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Pattern for Absorption and Emission Transitions Involved in Luminescence

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Abstract- Absorption and emission patterns are mechanically drawn in order to understand the transitional movement of electron from one energy state to another involved in the mechanism of luminescence study. Both the lower state orbital kinetic energy of the electron as well as the kinetic energy gained by the same revolving electron due to the absorption of photonic energy are responsible during absorption transition for the jumping of electron from lower energy state to higher energy state. Thus, the electron is gained by an excess amount of kinetic energy for uplifting from lower level to upper level against the electrostatic pull. Similarly, both the upper state orbital kinetic energy of the electron and the electrostatic pull are responsible during emission transition for the putting of electron from higher energy state to lower energy state. On reaching at the depth of lower orbit, the electron is strictly prohibited to fall further accordingly. Therefore, at this moment as soon as the electron enters into it's lower orbit, only the orbital component of kinetic energy required for the revolutionary motion remains with the electron. The rest part of the kinetic energy of the electron is transformed into the photonic emission of luminescence light.

Keywords- Absorption Transition, Emission Transition, luminescence

I. INTRODUCTION

Absorption and emission transitions of electron are both related with the result of absorption and emission of photon respectively. These transitions occur in between two levels of energies, one called the lower of less energy Ei, while the other of relatively higher energy Ef. Ei is the sum of orbital K.E and uniquely defined electrostatic P.E of the electron in the lower orbit. Similarly, Ef is the sum of K.E and P.E in the upper orbit. It is a rule that the K.E of electron in the lower orbit is greater than the K.E of the electron in the upper orbit. While, the P.E of the electron in the lower orbit is less than the P.E in the upper orbit. But, the total energy Ef > Ei. According to quantum theory of Plank, the photon is the bundle of energy and hν is the formula for it [1]. When such an energy of photon is absorbed by any of the electron in it's lower orbit, the electron from the lower level of energy Ei goes to upper level where it's energy becomes –

$$Ei + h\nu = Ef$$

While, after return from higher level to lower level, a part of the energy of the electron from Ef is transformed into photonic energy hν by the emission of light due to the change –

$$Ef - h\nu = Ei$$

II. THEORY

Before absorption of light, when the electron is in it's lower orbit, it's motion is regulated by such an electrostatic attractive force which acts on the electron ever normally to it's orbital velocity. The magnitude of this force is numerically equal to the centripetal force depending upon the velocity of electron needed for the revolution around a circular orbit [2]. The comparison of these two forces provides a key factor for finding the height of the orbit and related orbital velocity of the electron in it's orbit. The equality of such forces applies a common centripetal acceleration to act on electron. However, it's magnitude also remains unchanged but the change in it's direction plays a dominant role to change the direction of velocity of the electron while revolving around a fixed orbit.

Absorption of light and emission of light both take place according to Bohr's theory of atom [3]. If the electron orbiting in its lower energy state Ei is excited by some outer agency of energy like by a photon of energy hν, it goes some where in the outer orbit where its final energy is found to be Ef. When it comes to its original ground state, it releases the photonic energy as a result of emission of light. These processes are of keen interest to study and emphasize the path for physical mechanism of motion of the electron during such transitions. Newtonian classical mechanics defining the relation of mass with velocity, force, acceleration and kinetic energy is adopted to achieve the path of electron during such transitions [4]. Although, the transition of electron from one state of energy to another state of energy takes place simply by two different types of processes but a common phenomena of exchange of K.E of electron and photonic

energy by transformation into each other is followed by according to -

$$½ (mV\nu^2) \sim h\nu$$

III. MECHANISM AND DISCUSSION

[A] ABSORPTION TRANSITION

when the photonic energy of light is incident on a luminescent material, the energy of light is absorbed by the electron of the atom revolving in it's lower orbit. Before absorption to take place, the electron possesses an orbital velocity Vi along the tangent of lower orbit. The electron revolves around the nucleus in a circular orbit because of the centripetal force applied by Coulomb's electrostatic force of attraction acting on electron towards the nucleus. When light is incident on the revolving electron, the electron absorbs energy hν from it. The electron gains the kinetic energy from the photon. The energy of photon hν is being only absorbed by the revolving electron from the lower orbit if it can raise the electron from it's orbit. Thus, every quantum of photon is not absorbed by the electron. A photon having discrete amount of energy is only able to excite the electron. This discrete amount of energy must match with the energy gap between the upper exited state and the lower ground state by the equation -

