(BL-3B)

Laser photoionization electron spectroscopy of polarized rare gas atoms excited with synchrotron radiation

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We have performed laser photoionization spectroscopy of polarized rare gas atoms in order to study spin-orbit interactions of many electron systems and exploit the possibility of the complete photoionization experiment. Rare gas atoms in a gas cell are excited by linearly polarized synchrotron radiation (85-100nm) supplied from the beamline BL3B and aligned toward the electric vector. The light beam of a Nd:YAG laser (532nm) intersects with the synchrotron radiation at a right angle and ionize the aligned targets. The electric vector of the laser can be rotated by using a half wave plate. Photoelectrons, emitted in the direction perpendicular to both the laser and synchrotron radiation, are detected with a 160° hemispherical electrostatic analyzer.

A two-dimensional spectrum of Kr is shown in Fig. 1. Major spots due to high photoelectron yield are aligned on two straight lines with a slope of unity; these spots are assigned to two final ionic states of Kr^+ [$^2P_{1/2,\ 3/2}$]. Since electronic states of excited Kr atoms are designated by a J_c- ℓ coupling scheme, a total angular momentum of the product ion J_f can be expected to be equal to that of a core ion of an excited state J_c. However, this picture seems to disagree with the present results in some cases. There are two possible explanations for this disagreement: the excited states designated by the J_c- ℓ coupling are influenced by mixing of J_c of 1/2 and 3/2, or an ejected electron exchanges angular momenta with the ion core during the photoionization process.

In Fig 2(a), the photoelectron yield for Ar(5s'$[1/2]_1$)→Ar^+($^2P_{1/2}$) + e^- (ℓ=1; j=1/2, 3/2) is plotted as a function of the angle ψ_e between the electric vector of the laser and the direction of the linear momentum of photoelectrons. The angular distribution should be interpreted in terms of a p wave from excited Ar aligned toward the electric vector of synchrotron radiation. We have obtained an asymmetry parameter ß of 1.96 from this result. The angular distributions have also been measured for photoelectrons produced by the process Ar(3d$[1/2]_1$)→Ar^+($^2P_{Jf}$) + e^- (ℓ=1 or 3; j=1/2, 3/2 or 5/2, 7/2) with J_f=1/2 and 3/2. As shown in Fig. 2(b), the ß values for these distribution curves are much smaller than that for photoelectrons from the 5s'$[1/2]_1$ state. We are planning the complete photoionization experiment to determine dipole matrix elements and a phase shift difference of each partial wave.

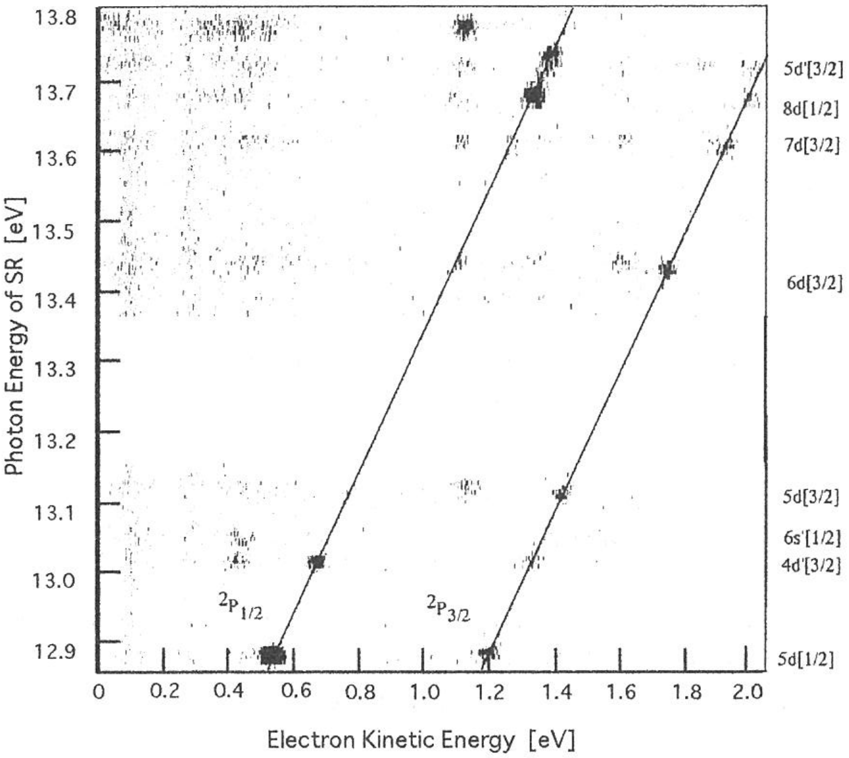

Fig 1. Two-dimensional spectrum of Kr. The electric vector of the laser is parallel to the direction of photoelectrons

