COLLISION OF POSITRONS WITH ALKALI-LIKE IONS USING CORE-CORRECTED GLAUBER APPROXIMATION

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Abstract :

Positron-ion scattering is a relatively new branch of atomic collision physics in comparison with electron-ion scattering. Katiyar and srivastava [1] have presented distorted wave calculations on positron impact excitations of various hydrogen-and helium-like ions. Abdel - Raouf [2] used the coupled static approximation for calculating elastic and positronium formation cross sections of different positron-ion scattering process. The aim of the present work is to investigate the elastic and inelastic scattering of positrons by alkali-like positive ions (particularly Be^+ and Mg^+) using the so called core corrected Glauber approximation. Our goal is to determine elastic and inelastic total cross sections of the preceding processes at a wide region of incident energies between 10 and 100 eV. The results will be compared with those obtained by other authors.

1. Introduction

The positron-ion scattering represents a relatively new branch of atomic collision physics. Trials to investigate such problems have been carried out by several authors. Thomas and Gerjouy [3] put a closed form of the Gluber scattering amplitude, and applied it to the excitation of atomic hydrogen by the impact of arbitrary structurless charged particles. On the other hand, Thomas and Franco [4] applied the Glauber's approximation to the inelastic scattering of electrons by hydrogen like ions with arbitray nuclear charge. Srivastava and Katiyar [1] extended the distorted wave calculations to positron impact excitations of various hydrogen - and helium - like ions. Abdel-Raouf [2] used the coupled -static frozen core partial wave Green's function expansion technique for calculating partial and total cross sections of elastic and positronium formation channels using Clementi-Rotti's wavefunctions [5]. On the other hand, Khare and Vijayshri [6] and Khare [7] applied the modified Glauber approximation to inelastic scattering of positrons from lithium and sodium atoms in the intermediate energy region. They used wavefunctions developed by Veselove [8] and very simplified models for the core potential. Various developments of Glauber approximations have been successfully used by Gien [9] in a series of papers dealing with the collision of positrons and electrons with alkali-metal atoms.

Nevertheless in the collisons of positroms with positive ions, it is expected that excitation channels are more probable to occure than the rearrangement channels. Both elastic and inelastic processes take place at energies closed to the intermediate energy domains of the collision of positrons with neutral atoms. The preceeding arguments emphasize the employment of different Glauber approximations for exploring these processes partcullary, in the present work, the so called core-corrected Glauper approximation.

In this paper, the core-corrected Glauber approximation (CCGA) is employed for claculating the differential and total elastic and inelastic cross sections of e^+ - Be^+ and e^+- Mg^+ scattering. The interaction potentials seen by the positrons are developed following Abdel Raouf [2] using Clemintti Roetti's wavefunction .[5]

2. Theory

The total interaction potential demonating the collision of positrons with positive ions in the model potential approach can be split into two parts : The first part is the scattering potential between the positron and the valence electron as well as between the positron and the remaining protons. The second part represents the interaction between the positron and the core electrons as well as the screened protons. Therefore the interaction potential can be put in the form :

$$V = V_v + V_c = \left(\frac{1}{x} - \frac{1}{|x-r|}\right)_v + \left(V^q_{cCoul}(x) + \frac{(Z^q_{eff}-1)}{x}\right)_c \qquad (1)$$

Where,

$$V^q_{cCoul}(x) = \sum_{j=1}^{M^q} N^q_j \left\langle \phi^q_j \left| \frac{1}{x-r_i} - \frac{1}{x} \right| \phi^q_j \right\rangle \qquad (2)$$

x, is the position vector of the positron relative to the infinitely heavy nucleus of charge Ze and |x-r| is the relative distance between the positron and valence electron , see Fig. (1)

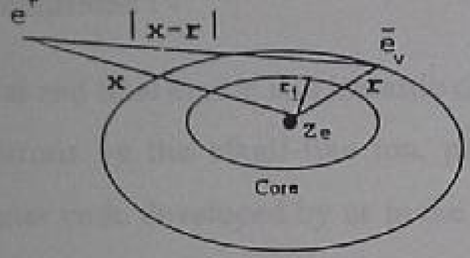

Figure 1. Configuration space of positron-positive ion scattering

Let us now write $\mathbf{x} = \mathbf{b} + \xi\hat{k}$ and $\mathbf{r} = \mathbf{s} + \zeta\hat{\mathbf{k}}$ where **b** is the impact parameter vector, and s is the projection of **r** on the impact plane which is perpendicular to the incident direction. $\hat{k}$ is the unit vector in the incident direction of postiron which is usually taken as z-direction. The core-corrected scattering amplitude, $F^{cc}_{\mu\nu}$ (q) corresponding to the (ns-ns) and (ns-np) transitions, is given by Gien. [9]

$$F^{cc}_{\mu\nu}(q) = \frac{ik_i}{2\pi}\int \phi^q_\mu \ \Gamma(b,r)\phi^q_\nu \ e^{iq\cdot b} d^2b dr \quad \begin{cases} \mu = \nu \ \ for \ elastic \ channels \\ \mu \neq \nu \ \ for \ inelastic \ channels \end{cases} \qquad (3)$$

