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High-resolution threshold photoelectron study of the Kr 4s satellite states

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Introduction

In the photoelectron spectrum of Kr, photoionization of 4s electron is accompanied with rich satellite structure, which corresponds to excited states of Kr^+, due to strong electron correlations.

Recently, high-resolution photoelectron and threshold photoelectron spectra were measured [1, 2]. Full width at half maximum (FWHM) of the observed peaks were ~27 meV and ~13 meV, respectively.

In the present study, a high-resolution threshold photoelectron spectrum of Kr, of which FWHM was ~7 meV, was measured in the photon energy region between the Kr^+ $4s^{-1}$ main line and the Kr^{2+} $^1D_2$ state.

Experiment

The experiments were performed on the beamline 20A of the Photon Factory. The experimental set-up and technique were same as our previous study[3]. In brief, photoelectrons extracted by a penetrating field were focused by a lens system and then led to a hemispherical electrostatic analyser. In the spectrum recorded the FWHM for ionization of the 4s shell was ~7meV.

Results and Discussion

A part of the observed threshold photoelectron spectrum at higher photon energy region is shown in Fig. 1. Rich satellite structures, 178 peaks including 48 newly observed peaks, were found in our whole spectrum. Although the feature of the observed spectrum is similar to the previous threshold photoelectron spectrum [2] except for the improved peak width, it is different from the previous photoelectron spectrum [1]. Although many lines measured in this study were assigned by comparison with the optically obtained energy levels [4], some of them could not be assigned.

In our spectrum, four Rydberg series were found. One is converging to the Kr^{2+} $^3P_2$ state and the others to the Kr^{2+} $^1D_2$ state. The Rydberg series converging to the Kr^{2+} $^3P_2$ state was observed for the first time. This series had been hard to observe, because high-n levels are hiding behind a strong peak at 38.290 eV, the (^{1}D)8s' $^2D_{5/2,3/2}$ state, and low-n levels overlap with the other levels. Owing to high-resolution, eight energy levels of the Rydberg series are separated in the present measurement between 38 and 38.3 eV region.

Generally, the energy levels of the Rydberg series could be expressed as following:

$$E_n = E_{limit} - RZ^2/(n-\ )^2, \qquad (1)$$

where R, E_{limit}, Z and are the Rydberg constant employing the reduced mass of Kr, the converging limit, the electric charge of the core ion, and the quantum defect, respectively. Since the observed eight levels belonging to the newly observed Rydberg series satisfy this formula very well, fitting the observed energy levels to this formula was performed. The converging limit, E_{limit}, obtained as the fitting result was 38.355 eV and it is in excellent agreement with the energy level of the Kr^{2+} $^3P_2$ state observed by a photoelectron-photoelectron coincidence measurement [5], 38.36 eV. There are (^{3}P)7p, (^{3}P)8p and (^{3}P)9p states observed by Alitalo *et al.* [1] near low-n Rydberg levels predicted by the fitting. This Rydberg series are , therefore, assigned to the (^{3}P)np series.

Three Rydberg series converging to the Kr^{2+} $^1D_2$ state were assigned to the (^{1}D)nd' $^2D_{3/2}$, (^{1}D)nd' $^2D_{5/2}$ and (^{1}D)ns' $^2D_{5/2,3/2}$ series. The converging limit, E_{limit}, obtained as the fitting result for the (^{1}D)nd' $^2D_{3/2}$ series was 40.180 eV and it is in complete agreement with the Kr^{2+} $^1D_2$ state energy observed by photoelectron-photoelectron coincidence measurement [5], 40.18 eV.

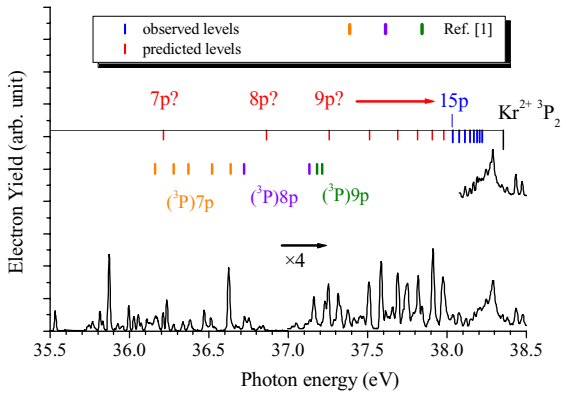

Fig. 1 A part of the observed threshold photoelectron spectrum

References

[1] S. Alitalo *et al.*, J. Electron Spectrosc. Relat. Phenom. **114-116**, 141 (2001)
[2] A. E. Slattery *et al.*, J. Phys. B **33**, 4833 (2000)
[3] Yoshii *et al.*, J. Mol. Specrosc. **186** 155 (1997)
[4] C. E. Moore "Atomic Energy Levels (NBS Circular) vol. 2" (Washington, DC: US Govt Printing Office 1952)
[5] R. I. Hall *et al.*, J. Phys. B **25,** 799 (1992)

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