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Ar(e, 3e) Double Ionization Experiment at Low Collision Energy*

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Abstract: Through comparing the experimental with the theoretical 3D plots for Ar, there are big deviations between them at low collision energy.

Key words: (e, 3e); double ionization; fivefold differential cross section
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1 Introduction

Electron-impact double ionization (DI) of an atom with simultaneous determination of the energies and angles of all participating particles can, under appropriate conditions, provide information to understand the dynamical electron-electron correlation during the collision and the DI mechanism[1]. The improvements in the electron analyzers and detectors as well as the introduction of multi-parameter coincidence measurements[2-4] resulted in a noticeable progress in the amount of experimental information and quality of the obtained data. Theory has made progresses too[5-8]. But large deviations still exist between the experimental and theoretical results, especially at low collision energy. In this paper, as a example for Ar, we show these deviations.

2 Experiment and Results

The fivefold differential cross section (5DCS) has been obtained using the multiparameter multicoincidence (e, 3e) spectrometer. The experimental set-up and procedure are described in details by Duguet et al[3] and Lahmam-Bennani et al[8]. Briefly, the important operating processes are as bellow.

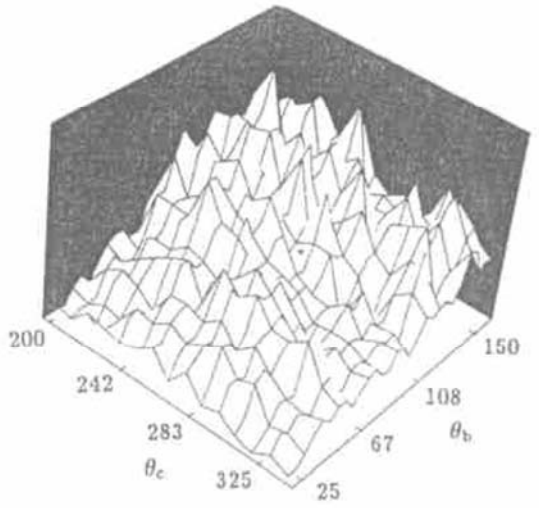

Fig. 1 Three-dimensional plot of the measured, relative 5DCS for DI of Ar^{2+} ($3p^{-2}$), plotted versus both ejection angles θ_b and θ_c. Kinematical parameters are: E_0= 561.4 eV, E_a= 500 eV, E_b= E_c= 9 eV, θ_a= + 1.5°, k= 0.4 (atomic unit), θ_K= 336°.

The incident electron beam is produced by an electron gun[9]. This beam is collided with the gas jet formed at the collision centre. The fast a-electron is received by a cylindrical analyser at a small scattering angle θ_a. The

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slow ejected b- and c- electrons are multi-angle analysed in a double toroidal analyser. Using the coincident measurement and imaging techniques, the 3D plot of fivefold differential cross section has been measured versus ejection angles θ_b and θ_c.

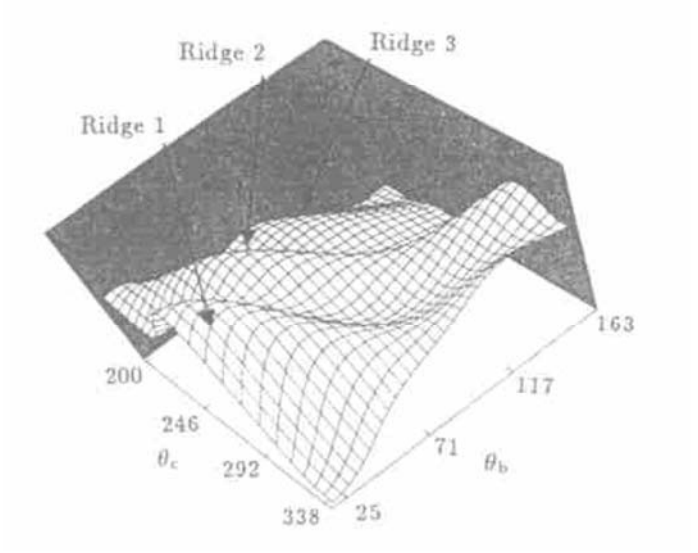

Fig. 2 Three-dimensional plot of the calculated 5DCS versus θ_b and θ_c. Kinematical parameters as in Fig. 1.

In this new Ar(e, 3e) experiment, the relative cross sections have been measured by fixing all the kinematical parameters: the incident energy is chosen as E_0= 561.4 eV, the scattered electron energy and angle are E_a= 500 eV and θ_a= 1.5°, respectively. The corresponding momentum transfer is k= 0.4 atomic unit, in the direction θ_k= 336°. The ejected electron energies are E_b= E_c= 9 eV.

The full sets of the experimental and theoretical data are shown as a three-dimensional plot of the relative 5DCS versus ejection angles θ_b and θ_c in Fig. 1 and Fig. 2, respectively. The theoretical result is based on the first Born approximation which include the first order mechanisms SO and TS1. Comparing the 3D plots between the experiment and theory, the big deviations about the two slow electrons how are emitted can be observed between experimental and theoretical results. In the experimental 3D plot in Fig. 1, it is obvious that the two slow electrons are preferentially emitted both backwards with respect to the incident direction. Meanwhile in the theoretical 3D plot in Fig. 2, the 3D plot seem to be attributed to 3 ridges, named as ridge 1, 2 and 3 shown in Fig. 2. In ridge 1, the two slow electrons are preferentially emitted both forwards with respect to the incident direction and it is the main attribution to the 5DCS. In ridge 2, the two slow electrons are preferentially emitted one forward and one backward. Whereas in ridge 3, the two slow electrons are preferentially emitted both backwards with respect to the incident direction and it is less attribution to the 5DCS, but it seems to fit to the experimental result about the two slow electrons emitted direction.

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低能电子碰撞 Ar(e, 3e) 双电离实验

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摘 要: 通过 Ar(e, 3e) 五重微分截面 3 维图的理论与实验比较发现, 在低能电子入射的情况下, 理论与实验存在较大的偏差.

关 键 词: (e, 3e) ; 双电离; 五重微分截面