Where q is the momentum transfer vector.The differential inelastic scattering cross section is obtained by

$$\frac{d\sigma_{\mu\nu}}{d\Omega} = \left|F^{cc}_{\mu\nu}(q)\right|^2 \qquad (4)$$

and the total inelastic cross sections can be written as

$$\sigma_{\mu\nu} = \frac{1}{k_i^2} \int_0^{\infty} q\,dq \int_0^{2\pi} d\phi \left| F_{\mu\nu}^{ec}(q) \right|^2 \qquad (5)$$

The function Γ (b, r) is defined as

$$\Gamma(b,r) = 1 - e^{i\chi(b,s)} \qquad (6)$$

where the phase shift χ (b,s) is given by

$$\chi(b,s) = -\frac{1}{\hbar v_i} \int_{-\infty}^{\infty} V(b,r)\,d\xi \qquad (7)$$

v_i is the velocity of the incident positron. V(b, r) is the interaction potential between the positron and the target ion considered.

3. Results and Conclusions : -

The differential and total elastic and inelastic cross sections were calculated for the scattering of positrons by the alkali-like ion, particularly Be^+ and Mg^+ using the generalized computer code developed by us in the energy region 10 - 100 eV. Figures (2) and (3) contain the differential cross sections restricted to energies above 50 eV,

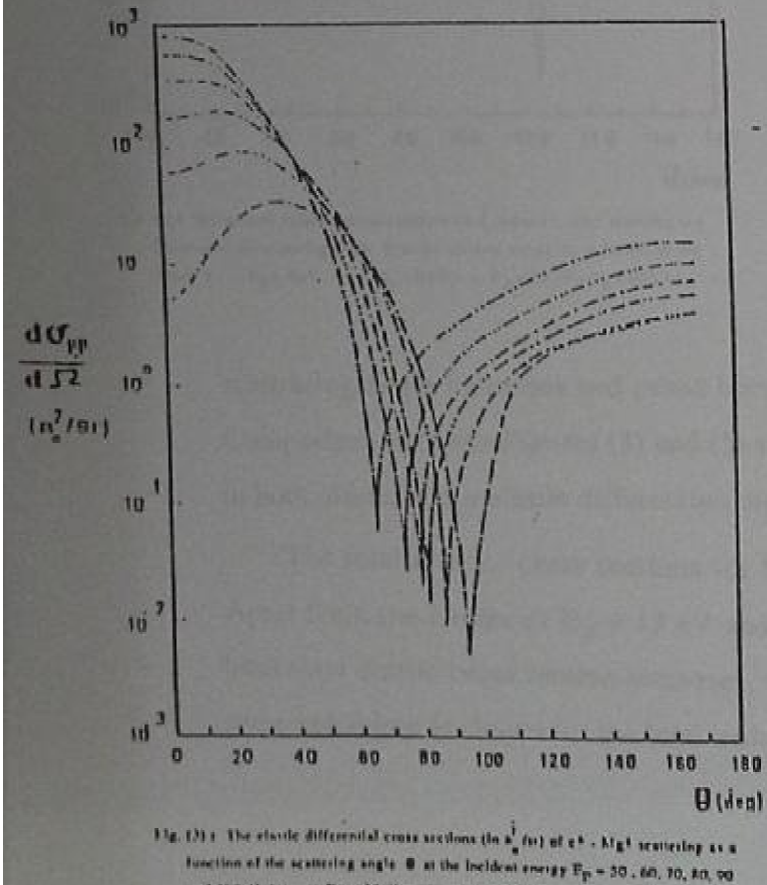

Fig. (3) : The elastic differential cross sections (in a_0^2/sr) of e^+ - Mg^+ scattering as a function of the scattering angle θ at the incident energy E_p = 50, 60, 70, 80, 90 and 100eV. (..... E_p = 50eV, — — E_p = 60eV; - - - E_p = 70eV; .... E_p = 80eV; —— E_p = 90eV; - - E_p = 100eV).

