1C, 16B/2004G210, 2006G230

State-selective Cross Sections of Double Photoionization in Ne

Tatsuo KANEYASU[1], Yasumasa HIKOSAKA[1], Eiji SHIGEMASA[1], Francis PENENT[2]
Pascal LABLANQUIE[2], Tomohiro AOTO[3], Kenji ITO[3]
[1]UVSOR, Institute for Molecular Science, Okazaki 444-8585, Japan
[2]Laboratoire de Chimie Physique-Matière et Rayonnement, 75231 Paris Cedex 05, France
[3]KEK-PF, Tsukuba, Ibaraki 305-0801, Japan

Introduction

Double photoionization (DPI) of atoms and molecules caused by the absorption of a single photon is a fundamental process in atomic and molecular physics. Since the simultaneous ejection of two electrons cannot be described by the single particle approximation, in which the photon interacts only with a single electron, the DPI process is entirely due to the electron correlation. The study of DPI has long attracted considerable interest in both experimental and theoretical researchers. Particularly in He atom, the direct DPI, ie., simultaneous two-electron emission, can directly be accessed from the mass-resolved ion yields. In contrast, valence DPI of heavier rare gas atoms leads to formation of various final states and the presence of the indirect processes should be considered. In theoretical works, DPI cross sections have been calculated for direct two-electron emission leading to specific final states, and thus it has been required to observe direct DPI state-selectively.

In this work we have investigated valence DPI of Ne by multi-electron spectroscopy [1]. By using a magnetic-bottle electron time-of-flight spectrometer, all electrons ejected in every multiple-photoionization event are analyzed in energy. From the coincidence data sets, cross sections of direct DPI have been obtained state-selectively in a photon energy region from 69.89 eV to 239.8 eV, by evaluating the contributions of the indirect processes.

Results and Discussion

Figure 1(a) shows an example of kinetic energy correlation map between the fast and slow electrons associated with valence DPI of Ne, which was measured at $h\nu$=200.4 eV. The complete information on energy correlation between ejected electrons allows the identification of Ne^{2+} final states and their formation mechanism. The diagonal lines on the map are corresponding to formation of the $2s^22p^4(^3P, ^1D, ^1S)$, $2s^12p^5(^3P, ^1P)$ and $2s^02p^6(^1S)$ states. To reveal relative intensities of individual Ne^{2+} states produced through the DPI, a histogram of the kinetic energy-sum for two electrons is constructed by summing the coincidence counts on the map. The relative intensities of the final states derived from the energy-sum spectrum in Fig. 1(a) are the sum of the direct and indirect DPI yields. The indirect processes, in which two-electron emission is mediated by singly charged excited state, are obviously seen as enhanced spots in 0-40 eV range of slow electrons on the 2D map in Fig. 1(a). To obtain the direct DPI cross section, we have evaluated its relative intensity compared to the total DPI cross section from a detailed analysis on slow electron energy distributions associated with individual Ne^{2+} states. The state-selective cross sections of direct DPI have been derived from the relative DPI intensities and the ratio between the direct and indirect processes, and are compared with theoretical state-selective cross sections [2].

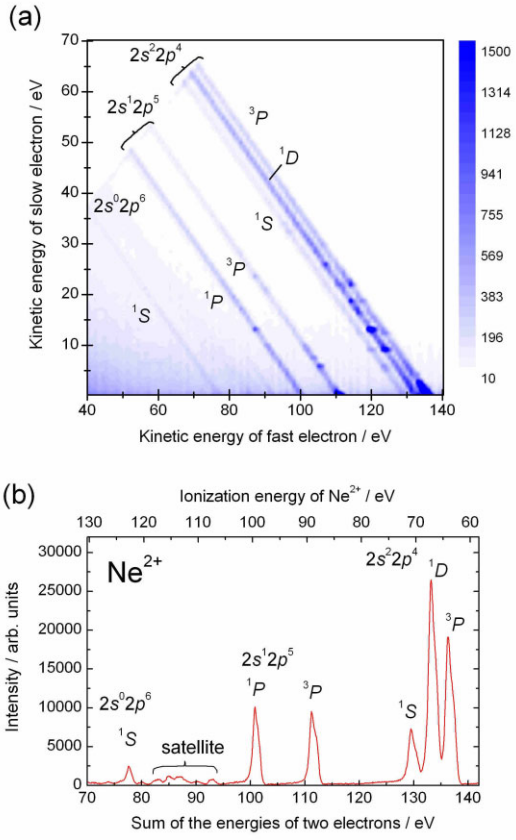

Fig. 1 (a) Two-dimensional map for kinetic energy correlation of two-electron coincidence pairs in Ne DPI at $h\nu$=200.4 eV. (b) Histogram of the kinetic energy-sum of the two electrons extracted from the 2D map in (a).

References

[1] J.H.D. Eland et al., Phys. Rev. Lett. 90, 053003 (2003).
[2] T. Kaneyasu et al., Phys. Rev. A, in press.

kaneyasu@ims.a.cjp