$$\Delta E = h\nu$$

Actually, the electron is provided an extra amount of kinetic energy as a result of absorption of photonic energy and transformation of it in the form of kinetic energy. This kinetic energy is gained by the electron for uplifting. A certain amount of kinetic energy is essentially required to project the electron from it's present state of kinetic energy. The photon gives to electron this value of kinetic energy which directs electron to move normally to it's orbital kinetic energy. Both these types of kinetic energies are used by the electron during uplifting from it's lower potential energy state to a state of higher potential energy. After absorbing photonic energy and getting it in the form of kinetic energy, the electron is found to have two types of velocities components, one Vi already exists as orbital velocity directed towards the lower orbit and the other is an additional gained component Vν directed towards uplifting in the direction opposite to attractive force. The uplifting velocity has a relation with the photonic energy of absorption by the relation –

$$h\nu = ½ (mV\nu^2)$$

At the time of born of Vν, both Vi and Vν act on electron mutually perpendicularly applied. Vi is normal to Coulomb's force while Vν is opposite to this force. These two components of velocities are used to derive a resultant velocity Vr which projects the electron to move in a two dimensional plane for a parabolic type of motion. Figure 1 shows that after absorption of photon and for a problem of absorption transition to solve, the electron is organized to get such a resultant velocity which can be easily retarded with the help of electrostatic force of attraction acting on it. As the projectile climbs upward, the direction as well as the magnitude of the force acting on electron goes on changing step by step and decreases drastically due to the climbing. This causes change of direction and decreasing magnitude of retardation to act on the resultant velocity as well as in its velocity components. Because, the electrostatic force acts towards the nucleus and is mainly opposite to the motion of electron carrying outside, the component of velocity towards it is retarded to zero value at the point of the vertex at the end of the climbing. While, the other orbital component of velocity is not much decreased, only a little value is decreased during the uplifting motion assisted by it. The velocity is decreased from Vi to Vf. Now, Vf is the only resultant velocity at the time of approach at the vertex situated at the height of upper level and is accurately directed tangentially along the orbit of upper level for a motion and for a while.

When the electron reaches to upper level, the orbital kinetic energy of the electron is less than the kinetic energy that was in the lower orbit. This decrease in kinetic energy is being used to increase the potential energy of the electron. On reaching at the optimum position towards upward motion, the kinetic energy gained by the electron due to the absorption of photonic energy hν is also totally lost in climbing, hence this amount of kinetic energy has been also fully used to increase the potential energy. Thus, the total increase in potential energy of the electron on reaching from lower level to the upper level is accompanied with the use of photonic energy hν in cooperation with the support and assistance of changing a part of orbital kinetic energy of lower level into potential energy. Thus, the energy of photon absorbed is not equal to the difference of potential energies of two states but it is equal to the difference of total energies of two states by the equation-

$$h\nu = Ef – Ei$$

The total energy of the electron in the upper level can be written as -

Ef = K.E of electron in the upper level + P.E of electron in the upper level.

= K.E of electron in the lower level – Increase in P.E of the electron due to the exchange of decreased amount of kinetic energy during transition of electron from the lower level of high kinetic energy to the upper level of low kinetic energy + P.E in the lower level + Total increase in P.E due to transition of electron from lower energy level to higher energy level.

= Ei – Increase in P.E of the electron due to the exchange of decreased amount of kinetic energy during transition of electron from the lower level of high kinetic energy to the upper level of low kinetic energy + Increase in P.E of the electron due to the exchange of decreased amount of kinetic energy during transition of electron from lower level of high kinetic energy to upper level of low kinetic

energy + Increase of P.E of the electron due to decrease of that much amount of kinetic energy which is gained from the photonic energy hν as a result of absorption by transformation and is used totally to increase the potential energy of electron during uplifting from low potential energy state to high potential energy state.

$$= Ei + h\nu$$

Thus, the absorption transition of electron as a result of absorption of energy from photon is well understood and the mechanism is adopted to clarify the up going pattern of the electron.

[B] EMISSION TRANSITION

For studying the emission of light, the emission transition of electron is considered to take place from higher energy level to lower energy level. It is observed that when the electron approaches at the vertex of parabolic motion of projectile as a result of absorption transition from lower orbit to higher orbit, the electron acquires a velocity Vf and having it's direction normal to the attractive electrostatic force. By this much amount of velocity, the electron begins to revolve around the upper orbit. However at the vertex, the direction of velocity of the electron is tangential to both the vertex as well as to the orbital path of the upper orbit but owing to the cause of application of the orbital velocity of upper state acting normal to the direction of electrostatic force of attraction, this electrostatic force of attraction takes a part to provide centripetal force necessary for revolutionary motion of the electron around the upper orbit for a moment and for a while. At the vertex, the force acting on the electron behaves as a centripetal force and the electron follows the rule of its nature of revolutionary motion on reaching at upper orbit. The electron cannot remain in the upper orbit forever and for a long because the upper orbit is not it's own permanent orbit for revolution suitably. Due to conditions imposed on electron by the atom to follow the rule of prior to go to it's original initial state for fulfilling the empty lower orbit as well as for the remaining in revolution permanently, the electron starts to leave the upper orbit very soon. The same force acting on electron can take it to follow the kind of parabolic motion of projectile. In such a motion, the acceleration caused by the force also remains normal to the velocity at the vertex. Because, the electron is very sensitive about its motion for the establishment of atomic stability, it follows the laws imposed on it.