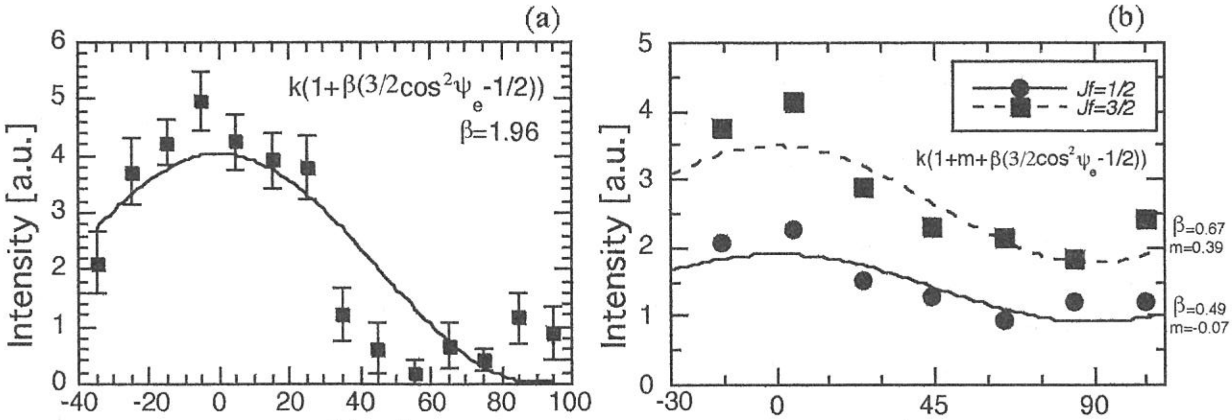

Fig. 2. Angular distributions of photoelectrons: (a) Ar(5s'$[1/2]_1$)→$Ar^+(^2P_{Jf})$ and (b) Ar(3d$[1/2]_1$) →$Ar^+(^2P_{Jf})$. Photoelectron yields were measured as a function of ψ_e.

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Spectator- and Participant-Like Behavior of a Rydberg Electron on Predissociation of Superexcited States of OCS

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Predissociation of superexcited states of OCS is studied by two-dimensional photoelectron spectroscopy using synchrotron radiation in the photon energy range of 15 - 16.5 eV.[1)] A two-dimensional photoelectron spectrum exhibits two kinds of characteristic patterns both of which are ascribed to autoionization of sulfur atoms. To clarify the point, we show a photoelectron spectrum of Figure 1 which is obtained as a cut through the two-dimensional spectrum along the electron kinetic energy axis at the phootn energy of 15.95 eV.[2)] The superexcited atom S* is produced by predissociation of a Rydberg state OCS*(R_B) converging to $OCS^+(\tilde{B}\,^2\Sigma^+)$. The pattern of the first kind results from predissociation processes in which the effective principal quantum number n of the Rydberg electron is almost conserved. This suggests that the Rydberg electron behaves as a spectator because of its negligibly weak interaction with the ion core (spectator predissociation). On the contrary, n of S* does not accord with that of OCS*(R_B) in the pattern of the second kind, indicating that the Rydberg electron participates directly into the electron exchange mechanism controlling conversion from OCS*(R_B) to a predissociating state (participant predissociation). With increasing n, OCS*(R_B) decays more preferentially by the spectator than by the participant predissociation. The spectator predissociation of OCS*(R_B) proceeds through a two-step conversion which involves Rydberg states converging to $OCS^+(\tilde{A}\,^2\Pi$ and $\tilde{X}\,^2\Pi)$ and a dissociative multiple-electron-excited state OCS*(*SAT*) asymptotically correlating with S* + $CO(\tilde{X}\,^1\Sigma^+)$. In contrast, the participant predissociation may be accounted for by a direct conversion from OCS*(R_B) to OCS*(*SAT*). The quantum yields are estimated from Figure 1 to be 0.07 and 0.02 for the participant and spectator predissociation, respectively, at the incident photon energy of 15.95 eV where OCS*(R_B) states with $n \sim 12$ lie. A simulation is performed to reproduce the partial cross section curve for the spectator predissociation by using a model in which the decay rates for the participant and spectator predissociation are assumed to be proportional to n^{-3} and n^0, respectively. The simulated and experimental cross section curves are in good agreement with each other at the photon energy higher than 15.8 eV.

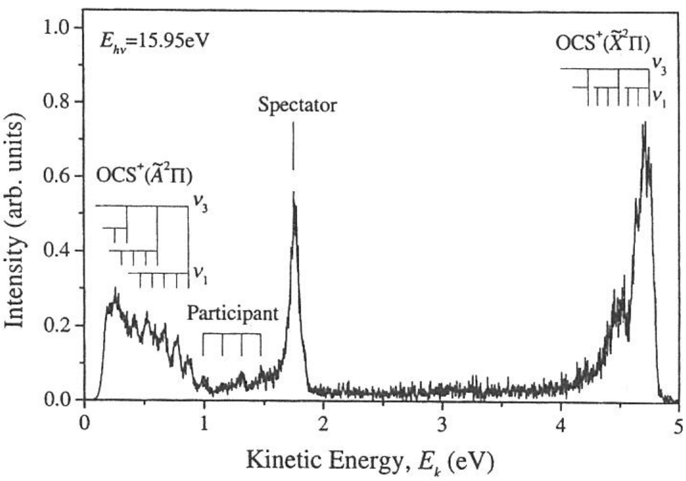

Figure 1. Photoelectron spectrum of OCS at the photon energy of 15.95 eV where OCS*(R_B) states with $n \sim$ 12 are located.

References

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2) Y. Hikosaka, H. Hattori, and K. Mitsuke, *ibid.* **110,** 335-344 (1999).