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Excitation cross-section of pottasium by electron-impact

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ABSTRACT : Despite of some well known drawbacks classical theories are useful for estimating the cross–section. The quantum mechanical principles are assumed to be well understood in the low energy atomic physics, anyway, their application to a complete atomic system comprises enormous technical difficulties, therefore, it is required to simplify the atomic system conceptually and develop mathematical approximation. The experimental results which are available are not enough and in many cases reliable experimental results are very difficult to gain. However, all the required data are not expected to be provided by the experimental any way, this is one of the fields where the theory is far away from the experiments, thus theoretical investigation have two distinct aims :

1. **To improve the basic understanding of the underlying processes.**
2. **To provide simple methods to obtain reasonable estimates of the cross section for the processes hence the much needed data.**

Several works have calculated theoretically and experimentally the results are found to be in better agreement with experimental results than those of the combined classical theory or micro-canonical distribution and also the first born approximation.

Keywords : Ionization cross section, inelastic collision, excitation cross section proton impact, high - spin alkali cluster direct excitation function and core polarization potential.

INTRODUCTION

The collision between a charged particle and a gas atom or molecule may cause a number of different effects. If no exchange of energy takes place through collision between charged particle and internal motion of the atom scattering will occur. If incident charged particle losses some kinetic energy in exciting internal motion in the atom, the collision is said to be inelastic. According to the situation of internal motion excitation, the inelastic may be further classified. When sufficient energy is transferred to lead to the electron of one or more electron from the atom. Non ionization inelastic collision consists of excitation of the distinct atomic state. The knowledge of good estimate will play very significant role in the field of astrophysics, Plasma Physics and upper atmospheric Physics, There are many other physical phenomenon which require proper understanding of the knowledge of cross-section for excitation of atom by charged particles specially electron.

Thomas (1973) had envisaged that incident electron gain kinetic energy $E_2 + u$ and simultaneously losses the same amount of potential energy Burgess *et. al.*, (1964) used Quantum mechanics to derive the binary encounter cross-section formulae. He assumed invariant condition cross-section for transformation form center of mass. As actually the collision rates are invariant. Prasad and Prasad (1963) have used the Gryzinski theory with $E_2 = u$ to calculate ionization cross-section for several atoms by electron and proton impact. Sheldon and Dugan (1965) have applied the same to electron impact excitation of cesium. Robinson (1965) has suggested using of Slaters rule to estimate E_2 and has claimed to get improved results for ionization cross-section. Burke (1969) has applied it to calculate the excitation and ionization cross-section for several atoms and diatomic molecules. The velocity distribution has been used by Roy and Rai (1965) to calculate the ionization cross-section of alkali atoms using vriens symmetrical model. Due to lack of strong bonds from pairing electron makes this system non-metallic, Vander Waal like complexes of metal atoms. we fined that sodium (Na) and Potassium (K) readily from high-spin alkali cluster containing 25 atoms.

The polarization of the 4p-4s and 3D-4p radiation produced by electron impact was measured and the result were used to determine the direct excitation function of the separate magnetic sublevels of the 4P state. Electron in alkali-metal like ions by electron-impact well above the threshold energy is calculated in the generalized born approximation and in a Semi-classical approximation. The angular distribution is peaked up at an angle which is essentially defined by energy momentum matching condition on the classical coulomb trajectory, around this angle, the semi classical description is in excellent agreement with quantum description. The semi classical total cross section is practically equal to the coulomb Born prediction. Directly probing the associated thermal expansion dynamics in red time using form to second electron diffraction. We are able to separate the contribution of hot electron from that of lattice heating.

Stone (2004) have used core polarization potential in a Dirac-Pack-Wave function code to calculate target atom wave function and a matching form of the dipole transition operate to calculate oscillator trenches and Born cross section. A Young-Ki-Kim (2001) developed Scattering formula has been shown to be very accurate yet simple to use Mason (1993) has reported that experimental efforts in Laser-assisted electron scattering with particular emphasis upon absorption of Photon and kinetic energy from the incident electron, the role of resonance formation in such collision cross-section is of major importance and reveal new information on dynamics of the collision process. Modern Theoretical treatment such as laser assisted collision are examined and shown to be only partially successful in explaining modern experimental results, the need for more rigorous theoretical calculation is realized.

MATERIAL AND METHODS

Burgess has used quantum Mechanics to derive binary encounter cross-section formulae by using exchange and interference

$$[dQ/d\varepsilon] = [dQ/d\varepsilon]_d\,[dQ/d\varepsilon]_e + [dQ/d\varepsilon]_i \qquad \ldots(1)$$

In the above differential equation first stand for direct collision in which the atomic electron gain energy second exchange collision for interference effect. Vriens (1969) has obtained correct formulae for symmetrical collision model. The total excitation cross-section in this model is given by

$$S = \pi e^4/E_1 + E_2 + U\ [(1/U_n - 1/U_{n+1}) + 2E_2/\in(1/U^2_n - 1/U^2_{n+1}) + (1/E_1 + \mathrm{U} - \mathrm{U}_{n+1} - 1/E_1 + U - U_n) + 2E_2/\in(1/(E_1 + U - U_{n+1})^2 - 1/E_1 + U - U_{n+1}) - \Phi/E_1 + U\ ln\ \{U_{n+1}(E_1 + U - U_n)/U_n(E_1 + U - U_{n+1})\} \qquad \ldots(2)$$

$$\Phi = \cos\ \{(R/E_1 + U_n)^{1/2}\ ln\ (E_1 + U - U_n/U_n)\} \qquad \ldots(3)$$

Where u_{n+1} should be replaced by E_1 for $u_n < E_1 < u_{n+1}$.