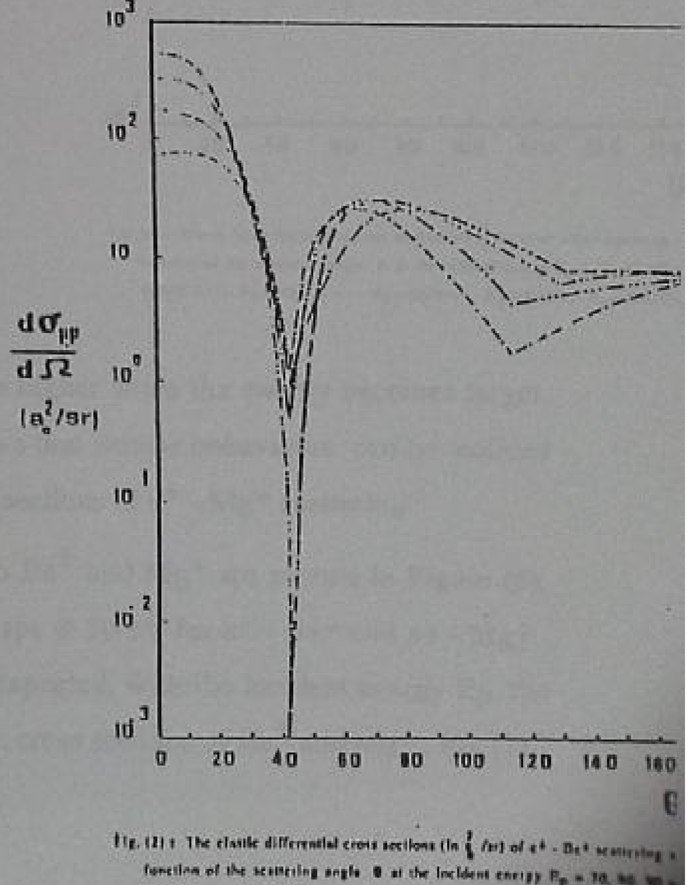

Fig. (2) : The elastic differential cross sections (in a_0^2/sr) of e^+ - Be^+ scattering as a function of the scattering angle θ at the incident energy E_p = 70, 80, 90 & 100eV. (- - - E_p = 70eV, - - - E_p = 80eV; —— E_p = 90eV; —— E_p = 100eV).

since the convergence of the Glauber series is suspected at lower energies. The figures demonstrate the oscillating behaviour of the differential cross sections as a function of θ, at different values of the incident energy E_p. This behaviour is characteristic to intermediate energy scattering processes, and was noticed by Gien [9] in the Glauber and modefied Glauber treatments of positron alkali - atom scattering. In complete analysis with the last two figures, the differential inelastic cross sections of e^+ - Be^+ and e^+ - Mg^+ are demonstrated in Figures (4 & 5). It is clear from Fig. (4) that the

