Post Collision Interaction Effect on the Magnitude of (e,2e) Autoionization Amplitude

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Abstract: Post collision interaction effect on the magnitude of the $He(e,2e)He^{+}$ direct and resonant amplitudes as a function of electron ejection angle has been considered. Calculated values are found in good agreement with the extracted experimental data. It is shown that the 3-body Coulomb interaction in final state may give a considerable contribution to the direct cross section, but a small account to the resonant cross section.

The ionization of atoms by electron impact is one of the most significant processes in the field of interaction of charged particles with matter. At intermediate high energies of incident electron (i.e. above 4 times the ionization potential) the first Born approximation become not relevant to describe the ionization process, and the high order effects like post collision interaction (PCI) become more important [1]. The influence of PCI on the shape and magnitude of the direct ionization cross section is widely investigated [1-3], however it's effect on the resonant cross section is less investigated. Here we will explore PCI effect on the both direct and resonant part of the electron impact ionization cross sections in the case of helium $2s^2$ (^1S) resonance. We neglect exchange effects. Atomic units are used throughout.

Let write down the direct and resonance cross sections of the (e,2e) reaction in the next form

$$f(\theta_e,\varphi_e) = N\left|T_{dir}(\theta_e,\varphi_e)\right|^2 \qquad (1)$$

and the one

$$d(\theta_e,\varphi_e) = N\left|t_{res}(\theta_e,\varphi_e)\right|^2 \tag{2}$$

Note that in the formulas (1) and (2) energies and momentum of the scattered electron are fixed, where ***N*** is the normalization coefficient, the energy independent resonant amplitude related to the energy dependent one as

$$T_{res}(\theta_e,\varphi_e) = \frac{t_{res}(\theta_e,\varphi_e)}{\varepsilon + i} \tag{3}$$

where $\varepsilon = \dfrac{E - E_r}{\Gamma_r / 2}$ is the deviation of the excitation energy E from the resonance energy position E_r measured in terms of the resonance half-width $\Gamma_r / 2$.

Total ionization amplitude in the region of the isolated autoionization state can be written as

$$T_{f_i}(\theta_e,\varphi_e) = T_{dir}(\theta_e,\varphi_e) + T_{res}(\theta_e,\varphi_e) \tag{4}$$

We present the resonant amplitude in the form

$$t_{res}(\theta_e,\varphi_e) = K_{res}(\theta_e,\varphi_e)\cdot c \tag{5}$$

where the factor $K_{res}(\theta_e,\varphi_e)$ represents the influence of the PCI on the resonance amplitude [4], c is constant connected to ejection angle factor.

Figure 1 shows the direct cross sections both theoretical and experimental in the vicinity of the $2s^2$ (^1S) resonance. All the experimental and theoretical cross sections are normalized to the direct cross section at its maximum. The direct cross section calculation with 3-Coulomb wave function(3C) for the final state gives a results, which are found to be in agreement with the experimental data in the 'binary' peak (positive angles) region except the 200eV incident energy. At latter value of incident energy the position of the peak appeared to be slightly shifted. In the 'recoil' peak (negative angles) region the calculated value overestimates the experimental one, specially for the100 eV incident energy case.

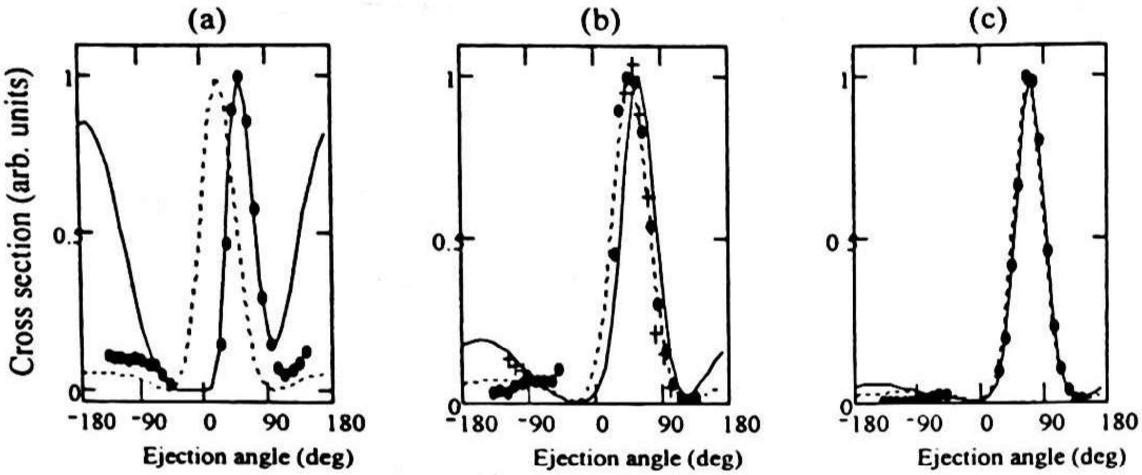

Figure 1. Direct ionization cross section is shown as a function of the electron-ejection angle for) incident electron energies 100eV (a), 200eV (b) and 400eV (c). The 3C model (solid curve), the PWBA (dots) and the experimental data from Ref. 6 (full circles) and Ref.7 (crests) are shown.

Magnitude of the resonance factor $K_{res}(\theta_e, \varphi_e)$ is shown in figure 2. The magnitude of $|K_{res}(\theta_e, \varphi_e)|$ is very close to the unit, even for the lowest energy 100eV, except the scattering angle region, where its value significantly differs from the unit (see [5]).