Several workers have calculated the ionization and excitation cross-section for different atoms. Gryzinkski himself suggested averaging of the cross-section over velocity distribution.

$$f(v_2) = \pounds\ V_2^{-3}\ \exp^{(-\beta/v2)} \qquad \ldots(4)$$

Where *l* and *b* are constant. Gryzinski has introduced a different velocity distribution function for the atomic – electron moving on the free fall trajectory and urged its use for the ground state of hydrogen atom.

$$F(v_2/v_0) = 4/\pi\ [1 + (v_2/v_0)^2]^{-2} \qquad \ldots(5)$$

$$\text{Where} \quad \frac{1}{2}mv_0^2 = U \qquad \ldots(6)$$

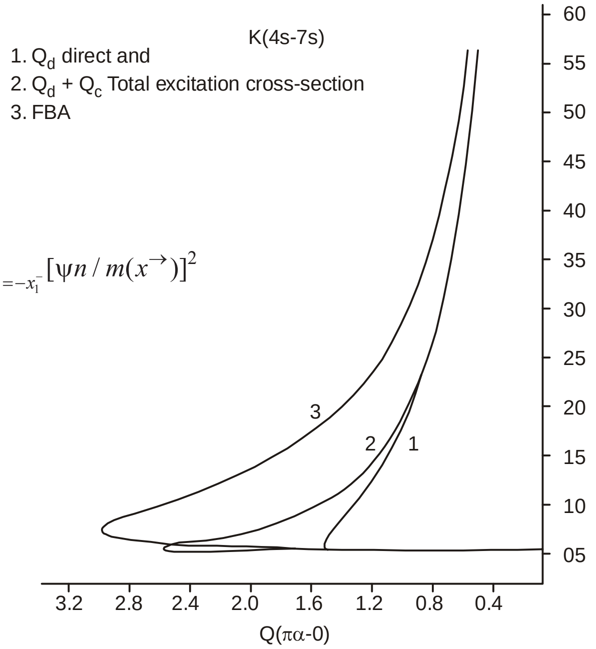
However quantum mechanical velocity distribution for atomic electron may be given by

$$f(v_2/v_0) = 4/\pi \quad [1/(2l + l)\ ]^+ \qquad \ldots(7)$$

DISCUSSION AND CONCLUSION

The entire cross-section for direct as well as exchange excitation have been calculated for a large number of non-resonance excitation in Li, Na, K, Rb and Cs at several incident energy ranging from 1.03 to 21.48 times the threshold of excitation variation of direct as well as total excitation cross-section with energy is shown graphically and compared with other available results. It is also observed that core polarization effect is not very noticeable for sodium but is larger for potassium.

Even at 56 eV, it is only 1/4th of the Born cross-section. But for 6s combined theory results are in good agreement with other theoretical results as is evident from Fig.1. The maximum effective lie excitation cross-section is given by Kieffer *et. al.,* (1969) is $0.43\pi^2 0$ at 4.75 eV. At this energy the total cross-section in the combined theory is $0.47\pi^2 0$ and direct cross-section being.$0.35\pi^2 0$.



$$\overset{2}{\underset{2}{v}}\sum\nolimits_{m=-x_1^-}^{1}[\psi n / m(x^{\rightarrow})]^2$$

Fig.1.

For the excitation of 6p the combined theory results is in better agreement with the FBA (First Born Approximation) than the 5p as evident from Fig.2 and 3. The combined theory curve lie between FBA and Faden and Faden (1973) curve. For the excitation of 7p level the agreement between combined theory and the FBA at higher energy is still better. The total cross-section in the combined theory has the maximum value of $0.45\pi a^2 0$ at 3.93 eV while the FBA has the maximum value of $0.599\pi a^2 0$ at 5eV. At this energy the total cross-section is $0.369\pi a^2 0$. But at 82.7 eV both the combined theory and FBA yield the same cross-section $0.062\pi a^2 0$.