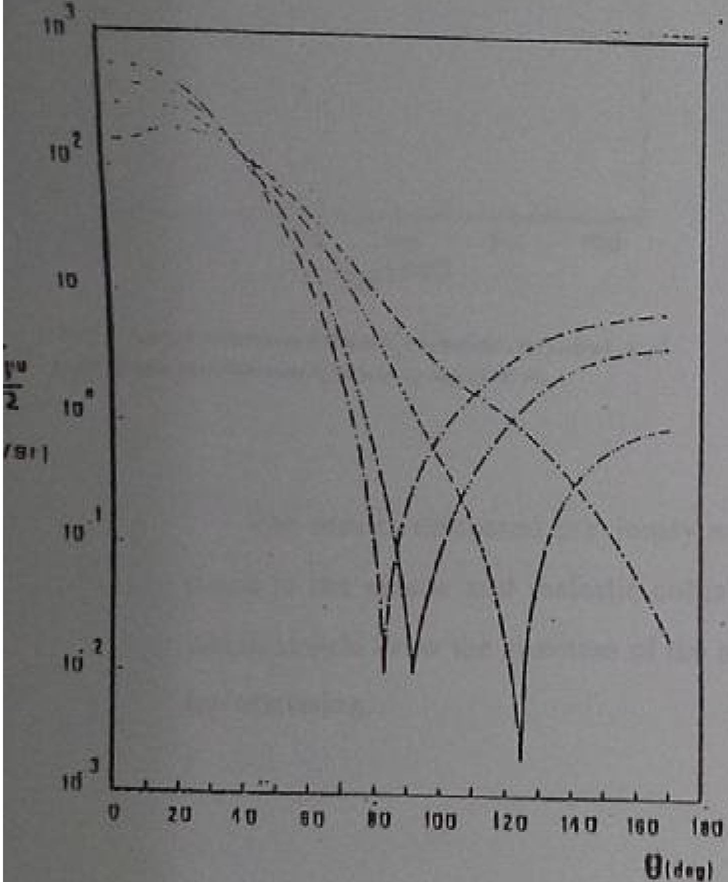

Fig. (5) : The inelastic differential cross sections (in a_0^2/sr) of e^+ - Mg^+ scattering as a function of the scattering angle θ at the incident energy E_p = 70, 80, 90 and 100eV. (- · · - E_p = 70eV, - — · — E_p = 80eV; - — E_p = 90eV; · · E_p = 100eV).

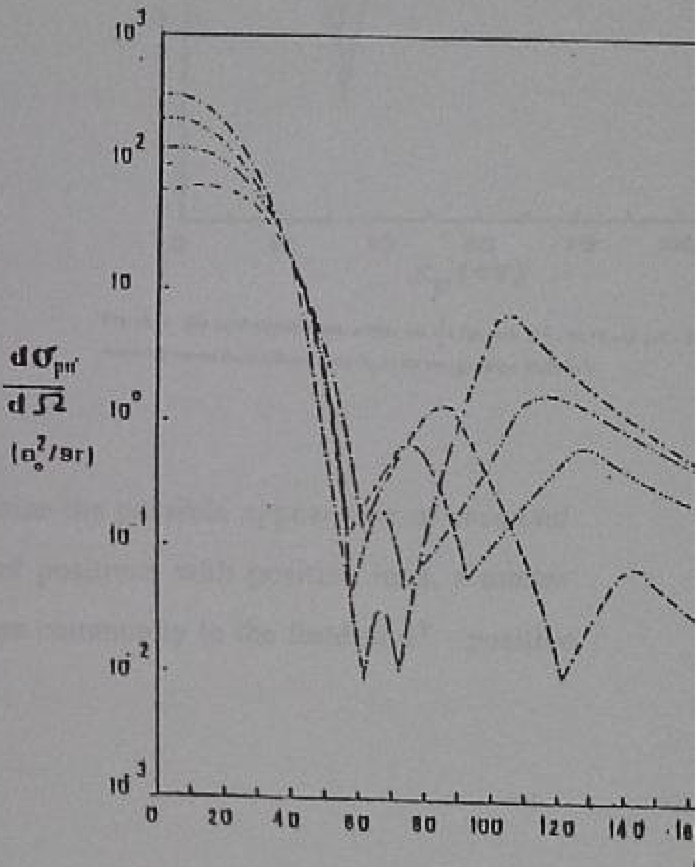

Fig. (4) : The inelastic differential cross sections (in a_0^2/sr) of e^+ - Be^+ scattering function of the scattering angle θ at the incident energy E_p = 70, 80, 90 100eV. (- · · · E_p = 70eV, - — · — E_p = 80eV; - — E_p = 90eV; --- E_p = 100eV;

scattrering angle increases and peaks become higher when the energy becomes larger. Comparison between Figures (3) and (5) shows that similar behaviours can be noticed in both elastic and inelastic differention cross sections of e^+ - Mg^+ scattering

The total elastic cross sections for both Be^+ and Mg^+ are plotted in Figure (6). Apart from the humps at E_p = 15 eV and cusps at 30 eV for e^+ - Be^+ and e+ - Mg^+ , both total elastic cross section increases, as expected, with the incident energy E_p. the same behaviour is shown for the total inelastic cross sections of Be^+ and Mg^+ , Fig (7) .

