

# Low energy Plasmon Satellite in X-ray Excited Auger Electron Spectra of Chloride of First Group Elements

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**ABSTRACT:** Using Plasmon oscillation theory, the energy separation and relative intensity of the  $K_{\alpha}$  satellites of the chlorides of first group element have been calculated. Our calculated values agree better with the experimentally observed values than the values calculated by Jun Kawai using multi vacancy theory. This suggests that the possible origin of  $K_{\alpha}$  satellites may be due to plasmon oscillations in compounds.

**KEYWORDS:** Plasmon, Satellite Volume Plasmon, Relative intensity

## I. INTRODUCTION

X-ray satellites or non-diagram lines on the high and low energy side of the parent emission lines, are well known in X-ray spectra. Plasmon theory has been very successful in explaining the origin of all those low and high energy X-ray satellites which are found at an energy distance of  $\hbar\omega_p$ , the plasmon energy, from the main emission X-ray line (1-7). Most of the workers (9-11) have used plasmon theory to explain only  $K_{\beta}$ , and  $K_{\gamma}$  satellites, but very little effort has been made to explain the  $K_{\alpha}$  X-ray satellites. Therefore, in this note the authors have made an attempt to explain the origin of the low energy X-ray satellites in chlorides of first group elements.

Several theories like charge transfer theory, shakeup theory and multiple ionization theory (12-15) have been put forward from time to time to explain the origin of low energy X-ray satellites. But those X-ray satellite whose energy distance from the parent line is equal to plasmon energy cannot be explain satisfactory by above mentioned theories. Jun Kawai (16) has observed many multiple structure & X-ray emission satellite of the low energy side of  $K_{\alpha}$  line of X-ray excited spectra of chlorides of first group element. Jun Kawai has only used multi vacancy satellite theory to calculate the relative intensity, but the calculation has not been done for the plasmon energy by the above mentioned theory nor can energy separation be estimated, since intensity graph are not given. This is also a well-known fact that multi vacancy theory may also Auger effect. Brouers (17) pointed out that plasmon excitation during X-ray emission process is the collective counter part of the usual Auger effect in which the primary X-ray transition excites a secondary electron. Hence Plasmon involvement in the satellite may also present.

## II. QUANTITATIVE ANALYSIS

Author presented two types of computations. First one is energy shift  $\Delta E$  in low energy side of X-ray excited Auger electron spectra of chlorides of first group elements. The second one is for relative intensity calculations based on transition probability.

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## III. CALCULATION ENERGY SHIFT

Author first calculate energy separation of  $K_{\alpha}$  satellites of first group element using formula given by Morton et al (7) as

$$\Delta E_p = \hbar \omega_p = 28.8 \left[ \frac{Z' \sigma}{W} \right]^{1/2} \quad \text{.....1}$$

Where-  $\frac{Z'}{W}$

In present case effective number of

$Z'$  = effective number of electrons taking part in plasmon oscillation

$\sigma$  = specific gravity of compounds

and  $W$  = molecular weight of compounds

By using equation no (1) energy separation of  $K_{\alpha}$  satellites of chloride of first group elements are calculated and shown in table (1)

## IV. CALCULATION OF RELATIVE INTENSITY

In order to confirm the involvement of plasmon in the emission of X-ray satellites, the author has calculated the relative intensity of plasmon satellite. The relative intensity of plasmon satellites depends on how the excitation of plasmon takes place. It is different in different processes. There are two processes, extrinsic and intrinsic; Bradshaw *et al*<sup>12</sup> have further divided the intrinsic process into two categories, one where the number of slow electrons is conserved, plasmon satellite will be weak and where the number of slow electrons is not conserved, the plasmon satellite is strong. The X-ray photo electron process comes under the second category.

Following Bradshaw *et al* (8), the transition probability  $P(\omega)$  per unit time per unit energy range at energy  $\hbar \omega_p$  for the emission of the plasmon satellite is given by-

$$P(\omega) = |f|^2 \sum_n e^{-\alpha} \frac{\alpha^n}{n!} \delta(\omega - \epsilon_p + a\omega_p - n\omega) \quad \text{.....2}$$

Where  $f$  is the matrix element for the process and  $\alpha$  is the dimensionless coupling constant between plasmon and electron. The weight factor represents  $e^{-\alpha} (\frac{\alpha^n}{n!})$  the strength of the nth satellite. Thus the relative intensity of the plasmon satellite with respect to the main emission line is given by

$$\frac{i}{I_0} = \frac{I_1}{I_0} = \frac{e^{-\alpha} \alpha^1 / 1!}{e^{-\alpha} \alpha^0 / 0!} = \alpha \quad \text{.....3}$$

The coupling constant  $\alpha$  is given by Langreth [18], as

$$\alpha = \frac{e^2 q_{max}}{\pi \hbar \omega_p} = 0.16 r_s \quad \text{.....4}$$

Where,  $q_{max}$  is the plasmon cutoff wave vector, and  $r_s$  is a dimension less parameter (12) given by

$$r_s = \left( \frac{47.11}{\hbar \omega_p} \right)^{2/3} = \left( \frac{47.11}{\Delta E} \right)^{2/3} \quad \text{.....5}$$

By using equation 4 the relative intensity of satellites with respect to main line are calculated and shown in table 2.

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**Table-1**

Energy separation of Low Energy volume plasmon of satellites of chloride of first group element

S. No.	Chloride of element	Effective no. of electrons $Z'$	Specific gravity $\sigma$	Molecular weight $W$	Energy separation $28.8(Z'\sigma/w)^{1/2} \text{ eV/}$
1	Lithium Chloride	8	2.86	42.39	21.187
2	Sodium Chloride	8	2.16	58.44	15.678
3	Potassium	8	2.98	74.55	16.291
4	Rubidium	8	2.80	120.92	12.395
5	Cesium	8	2.988	168.36	12.537

**Table-2**

Relative intensity of low energy volume plasmon satellite of chloride of first group elements

S. No.	Chloride of element	Dimensionless parameter	Relative intensity 0.16x dimensionless parameter	Relative intensity observed $i'$
1	Lithium	1.70	0.27	0.34
2	Sodium	2.08	0.33	0.35
3	Potassium	2.03	0.32	0.36
4	Rubidium	2.43	0.38	0.33
5	Cesium	2.42	0.38	0.32

## V. COMPARISON WITH EXPERIMENTAL RESULTS AND DISCUSSIONS

The author has used equation (1) to calculate the plasmon energy of chlorides of first group elements and then by using equation (4), and calculated the relative intensities of the same compounds. The calculated intensities of the compounds are found to be in good agreement with the experimental values of the Jun Kawai [16].

Thus the author concludes that the origin of low energy satellites of  $K_{\alpha}$  X-ray emission line in the case of chlorides of first group element are due to plasmon excitation, while the explanation given by Jun Kawai [16] may also be true.

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