PREFACE

A considerable amount of theoretical (Bohm and pines in 1951-53) and experimental (Morten and Robines in 1955-56) work have shown that electron gas in a metal behaves as free particle within a range of Debye Length $\lambda_D$ and beyond that they behave collectively and oscillate, with frequency $\omega_p$. These collective oscillations are quantized and a quantum of energy is called plasmon.

Plasmon oscillations in metal can be excited, when an imbalance of electrostatic charges is created in the electron gas, either by fast energetic transiting charged particles or during the excitation or de-excitation of the atom. Ferrell in 1956 and later Nozieres and Pines in 1959 advanced the theories, that X-ray transition in metal could be accompanied by the excitation of one or more plasmons and as a result, it may complicate the structure of the X-ray emission and absorption spectra. When a plasmon is excited during an X-ray emission process, one can get a low energy X-ray plasmon satellite, because an energy of amount $\hbar \omega_p$ will be used in exciting a plasmon oscillation in the electron gas.
Shmidt in 1961 and later Steinmann (1968) and Neddermeyer et al. in 1970, suggested that plasmon on decay can transfer its energy to a conduction electron which subsequently fills the core vacancy, giving rise to an emission of an X-ray photon. This X-ray emission line, due to plasmon energy gain, will possess energy higher than the parent emission line by an amount $\hbar \omega_p$. This line is known as high energy X-ray emission plasmon satellites.

Several theories have been put forward to explain the origin of these satellites from time to time. But still there are some X-ray satellite, especially that whose energy distance from the parent line is equal to the plasmon energy, not explained by the conventional theories except by plasmon oscillation theory of Bohm and Pines (1951-53). In fact for X-ray satellites of compounds, a plasmon oscillation in solid theory is the only theory, which can calculate their relative intensity.

Plasmon theory has been used by several workers to explain the existence of $K\alpha', K\beta', K\gamma', L\alpha, L\beta'$ X-ray satellites only. But no attempt has been made so far, to use this theory to explain the X-ray satellites of $L_{\beta_1}$ main emission lines.
The Author, could guess on the first sight, the involvement of surface plasmon excitation in satellites from the energy separation of these satellites and the plasmon energy is given by-

\[ \hbar \omega_p = 28.8 \left( \frac{Z\sigma}{W} \right)^{1/2} \text{ ev} \]

and, surface plasmon energy is given by-

\[ \hbar \omega_S = \frac{\hbar \omega_p}{\sqrt{2}} = 20.37 \left( \frac{Z\sigma}{W} \right)^{1/2} \text{ ev} \]

Where, \( Z \) is the effective number of electrons, taking part in the plasmon oscillation, \( \sigma \) is the specific gravity and \( W \) is the molecular weight plasmon oscillation theory is used to explain the X-ray satellites of \( \alpha_3, \alpha_4 \) and \( \alpha_5 \) with respect to \( L_{\alpha_1} \) parent line in 4d transition elements (Zr, Nb, Mo, Ru, Rh, Rd) and transition metal oxides (Fe\(_2\)O\(_3\), Fe\(_3\)O\(_4\), Cr\(_2\)O\(_3\), CrO\(_3\)) based on their core level 2p peaks.

The Author has not assigned the above satellites on only energy separation consideration but has also calculated the relative intensities.

The relative intensity of plasmon satellites depends upon the process of excitation of plasma oscillations. There are two processes of excitation, one is extrinsic and the other is the intrinsic. In the
extrinsic process, the excitation of the plasmon occurs during the transport of the electron through the solid, and this is also known as "fast electron process". The second process in which the excitation of plasmon takes place simultaneously with creation of a hole, this process is called intrinsic process, and also known as 'slow electron process'.

Bradshaw et al. [26] have divided this process into two classes;

1- Where the number of slow electrons is not conserved

2- Where the number of slow electrons is conserved.

Electrons are termed "slow" when bound in a core state, or when having a very low kinetic energies just above the fermi level. In this process where the slow electrons are conserved, the plasmon satellites will be weak, but where the slow electrons are not conserved plasmon satellites will be strong. Thus there will be two types of equation for calculating the relative intensity of the single plasmon satellites.

Author has calculated the relative intensity of the plasmon satellites of non-conserved-slow electron by the relation -
\[ i_1 = \frac{l_1}{l_0} = \frac{e^{-\alpha} \alpha^1/1!}{e^{-\alpha} \alpha^0/0!} = \alpha \]

\[ = 0.1 \quad 2r_s - 0.1 \]

Where,
\[ r_s = \left( \frac{47.11}{\hbar \omega_p} \right)^{2/3} \]

Using equations (1 & 2) the author has for the first time, calculated the surface energy separation and relative intensity of transition metal oxides (Fe_2O_3, Fe_3O_4, Cr_2O_3, CrO_3), and our calculated and estimated values are in agreement with the calculated values of M. Aronniemi et al. [144]. In this process, the intensity of low and high energy plasmon satellites both are strong, that is their intensity is more, in comparison with those satellites which are obtained by the second process given below.

Author has also calculated relative intensity, in both the cases with new modification in the light of Bradshaw [27] and Lengreth's [122] work, which explains that not only intrinsic process, but extrinsic process and their relative contribution may also contribute in relative intensities. The combined effect of intrinsic and extrinsic plasmon excitation intensity variation was suggested by Lengreth [125, 134-139] as:-
\[ i = \frac{l_s}{l_m} = \alpha_n \sum_{m=0}^{n} \left( \frac{\beta}{\alpha} \right)^m m! \]  

The value of $\beta$ [39] is taken as $\beta = 0.12 r_s$ which is purely intrinsic, $r_s = (47.1/ \hbar \omega_s)^{2/3}$ is dimensionless parameter [30] and $\alpha = 0.47 r_s^{1/2}$ [31] in the place of $\alpha = (1+l/L)^{-1}$ used by Pardee et al. [119]. The equation contains a series of terms. The first term of the equation is purely extrinsic, while second term is purely intrinsic. The other terms are containing the relative contributions of both extrinsic and intrinsic. The speciality of this formula is that each term alone or simultaneously with other terms is able to give the relative intensity. This formula also includes both the categories mentioned by Bradshaw [27] and gives better results as compared with traditional methods for calculation of the relative intensity.

Using the equations (1 and 3), the Author has for the first time, calculated the relative intensity of high energy X-ray satellites, with respect to $L\alpha_1$ parent line in 4d Transition Metal (Zr, Nb, Mo, Ru, Rh, Rd) metals. The calculated and estimated values are in agreement with the calculated values of Surendra Poonia and S.N.Soni [133].

In the present research work, First chapter deals with the introduction to the low and high X-ray plasmon satellites, and the
second chapter about the theory of plasmon satellites in solids. In third chapter, Review of theories of low & high X-ray plasmon satellites have been described. Chapter fourth is meant for formulation of the problem and calculation of relative intensity and energy separation of X-ray plasmon satellites and the fifth chapter shows the involvement of surface plasmon in X-ray satellite and the last chapter sixth, deals the summary and conclusion of the present research works.