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Variational study of atomic hydrogen ionization by electrons impact

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Triple differential cross section results of the electron impact ionization of hydrogen atom are performed in the so-called Schwinger-Born approximation of variational principle of Schwinger. In the theoretical calculations the first Born term was calculated analytically, and the second Born term was determined in the closure approximation using semi-analytical calculations. The theoretical results were corrected by the so-called Gamow factor in order to include post-collision effects, then compared with experiments performed with an incident electron energy of E_i = 250 eV and with those of other models. Better agreement was found between our results and experimental data even for high values of the ejected electrons energy (50 eV).

1. Introduction

We investigate in this work the ionization of hydrogen atom by electrons impact. The triple differential cross sections have been calculated in the framework of Schwinger-Born (SB) approximation of variational principle of Schwinger. The TDCS obtained in this work have been compared to the experimental results of Weigold *et al* [1] as well as to other theoretical ones [2],[3].

2. Theory

In the ionization of the atomic target by electron impact, the non-relativistic TDCS is given by

$$\frac{d^3\sigma}{dE_e d\Omega_e d\Omega_s} = \frac{1}{(2\pi)^2}\frac{k_e k_s}{k_i}|T_{\alpha\beta}|^2$$

$T_{\alpha\beta}$ is the matrix element describing the transition of the projectile–target system from the initial state $|\alpha\rangle$ to the final state $|\beta\rangle$, which is the variational amplitude defined as

$$T_{\alpha\beta} = \sum_{i,j}\langle\beta|V|i\rangle\left(D^{-1}\right)_{ij}\langle j|V|\alpha\rangle$$

$$D_{ji} = \langle j|V - VG_T^{+}V|i\rangle$$

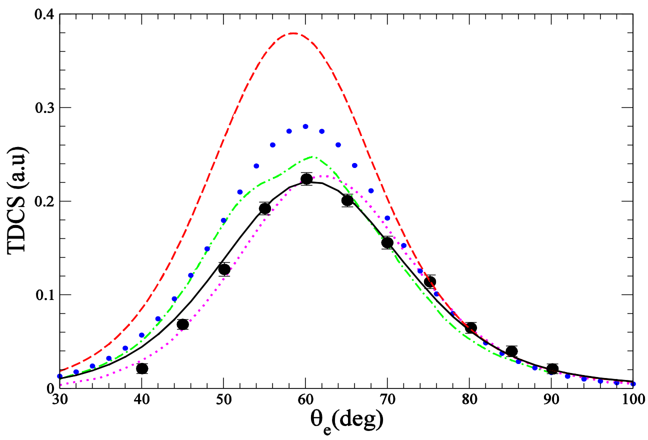
V is the target - projectile interaction and G_T^+ the target propagator.

In this study calculations were performed in the Schwinger-Born approximation, that is $|i\rangle = |\alpha\rangle$ and $|j\rangle = |\beta\rangle$ where $|\alpha\rangle = \varphi_{\mathbf{k}_i}(\mathbf{r}_0)\varphi_H(\mathbf{r}_1)$ and $|\beta\rangle = \varphi_{\mathbf{k}_s}(\mathbf{r}_0)\psi_{k_e}^{(-)}(\mathbf{r}_1)$. The incident and scattered particles are described by a plane wave. $\psi_{k_e}^{(-)}(\mathbf{r}_1)$ is the continuum state of the ejected electron described by the Coulomb wave function which satisfies the incoming boundary condition.

To include the post-collision interaction (PCI) between the outgoing scattered and ejected electrons in the TDCS, the amplitude $T_{\alpha\beta}$ is multiplied by the Gamow factor [4].

3. Results and discussion

The figure shows the measurements of TDCS of Weigold *et al* [1] for electron-impact ionization of H for an incident energy E_i = 250 eV an ejected energy E_e = 50 eV and a scattered angle θ_s= 25^0, our results of SB, first Born and second Born [5] approximations, and those of BBK model [2] and second Born approximation of Dal Cappello *et al* [3] including 294 intermediate states . SB results



First Born:*small circles*. Second Born:*dashed line*. Dal Cappello Second Born:*dashed-dot*.BBK:*dot line*. SB:*fullline*. Experiments: *full circles with error bars*.

4. References

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