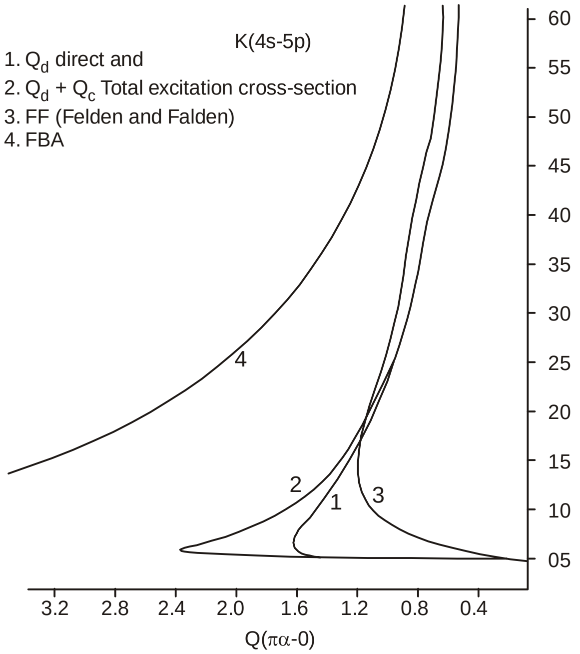


Fig.2.

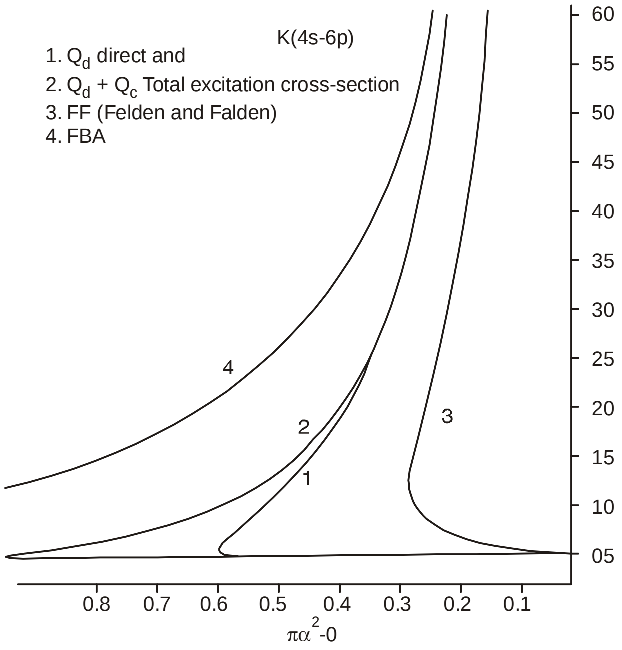


Fig.3.

Energy in a sheld unit	4*s*-5*s* $E_{t = 2.6069}$		4*s*-6*s* $E_{t = 3.4032}$		4*s*-7*s* $E_{t = 3.7534}$		4*s*-5*p* $E_{t = 3.0625}$		4*s*-6*p* $E_{t = 3.5953}$		4*s*-7*p* $E_{t = 3.8520}$		4*s*-5*d* $E_{t = 3.7424}$	
	Qd	*Qe*	*Qd*	*Qe*	*Qd*	*Qe*	*Qd*	*Qe*	*Qd*	*Qe*	*Qd*	*Qe*	*Qd*	*Qe*
1.03	0.361	0.249	0.294	0.272	0.152	0.098	0.328	0.152	0.282	0.274	0.268	0.284	0.0443	0.0302
1.04	0.421	0.276	0.360	0.299	0.152	0.095	0.625	0.92	0.543	0.850	0.268	0.279	0.0422	0.0292
1.08	0.428	0.269	0.360	0.287	0.152	0.088	1.25	0.582	0.554	0.856	0.268	0.266	0.0421	0.0228
1.16	0.428	0.256	0.389	0.264	0.250	0.086	1.50	0.713	0.552	0.285	0.264	0.244	0.0409	0.248
1.32	0..482	0.233	0.356	0.229	0.148	0.069	1.50	0.574	0.544	0.281	0.259	0.210	0.0402	0.0893
1.54	0.485	0.098	0.337	0.084	0.148	0.087	1.48	0.383	0.525	0.142	0.248	0.069	0.0388	0.0824
2.22	0.487	0.066	0.328	0.042	0.180	0.028	1.29	0.198	0.485	0.068	0.228	0.032	0.0366	0.0069
3.56	0.385	0.022	0.282	0.024	0.120	0.006	1.23	0.078	0.413	0.023	0.291	0.022	0.0302	0.0029
6.32	0.333	0.066	0.228	0.004	0.084	0.001	0.970	0.018	0.327	0.006	0.244	0.003	0.0230	0.0005
11.24	0.248	0.022	0.163	0.002	0.068	0.003	0.690	0.004	0.229	0.002	0.099	0.005	0.0259	0.005
21.48	0.267		0.028		0.036	0.005	0.442	0.006	0.239	0.004	0.063	0.006	0.0100	0.008

Where $\psi nlm(x \times^{\rightarrow})$ is the Fourier transformation of the the one electron orbital $\psi nlm(x)$.

Excitation cross section (in πa^2) for non resonance transition of potassium in calculated using combined classical theory E_t = threshold of excitation in eV. **Qd** is cross section for direct and **Qe** for change excitation.

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