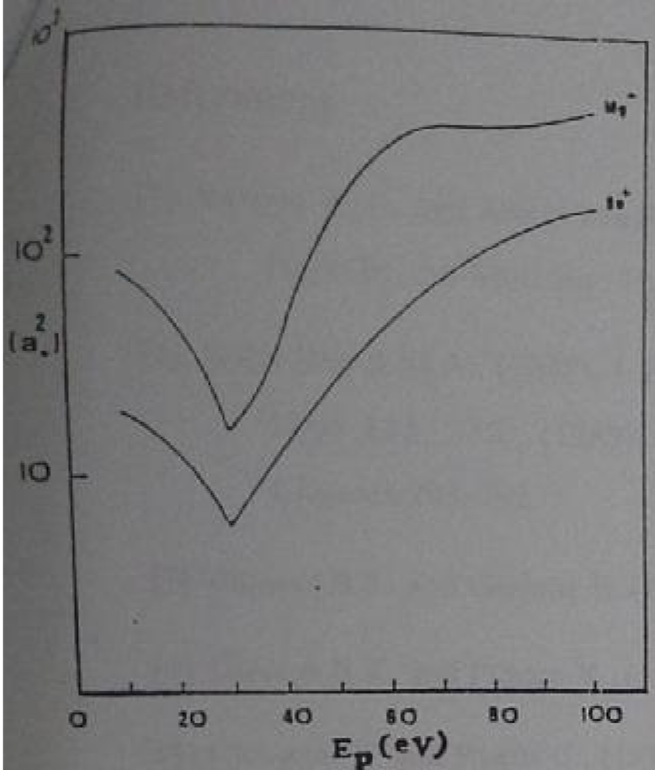

Fig. (3) : The total inelastic cross section (in a_0^2) for both (e^+ - Be^+) and (e^+ - Mg^+) scattering versus the incident energy E_p in the energy range 10-100 eV.

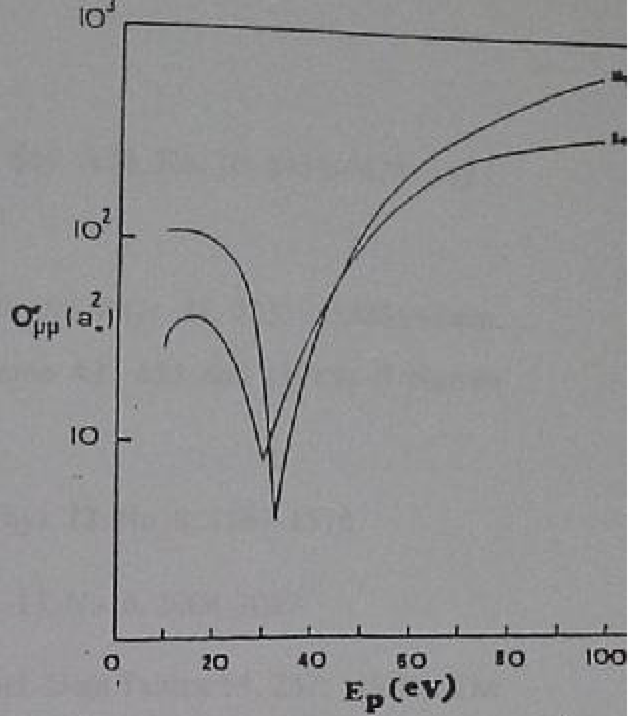

Fig. (4) : The total elastic cross section (in a_0^2) for both (e^+ - Be^+) and (e^+ - M
scattering versus the incident energy E_p in the energy range 10-100 eV.

The results discussed previously emphasize the possible appearence of resonant states in the elastic and inelastic collisions of positrons with positive ions, a matter which should draw the attention of the positron community to the field of e^+ - positive ion scattering.

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Figure Captions

Fig. (1) : Configuration space of positron-postive ion scattering.

Fig. (2) : The elastic differential cross sections (in a_0^2 /sr) of e^+ - Be^+ scattering as a function of the scattering angle θ at the incident energy E_p = 70, 80, 90 and 100eV. (-- ·· -- E_p = 70eV, - ·-- ·· E_p = 80eV; - ···-··· E_p = 90eV; --·-- E_p = 100eV;).

Fig. (3) : The elastic differential cross sections (in a_0^2 /sr) of e^+ - Mg^+ scattering as a function of the scattering angle θ at the incident energy E_p = 50 , 60, 70, 80, 90 and 100eV. (--- · --- E_p = 50eV, -- ··· -- E_p = 60eV; -- ·· -- E_p = 70eV; --·-- E_p = 80eV ; ·····- E_p = 90eV; - ·· - E_p = 100eV).

Fig. (4) : The inelastic differential cross sections (in a_0^2 /sr) of e^+ - Be^+ scattering as a function of the scattering angle θ at the incident energy E_p = 70, 80, 90 and 100eV. (-- · -- E_p = 70eV, - ··· - ··· E_p = 80eV; - ···-·E_p = 90eV; -·- E_p = 100eV;).

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Fig. (6) : The total elastic cross section (in a_0^2) for both (e^+ - Be^+) and (e^+ - Mg^+) scattering versus the incident energy E_p in the energy range 10-100 eV.

Fig. (7) : The total inelastic cross section (in a_0^2) for both (e^+ - Be^+) and (e^+ - Mg^+) scattering versus the incident energy E_p in the energy range 10-100 eV.