Impact of laser polarization on spectra of Eu $4f^76p_{3/2}$ n*l* autoionizing states

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Synopsis Experimental spectra of the Eu $4f^76p_{3/2}$ n*l* autoionizing states are investigated with three-step isolated-core excitation technique, while the impact of laser polarization on the spectra is studied for the first time.

The Eu atom is a very challenging system due to its half-filled 4f shell and much more complex nature in its spectrum. Although some studies on the Eu atom have been reported[1-2], no works on the Eu $4f^76p_{3/2}$ n*l* (*l*=0,2) autoionizing states have been seen. This work will devote to the spectra of these autoionizing states with three dye lasers.

The bound Eu $4f^76$sn*l* Rydberg states are populated from the ground state via the $4f^76$s6p states by two-step excitation, from which the Eu $4f^76p_{3/2}$ n*l* autoionization spectra are obtained by tuning the wavelength of the third laser around the Eu $4f^76$s⁺—$4f^76p^+_{3/2}$ ionic line. Then, different configurations of polarization of three lasers are applied to fulfill the three-step ICE scheme in order to observe their spectral differences. To have a better understanding about the the impact of laser polarization on the spectra, the complex features are explained with the physical principles, such as the selection rules of total angular momentum under different excitation paths, and those of magnetic quantum number under different configurations of polarization of three lasers.

The wavelength of the third laser λ_3 is scanned from 394 nm to 402 nm to cross the ionic line of the $4f^76$s⁺—$4f^76p_{3/2}$⁺ (J=4) , while the wavelength of the first two lasers, λ_1 and λ_2, are fixed at 564.74 and 529.61 nm. All lasers are linearly polarized, which are set either parallel (π) or perpendicular (σ) to the MCP detector (i.e., direction of electric field to collect the ions), corresponding to the two cases where the selection rule of $|\Delta M| = 0$ or $|\Delta M| = 1$ applies. With this method，spectra of several n values for the Eu $4f^76p_{3/2}$ n*l* (*l*=0,2) autoionization Rydberg series have been obtained. As an example, the observed spectrum of Eu $4f^76p_{3/2}$6d autoionizing state is shown in figure 1, to be compared with a multi-peak fit to the famous Fano-Beaulter line shape.
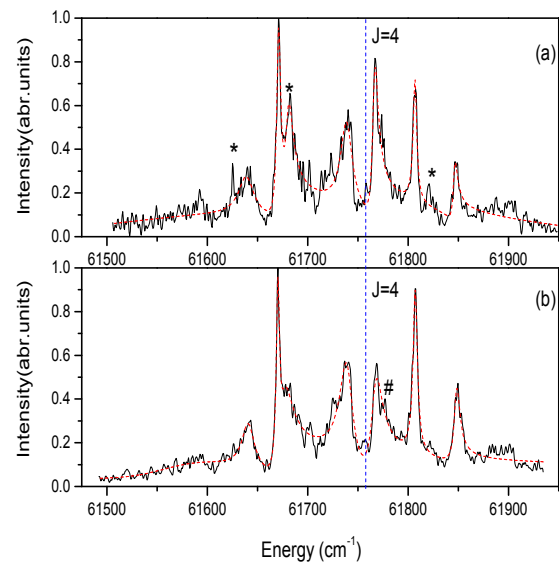

Figure 1. Observed spectrum (black) $4f^76p_{3/2}$6d autoionizing state with a multi-peak fit (red) ,(a) $|\Delta M|$=0 and (b) $|\Delta M|$=1.

As shown in figure 1, instead of a single broad profile of Eu $4f^76p_{3/2}$6d autoionizing state, many narrow peaks originated from other autoionization series are superimposed, leading to a structured spectrum. This phenomenon manifests the heavy configuration interaction among the Eu $4f^76p_{3/2}$6d autoionizing state and $4f^76p_{/12}$ n*l* and $4f^75d_{1/2,3/2}$ n*l* autoionization series. Some differences can be found in the two spectra, particularly those peaks marked with sign *or # , which demonstrates the impact of different kinds of polarization schemes. The similar effects are also observed on the spectra of the Eu $4f^76p_{3/2}$ ns autoionizing states .

References

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