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Collisional Alignment and Orientation Parameters of Ra Atom at 75 eV.

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Abstract: *Collision is basically an interaction between two or more particles. Its study for atoms and molecules has proved quite useful from the pt of view of basic as well as applied research activities in atomic and molecular physics.In this paper we shall study the collision dynamics of the excitation process of Ra atom using distorted wave approximation theory.Results are presented for the alignment and orientation parameters at 75eV.*
Key Words*; distorted wave approximation theory,alignment and orientation parameters, excitation process, Ra atom,*

I. Introduction

In the atomic and molecular physics, The subject of electron-atom collision has received the maximum attention. [1,2,7,8, 9,10]. There has been considerable interest and progress in the recent years for both theoretically and experimentally in the study of electron impact excitation of atoms [3,5,6,8]. In the present paper we carried out various set of parameters in the excitation of n^1D state of Ra atom from ground state n^1S. Results are presented at incident electron energy 75 eV . Though there is no experimental and theoretical data to compare with our results. We have carried out two types of calculations viz. Relativistic Distorted Wave (RDW) and Non-Relativistic Distorted Wave (DW) approximation methods. The results obtained from these two methods are compared with each other. The comparison thus provides the importance of relativistic effect.

II. Theoretical Consideration

The earlier traditional experiments had focused attention, mostly, in measuring the cross sections results. However the current efforts are now to perform perfect scattering experiments which can provide complete information about the dynamics of electron- atom scattering process

The scattering experiments where the polarization of the light emitted during the decay of excited atoms is measured in coincidence with the scattered electrons are called as scattered electron-emitted photon coincidence experiments. It is well known that in order to determine the polarization state of any radiation following measurements are needed,

(i) η_3, which determine the degree of linear polarization with respect to x and y-axes (in collision frame),

$$\eta_3 = \frac{I(0^0) - I(90^0)}{I(0^0) + I(90^0)} = \frac{I(0^0) - I(90^0)}{I} \tag{1}$$

where, $I(\beta)$ denotes the intensity of light transmitted by a linear polarization analyzer oriented at an angle 'β' relative to the direction of incident beam (i.e., z-axis in collision frame). I is the total intensity of the emitted radiation.

(ii) η_1, which determine the degree of linear polarization with respect to two orthogonal axes oriented at 45° to the z-axis (in collision frame),

$$\eta_1 = \frac{1(45^0) - I(135^0)}{I(45^0) + I(135^0)} = \frac{I(45^0) - I(135^0)}{I} \tag{2}$$

(iii) η_2, which determine the degree of circular polarization which is defined as

$$\eta_2 = \frac{I^+ - I^-}{I^+ + I^-} = \frac{I^+ - I^-}{I} \tag{3}$$

where, I^+ and I^- are intensities of light transmitted by polarization analyzers with positive (i.e. left handed circularly (LHC) polarized light) and negative helicities i.e. (right handed circularly (RHC) polarized light respectively.

Stokes parameters gives us complete information about the S-D excitation process. But for a better physical interpretation of stokes parameters we may also express them in terms of these parameters.

$$L_\perp = -2P_3(1-h), \tag{4}$$

$$h = \frac{(1+P_1)(1-P_4)}{4-(1-P_1)(1-P_4)}, \tag{5}$$

$$P_\ell e^{2i\gamma} = P_1 + iP_2, \tag{6}$$

Where

$L_\perp$ is the angular momentum transferred perpendicular to the scattering plane, (Also called orientation of excited state of charge cloud of the atom)

γ is the alignment angle of charge cloud of the exited D state,

h is the height of charge cloud

P_ℓ is the linear polarization.

Though the S-D excitation process is triple coincidence (D-P-S) The helicity of P-S photon is '+' or '-' so above relations can be written as $\tilde{L}_\perp^+, \tilde{L}_\perp^-, \tilde{\gamma}^+, \tilde{\gamma}^-$ defined as

$$\tilde{\gamma}^\pm = \tan^{-1}\left(\frac{P_2^\pm}{P_1^\pm}\right), \tag{7}$$

$$\tilde{L}_\perp^\pm = -2P_3^\pm\left(1-\tilde{h}^\pm\right), \tag{8}$$

Where

$$\tilde{h}^\pm \frac{(1+P_1^\pm)(1-P_4^\pm)}{4-(1-P_1^\pm)(1-P_4^\pm)}, \tag{9}$$

III. Distorted Wave Approximation Theory

Consider electrons having energy 'E_i' incident on an atom (with nuclear charge 'Z' and N electrons) in ground state, denoted by 'a'. As a result of collision, electrons excite the target to a higher state, denoted by 'b' and they scattered with energy 'E_b'.

