A STUDY ON THE PARAMETERS OF ALKALI ATOMS USING DIFFERENTIAL CROSS SECTIONS.

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ABSTRACT

We have carried out distorted wave (DW) calculations for electron impact 3 2S – 3 2P, 4 2S – 4 2P and 5 2S – 5 2P resonance excitation of sodium, potassium and rubidium atom at incident electron energies in the range 100-210 eV. Detailed results for different collision parameters are reported which include unresolved fine-structure differential cross sections for these transitions. Good agreement is found on comparison with the theoretical calculations at 100eV, 150eV, 200eV and 210eV incidence energies. And our calculation at 105eV, 155eV & 205eV incidence energies show good result.

Keywords: *Alkali atoms, Differential cross section, collision parameters.*

INTRODUCTION

Electron excitation of alkali atoms have been extensively studied both theoretically and experimentally in various collision parameters [1,2]. From this point of view, the electron impact excitation of alkali atoms are considerable attention [2,3]. The study of relativistic effects of alkali atom at different transition would be most interesting.

For the differential cross sections (DCS) of electron excitation of the alkali atoms have been reported by Vuskovic et al [4] while Chen and Gallagher [5] and Zapesochnyi et al [6] and others review [7,8,9,10]. Much later [11,12] performed relativistic distorted wave (RDW) calculations and DWBA calculation for the DCS for the resonance transitions of many alkali atoms and compared their results with the experiment and each other. In this paper we take DWA method to study the electron excitation of alkali atoms for three different transition (for sodium 3 2S – 3 2P, potassium 4 2S – 4 2P and rubidium 5 2S – 5 2P) resonance transitions and report our extensive results for differential cross sections. However, presently we will show our results at 105eV, 155eV & 205 eV incidence energies and behavior of the curve show a good result for the same

incident energies. We therefore, consider these excitations also in the present paper show good calculation for the DCS. [13-16]

THEORETICAL CONSIDERATIONS

Distorted Wave Approximation (DWA) Theory

T-matrix can be written from an initial state 'i' to any final state 'f' (with magnetic sub state M) for electron impact excitation of an N-electron atom

$$T_{if}(M) = \left\langle \chi_f^- \middle| V - U_f(\mathbf{r}_{N+1}) \middle| \chi_i^+ \right\rangle \quad (1)$$

Where

$$\chi_{i(f)}^{+(-)} = A\phi_{if}(\mathbf{r}_1, \mathbf{r}_2, \ldots\ldots\ldots, \mathbf{r}_N) F^{+(-)}(\mathbf{k}_{i(f)}, \mathbf{r}_{N+1}) S_{i(f)}(1,2,\ldots\ldots\ldots, N; N+1) \quad (2)$$

$$V = -\frac{Z}{\mathbf{r}_{N+1}} + \sum_{j=1}^{N} \frac{1}{|\mathbf{r}_j - \mathbf{r}_{N+1}|} \quad (3)$$

is antisymmetrization operator. Z is the nuclear charge of the target atom. Si(f)(1,2,…….,N,N+1) is the initial (final) state spin function for the composite projectile electron and target atom system. is the bound state initial (final) wave function of the target atom. F+(-)(ki(f), r) is the projectile distorted wave in the initial (final) channel with wave vector ki (kf) and satisfies following equation

The distortion potential U in the initial (final) channel is given by

Here is static potential. The exchange potential V is taken to be the widely used form[13].

From eq.(1) the direct and exchange T-matrices are evaluated for the excitation of each magnetic state M of the final excited state. We obtain the T-matrices for the singlet (s) and triplet (t) modes separately. Further, the scattering amplitude for each magnetic sub state M of the final excited state is related to the T-matrix by [17-19]

RESULTS AND DISCUSSION

Using the DWA method we calculate the DCS for sodium 3 2S – 3 2P, potassium 4 2S – 4 2P and rubidium 5 2S – 5 2P excitations. Atomic target wave functions for the ground n 2S and the excited n 2P (n=3,4,5) are obtained from the Hartree-Fock atomic structure code of Fischer [14]. These are also used to obtain the distortion potential for obtaining the distorted waves in eq.(4). The calculations are performed in the incident electron energy range from 100 to 210eV.

In figure 1 & 2, we present our DWA results of differential cross-sections for the individual 3 2P & 4 2P excitation of Na & K atoms respectively at 105eV, 155eV & 205 eV incident electron energies. These result show good behavior as results on slightly higher incident energies at 100eV, 150eV, 200eV & 210eV for DWA & RDW calculations [10]. In figure 3, we present our DWA results of differential cross-sections for the individual 5 2P excitation of Rb atom. The result at 105eV, 155eV & 205 eV incident electron energies show good result. The comparison of DCS at different incident energies for DWA & RDW are behave good at 100eV, 150eV, 200eV & 210eV calculations [20-22].

CONCLUSIONS

In this paper, we have presented our DWA calculations of the DCS parameter in detailed manner for the alkali atoms at different transitions atom. The nature of the curve show good behavior at different incident energies. The result of above and below of our incident energies show close agreement of the DWA and RDW calculations for the DCS and various sensitive parameters suggest that the relativistic effect may not be very important here. Thus we feel confidence that our other results for DCS parameter reported here would be quite reliable and useful for the future comparison purposes.

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