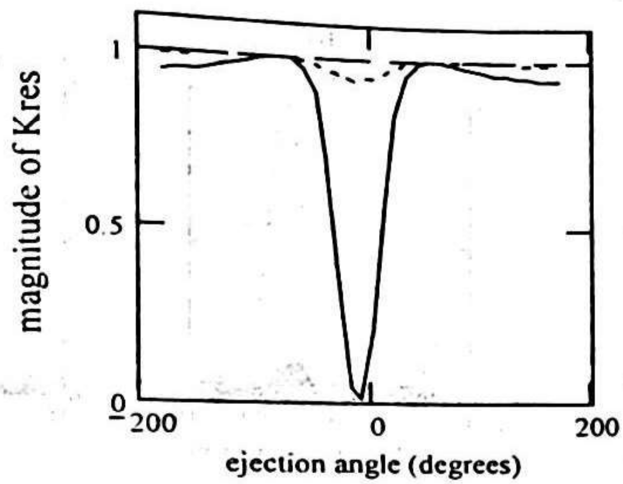

Figure 2. The magnitude of the resonance factor $K_{res}(\theta_e, \varphi_e)$ for incident electron energies: 100eV (solid curve), 200eV (dots) and 400eV (dashes).

The resonant cross section data (see figure 3) has been extracted from the experimental data using formula

$$d = b + 2f - \sqrt{(b + 2f)^2 - (a^2 + b^2)} \qquad (6)$$

It is seen that the $d(\theta_e, \varphi_e) \approx f(\theta_e, \varphi_e)$ in the binary peak region for all the incident energies as it was noticed by Kheifets[6].

The parameter $|c|$ found by fitting the theoretical function $d(\theta_e, \varphi_e)$ to the extracted data . It is seen that the anisothropy of the experimental resonant cross section (firstly, revealed by Balashov et al [7]) may not be caused by the PCI, and it can probably be related to the experimental uncertainties.

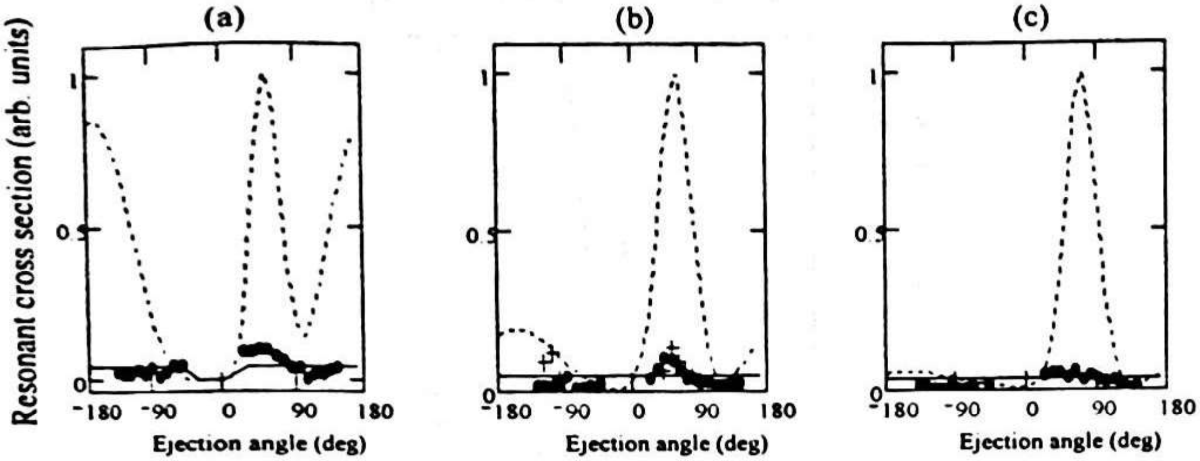

Figure 3. Extracted from the experimental data of Ref.8 (full circles) and Ref.9 (crests) resonant ionization cross section for the electron incident energy of 100 eV (a), 200 eV (b) and 400 eV (c) shown as a function of the electron-ejection angle. Also shown theoretical calculation of the 3C model (solid curve). Dot curve is the direct cross section.

References

1. Stefani G., Avaldi L., Camilloni R. (1993) Journal de Physique IV, 3,
Colloque C6, suppl. JP II, 1.
2. Brauner M., Briggs J. S. and Klar H., (1989), J. Phys. B: At. Mol. Opt. Phys. 22, 2265
3. Berakdar J., (1996), Phys. Rev. A, 55, 800
4. Godunov A.L., Kunikeev Sh. D., Novikov N.V. and Senashenko V.S..(1989) Zh. Eksp. Teor. Fiz. 63, 1638-49
5. Balt-Erdene Kh., Khenmedekh L., Lhagva O. and Madsen J. N. 1998 J.Phys.B: At.Mol.Opt.Phys. 32, L35
6. Kheifets A.S., (1993), J.Phys.B: At.Mol.Opt.Phys.26, 2053
7. Balashov V.V., Martin S.E. and Crowe A. (1996) J.Phys.B: At.Mol.Opt.Phys.29, L337
8. Lower J. and Weigold E. 1990 J.Phys.B: At.Mol.Opt.Phys. 23, 2819
9. McDonald D. G. and Crowe A. 1993 J.Phys.B: At.Mol.Opt.Phys. 26, 2887