Than the T-matrix for the electron-impact excitation of an atom from initial state i to final state f in distorted wave approximation can be written as.

$$T_{if}^{DW} = \left\langle \chi_f^-(1,2,\ldots\ldots,N+1)\,|V-U_f(N+1)|\,\chi_i^+(1,2,\ldots\ldots,N+1)\right\rangle \tag{10}$$

where V is the target-projectile interaction given by

$$V = -\frac{Z}{r_{N+1}} + \sum_{j=1}^{N}\frac{1}{|r_j - r_{N+1}|} \tag{11}$$

Where r_j = (j=1, 2, …. N) is the position cordinate of the target electrons and r_{n+1} is the projectile electron with respect to the nucleus of the atom.

U_f is the distertion potential which is taken to be a function of radial cordinates of the projectile electrons only.

The wave function $X_{if}^{+(-)}$ is the combined wave function of the target atomic wave function ϕ_{if} and the projectile electron distorted wave function $f_{i(f)}^{DW+(-)}$

$$\chi_{if}^{+(-)}(1,2,\ldots\ldots,N+1) = A\Phi_{if}(1,2,\ldots\ldots,N)\;F_{if}^{DW+(-)}(k_{i(f)},N+1) \tag{12}$$

$k_{i(f)}$ is the projectile electron and scattered electron wave vector after the excitation process. A is the antisymmetrization operator which takes into account the effect of electron exchange between projectile and target atom electrons.

3.1 Non-Relativistic Distorted wave Approximation Theory : In the non-relativistic distorted wave (DW) method the target is described by Hartree-Fock wave functions which is obtained by Fisher code [4] and distorted wave projectile electron wave function are obtained by solving Schrodinger wave equation.

3.2 Relativistic Distorted wave Approximation Theory : In the relativistic distorted wave (RDW) method, the target atom is represented by multi-configuration Dirac-Fock wave functions which is obtained by using Graphs 92 programme of Prapia [11] and the projectile wave function are obtained by Dirac equations.

