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Differential cross sections for four-body single charge transfer processes

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Synopsis Projectile angular-differential cross sections for single-transfer and transfer excitation in collisions of bare ions with helium-like atoms have been calculated in the framework of four-body Coulomb-Born distorted wave (CBDW-4B) formalism in both prior and post forms. The effect of static and dynamic electron correlations is explicitly taken into account through the perturbation potential.

For many years, the study of electron capture processes in heavy particle collisions with atoms has been an active field of research. Most of the work in this area has involved total cross sections. However, the recent development of the cold-target-recoil ion-momentum spectroscopy (COLTRIMS) method has opened the door for measuring FDCS (fully differential cross sections) which represent a more sensitive test of theory. Recently Schulz et al [1] have published experimental four-body FDCS results for charge transfer from helium atom. In the present theoretical investigation, we have focused our attention on the determination of single electron transfer with target excitation (TTE) for the impact of bare ions with helium-like atoms in the intermediate and high energy range. A large number of calculations have been carried out to investigate single-electron capture in alpha-helium collisions based on four-body methods, such as boundary-corrected first Born approximation (CB1-4B) [2], continuum distorted-wave Born initial state formalism (CDW-BIS) [3], continuum distorted-wave approach (CDW-4B) [4], second-order Born distorted wave method (BDW-4B) [5] and boundary corrected continuum intermediate state (BCCIS-4B) [6] approximation. The three-body first-order Coulomb-Born distorted wave (CBDW-3B) formalism [7,8] have been used to calculate the cross section for single electron capture for H^+ + He and He^{2+} + He collisions. The post and prior forms of the transition amplitude are

$$T_{if}^{(post)} = <\chi_f^- \mid V_f - V_f^\infty \mid \chi_i^+>$$

$$T_{if}^{(prior)} = <\chi_f^- \mid V_i - V_i^\infty \mid \chi_i^+>$$

The interaction potentials may be represented as follows:

$$V_i = \frac{Z_P Z_T}{R} - \frac{Z_P}{s_1} - \frac{Z_P}{s_2},\; V_i^\infty = \frac{Z_p(Z_T-1)}{R_T}.$$

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$$V_f = \frac{Z_P Z_T}{R} - \frac{Z_T}{x_1} - \frac{Z_P}{s_2} + \frac{1}{r_{12}},$$

$$V_f^\infty = \frac{(Z_P-1)(Z_T-1)}{R_P}$$

.Here $\chi_i^+(\chi_f^-)$ is the asymptotic distorted state of the system in the initial (final) channel.

$$\chi_i^{(+)} = e^{i\vec{k}_i\cdot\vec{R}_T}\,\varphi_i(\vec{x}_1,\vec{x}_2)\,e^{-\frac{\pi}{2}\alpha_i}\,\Gamma(1+i\alpha_i)\times {}_1F_1\{-i\alpha_i;1;i(k_iR_T-\vec{k}_i\cdot\vec{R}_T)\}$$

and

$$\chi_f^- = e^{-\frac{\pi}{2}\alpha_f}\,\Gamma(1-i\alpha_f)\,e^{i\vec{k}_f\cdot\vec{R}_P}\times\varphi_p(\vec{s}_1)\varphi_T(\vec{x}_2)\times {}_1F_1\{i\alpha_f;1;-i(k_fR_P+\vec{k}_f\cdot\vec{R}_P)\},$$

where

$$\alpha_i = \frac{\mu_i Z_P(Z_T-1)}{k_i},\; \alpha_f = \frac{\mu_f(Z_P-1)(Z_T-1)}{k_f}.$$

Here $\varphi_i(\vec{x}_1,\vec{x}_2)$ is the initial bound state of helium like atoms. $\varphi_p(\vec{s}_1)$ and $\varphi_T(\vec{x}_2)$ be the bound state of hydrogen-like projectile and target ions respectively. We found that our calculated results are in good agreement with the available experimental and other theoretical works.

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