The downfall of electron from the upper level is assisted by the upper state orbital velocity Vf in the presence of electrostatic pull. Although, on reaching at upper orbit, the electron has only one component of velocity left towards the orbit of upper level but due to the presence of electrostatic force still acting on it, the force is able to enhance the aligned velocity component from it's zero value. Such a component of velocity is compulsorily required to assist orbital velocity for a down fall projectile motion of electron. Figure 1 also shows that for a problem of emission transition to solve, the electron is organized to take over such a resultant velocity which can be easily accelerated by the electrostatic force of attraction acting on it. Two dimensional downfall parabolic motion of electron begins to develop again for emission transition to take place. As the electron goes towards downward plane, the direction as well as the magnitude of electrostatic attractive force goes on changing and increases respectively. This results an overall increasing magnitude of acceleration to act on the resultant velocity of the electron in it's passage. On reaching at the depth of lower orbit, the resultant velocity of the electron can be resolved into two components. One linear along the tangent of lower orbit while the other along the force of attraction. Because, the electrostatic force acts mainly along the centre towards the nucleus, the velocity component towards it is highly accelerated. Only a little increment in velocity component needed for revolution and directed towards the lower orbit is achieved due to downfall acceleration. When the electron reaches to a depth of lower orbit, the resolved components of velocities as a result of acceleration produced by electrostatic force of attraction get a value Vi exactly directed towards the tangent of lower orbit and a value V**v** directed towards the centre of the orbit. The kinetic energy of the electron associated with these components of velocities will be ½ (mVi^2) and ½ ($mV\mathbf{v}^2$). After reaching to the depth of lower orbit, the electron is prohibited to fall further accordingly. At this moment, for the establishment of atomic stability, the kinetic energy responsible for carrying electron downwards strait to the nucleus is transformed into photonic energy hν by the emission of light due to -

$$\tfrac{1}{2}\,(\,mV\mathbf{v}^2\,) = h\nu$$

While, under the remaining attained lower state orbital velocity Vi and provision of electrostatic centripetal force, the electron is forced to revolve in the existing original lower level of the orbit. Thus, the emission transition of electron with a result of emission of light in the form of photon is well understood and the mechanism is adopted to clarify the down going pattern of the electron.

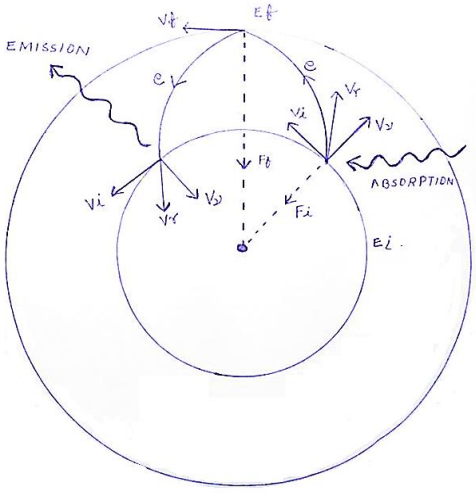

Figure.1. Pattern for absorption and emission transitions of electron involved in luminescence

IV. CONCLUSION

The phenomena of conversion of photonic energy for increasing a part of kinetic energy of the electron and similarly, the conversion of a part of kinetic energy of the electron for emitting photonic energy are used in this description to explain the absorption and emission of light resulted due to absorption and emission transitions of the electron respectively. The theory is formulated in order to co relate the mutual evidences drawn in favor of the mechanism behind it. During the absorption transition as a result of absorption of photonic energy, a part of orbital kinetic energy of the electron is used to uplift the electron with the help of gained kinetic energy against the electrostatic pull. Thus, the absorption transitional movement of the electron occurs from a state of lower potential energy to a state of higher potential energy. Similarly, during the emission transition of the electron, the potential energy of the electron is decreased by the electrostatic pull. The decrease in potential energy is used to increase the kinetic energy of the down going electron. Thus, the emission transitional movement of the electron takes place from a state of lower kinetic energy to a state of higher kinetic energy. An appropriate component of kinetic energy directed towards the lower orbit is achieved by the electron for the revolutionary motion. While, the rest part of the kinetic energy gained by the electron is directed to carry the electron below accordingly. But, the electron is strictly prohibited to go below a certain level. Therefore, the electron loses it's extra amount of gained kinetic energy by the transformation into photonic energy of light before going into lower orbit for revolutionary motion. The pattern presented here seems to be firstly disclosed in this manner and is therefore very helpful to realize the mechanism of luminescence.

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