Fig.1

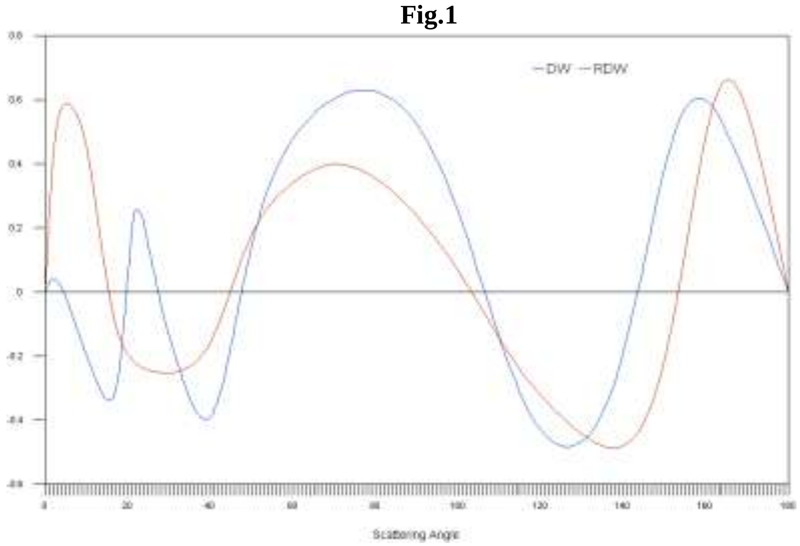

Fig.2

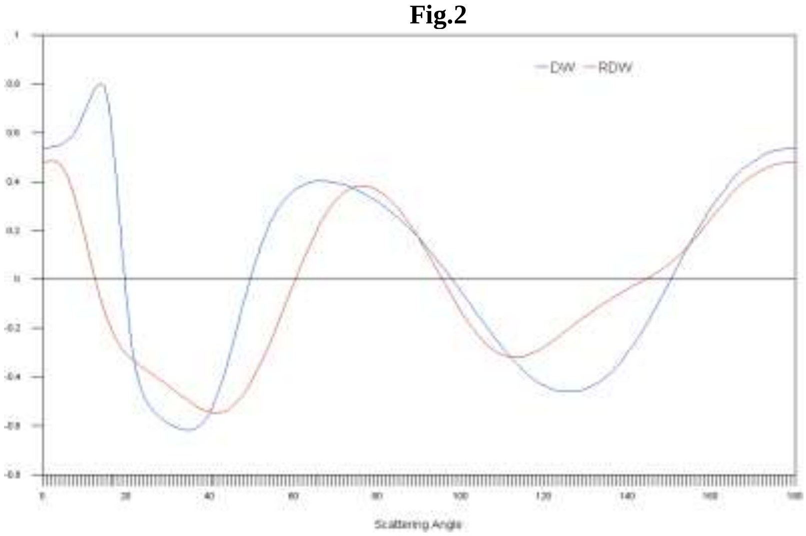

Fig.1&2   Alignment parameters[γ+,γ-] for the excitation of Ra atom

Fig.3

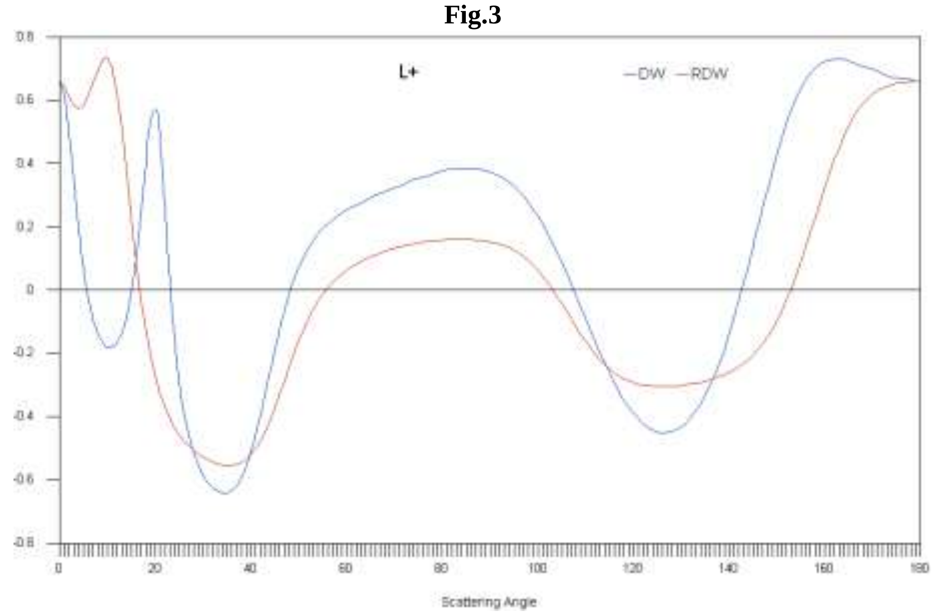

Fig.4

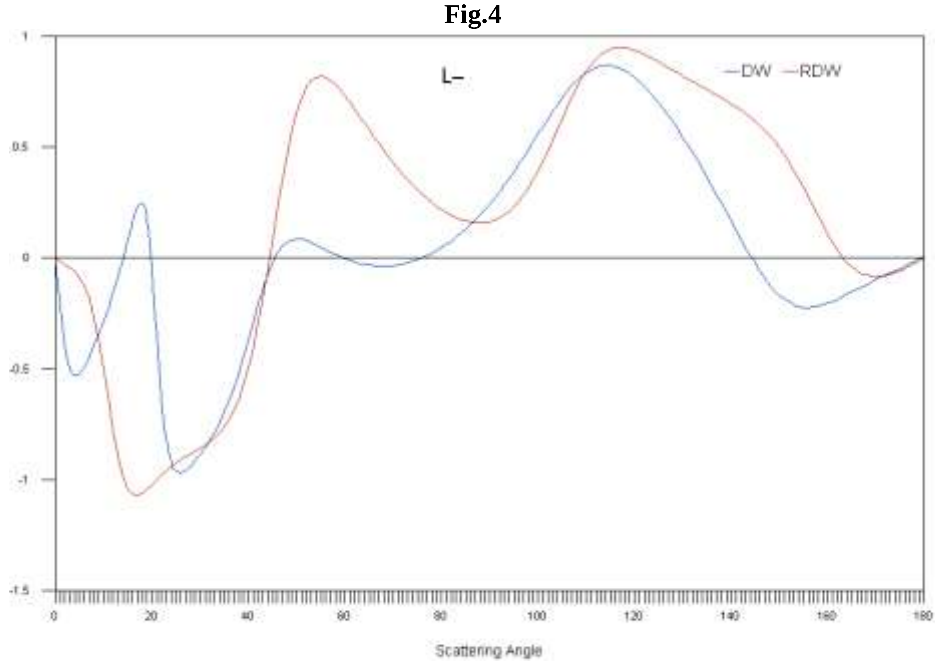

Fig.3&4 Orientation Parameters [$L_{\perp}$ +, $L_{\perp}$-] for the excitation of Ra atom

IV. Result and Discussion :

Here we have carried out the calculations for achieving the various set of parameters($\tilde{L}_{\perp}^{+}, \tilde{L}_{\perp}^{-}, \tilde{\gamma}^{+}, \tilde{\gamma}^{-}$) for the excitation of Ra atom from ground state 6^1 S to the excited state 6^1 D state by the electron impact at 75 eV . We do not have any other theoretical or experimental data to compare with our calculations. We therefore compare the two types of calculations using DW and RDW. We find that both DW and RDW calculations agree qualitatively and quantatively in reasonable manners at this energy level.

V. Conclusions

We have presented our DW and RDW Culculation for various set of parameters ($\tilde{L}_{\perp}^{+}, \tilde{L}_{\perp}^{-}, \tilde{\gamma}^{+}, \tilde{\gamma}^{-}$) in excitation of Ra atom. The nature of the curve show good behavior at incident electron energy at 75eV. It would be interesting to have other theory and experimental Confirmation of these results.

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