SCATTERING OF POSITRONS BY HYDROGEN AND HELIUM ATOMS FOR SUPERELASTIC AND INELASTIC PROCESSES

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ABSTRACT

Using Born and Glauber eikonal approximations, a systematic study is made to calculate the scattering cross-sections for inelastic and superelastic scattering of positrons by hydrogen and helium atoms. The differential scattering cross-sections (DCS) are calculated at the incident energy $E \leqslant 800$ eV in the angular range $\theta \leqslant 110$. Results at 200 and 400 eV are compared with other similar results. The present differential scattering cross-sections are in good agreement with compared results.

INTRODUCTION

In recent years studies on the intermediate incident energy region of charged particles[1] have been considered as very important and exciting. However, this region is difficult to treat theoretically, because it includes all types of collision processes viz elastic, superelastic, inelastic and ionization in a manner that their effects on one another cannot be ignored; at the same time information obtained in this energy region is not only important from the theoretical point of view, but also in the experimental studies of other fields like engineering and biology. Especially, inelastic and superelastic scattering of charged particles by hydrogen and helium atoms has been considered as important processes in astrophysics and plasma physics. Availability of collision cross-sections for superelastic and inelastic processes is found to be scarce in the literature. Motivated by this and the encouragement of our studies[2] on hydrogen, helium and lithium atoms gave us scope to continue these studies[3,4] for the present superelastic and inelastic processes of hydrogen and helium atoms. The advantages of the presently employed Born approximations[5] are discussed in our recent work[2]. The present differential scattering cross-sections, for positron scattering by hydrogen and helium atoms are given in table 1 along with other results[6]. Finally the present results are compared with other results.

THEORY

Throughout the work atomic units are used. The basic theory for the construction of interaction potential V and the scattering amplitudes for positron scattering by atoms in Born[5] and Glauber eikonal Series[7] approximations was discussed earlier[2]. For a better understanding of the present work the scattering amplitudes can be written as

$$F^{d}_{\mathrm{HHOB}} = F^{(1)}_{B} + \mathrm{Re1}\, F^{(2)}_{B} + \mathrm{Re2}\, F^{(2)}_{B} + F^{(3)}_{\mathrm{GES}} + \mathrm{Im}\, F^{(2)}_{B}, \quad (1)$$

$$F^{d}_{\mathrm{GES}} = F^{(1)}_{\mathrm{GES}} + F^{(2)}_{\mathrm{GES}} + F^{(3)}_{\mathrm{GES}}. \quad (2)$$

All the individual terms and approximations made in (1) and (2) were discussed earlier[2]. The differential scattering cross-sections for positron scattering by atoms can be obtained from (1) and (2).

$$\sigma^{\mathrm{HHOB}} = \frac{K_G}{K_i} |F^{d}_{\mathrm{HHOB}}|^2, \quad (3)$$

$$\sigma^{\mathrm{GES}} = \frac{K_G}{K_i} |F^{d}_{\mathrm{GES}}|^2, \quad (4)$$

where K_G, K_i are the final and incident momenta of the scattered positrons. Using (3) and (4) the differential scattering cross-sections for positron scattering by hydrogen and helium atoms for superelastic and inelastic processes are calculated at $E = 200$ and 400 eV. These results are given in table 1 along with other similar results.

RESULTS AND DISCUSSION

Table 1 shows the present results for inelastic and superelastic scattering of positrons by hydrogen and helium atoms at the incident energies 200 and 400 eV in the angular region $\theta \leqslant 110$. Glauber eikonal Series results (GES)[7] are also presented in this table for comparison. One of the drawbacks of GES[6,7] is that it gives identical results for both electron and positron interactions with atoms[6,7]. The results obtained by GES[5,6] were found to be lower in value than the

Table 1 *Differential scattering cross-sections for inelastic and superelastic scattering of positrons by hydrogen and helium atoms.*

Scattering angle	Hydrogen (inelastic)		Helium (inelastic)				Hydrogen (superelastic)	
	400 eV	200 eV	400 eV	GEs[6]	200 eV	GEs[6]	400 eV	200 eV
θ	$a-b$	$a-b$	$a-b$	$a-b$	$a-b$	$a-b$	$a-b$	$a-b$
10	1.325 − 1	3.138 − 1	4.160 − 2	6.80 − 2	5.148 − 2	1.30 − 1	5.436 − 0	2.051 + 1
20	4.283 − 3	3.072 − 2	2.925 − 3	6.11 − 3	9.927 − 3	2.58 − 2	3.453 − 1	1.576 − 0
30	7.219 − 4	4.383 − 3	1.143 − 3	7.64 − 4	2.493 − 3	5.37 − 2	6.635 − 2	3.410 − 1
40	3.266 − 4	1.880 − 3	1.124 − 3	1.21 − 4	2.815 − 3	1.17 − 3	2.025 − 2	1.172 − 1
50	2.024 − 4	1.163 − 3	3.944 − 4	3.82 − 5	1.713 − 3	4.03 − 4	9.346 − 3	5.722 − 2
70	1.273 − 4	6.574 − 4	2.501 − 4	9.16 − 6	1.208 − 3	8.64 − 5	5.886 − 3	3.143 − 2
90	1.074 − 4	5.029 − 4	1.108 − 4	3.62 − 6	8.943 − 4	3.37 − 5	6.230 − 3	2.903 − 2
110	9.969 − 4	4.425 − 4	8.534 − 5	1.44 − 6	6.351 − 4	1.77 − 5	6.807 − 3	2.879 − 2

The symbol $a \pm b$ denotes $a \times 10^{\pm b}$

compared experimental and theoretical results. All the deficiencies in Glauber-related approximations[6,7] are solved in the present method.[5,7] Table 1 shows that the GE results are higher than the present results throughout the angular region and that these two types of results are just comparable at very small angles. Unfortunately no other data are available for inelastic and superelastic scattering of positrons by hydrogen and helium atoms for comparing our present results. We expect that it would provide a reasonable description of the present scattering processes of positrons by hydrogen and helium atoms.

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ANNOUNCEMENT

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