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Observation of Inner/ Outer-Photoionization of Beryllium Atoms

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Introduction

Following He atom ($1s^2$), Be ($1s^22s^2$) is the next simplest closed-shell atom. Autoionization of Be atom is important process because this phenomenon is conesquence of electron correlation within a relatively simple system. Therefore detailed theoretical calculations have carried out using several methods [1]. On the other hands, few experimental data have existed [2] because the toxicity of Be as well as the characteristics of law vapor pressure causes the difficulty of experiment. Then an observation with high resolution is needed for the purpose of quantitative analysis, which provides valuable information about autoionization process.

We observed inner-shell photoionization of Be as well as outer-one and reported measurements about autoionization-profile of Rydberg states in this paper.

Experiment

The experiment concerning inner-shell photoionizaiton was performed at BL-16B, while the spectrum of outer-shell photoionization were measured at BL-20A. The monochromatized photons interacted with the vapor of Be emerging from electron bombardment oven at about 1100°C. The created photo-ion was detected through Time of Flight mass spectrometer to distinguish between singly and doubly charged photo-ions.

Results and Discussion

Inner-shell photoionization

To obtain data with high resolution, we focused on the several autoionizing Rydberg series. Consequently, a sequence of the inner-shell autoionizing Rydberg series were observed, which converge to $1s(2s2p^3P)$, $1s(2s2p^1P)$, $1s(2s3s^3S)$ and $1s(2s3s^1S)$. Figure 1 shows the spectra of singly and doubly charged photoionization in the photon energy region of $1s(2s2p^3P)nl$ Rydberg states. We identified the resonance belonging to above 4 series, most of which were observed at the first time in this detailed investigation. The analysis revealed the autoionization parameters of resonance energy position E, resonance width Γ and Fano parameter q. From the resonance position, the energy limits of these 4 series were determined using Rydberg formula.

Outer-shell photoionization

Figure 2 shows the spectrum of singly charged photoionization of Be in the region of 2s double excitation. The Rydberg series converging to the $1s^23s$ limit were measured. Another interloper, $1s^23p4s$, which is the first member of the $3pns$ series converging to the $1s^23p$ limit was also observed. It almost overlapped 3s5p state. The comparison with theoretical calculation revealed the difference of the profile in the vicinity of $1s^23p4s$ state. That suggests these experimental results could contribute to the progress of the theory regarding to series perturbation involved two- electron double excitations.

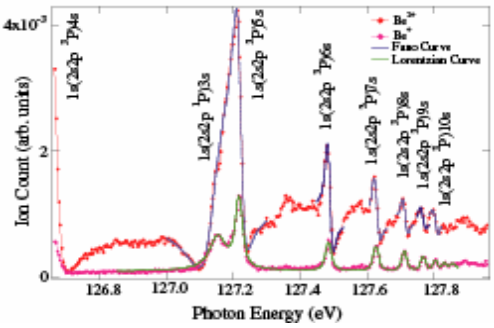

Figure 1: Be^{2+} (red line) and Be^+ (purple line) photoionization spectrum with fit curve of Fano profile (blue line) and of Lorentzian distribution (green line).

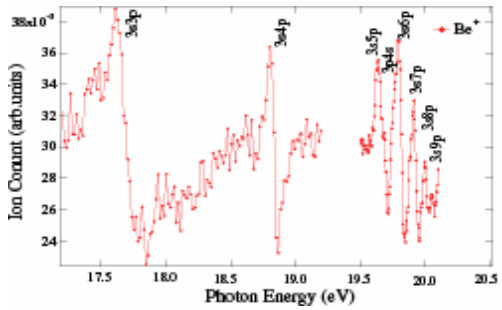

Figure 2: Be^+ photoionization spectrum in the region of 2s excitation. $1s^23snp$ (n=3-9) Rydberg states and $1s^23p4s$ resonance were observed.

References

[1] L. Voky et al., Phys. Rev. **A**46, 3945 (1992), D. –S. Kim et al., Phys. Rev. **A**61, 062701 (2000), C. D. Lin et al., Phys. Rev. **A**51, 1286 (1995).
[2] M. O. Krause et al., Phys. Rev. Lett. 59, 2736 (1987), R. Wehlitz et al., Phys. Rev. **A**68, 052708 (2003).
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