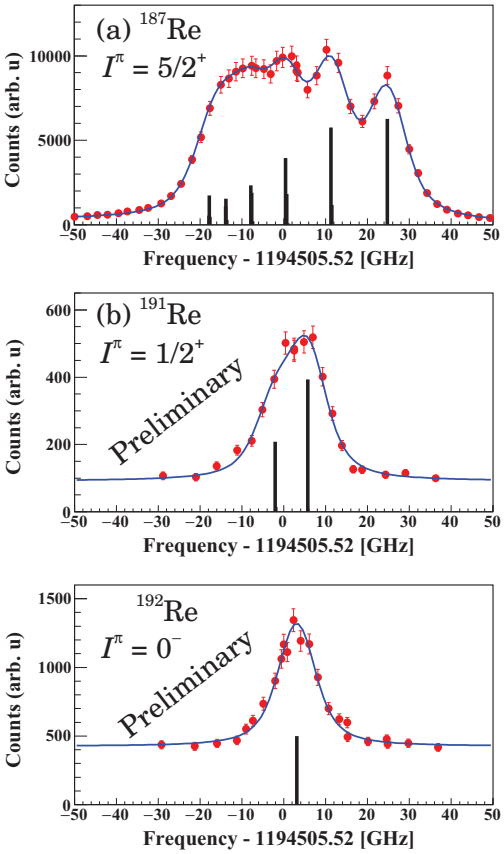

Fig. 1. Measured HFS spectra of (a) ^{187g}Re, (b) ^{191g}Re, and (c) ^{192g}Re.

indicate the optimal fit to the HFS spectra achieved by applying the same Voigt function (FWHM ≈ 11 GHz) as the laser response function for each atomic transition. The black lines in the figure indicate the expected HF transitions deduced from the fitting analysis. In the analysis we assumed $I^\pi = 1/2^+$ for ^{191g}Re and $I^\pi = 0^-$ for ^{192g}Re. We can reliably fit the HFS spectrum of ^{192g}Re by using a single component ($I = 0$) fitting function, that matches identical to the laser response function. Moreover, the broader spectrum of ^{191g}Re was well fitted under the assumption of $I^\pi = 1/2^+$. Further analysis, including theoretical interpretations, is currently underway.

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