# Theoretical Model For The Existence Of A D-Medium Inside An Atom

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**Abstract**— The objective of this research work is to develop a theoretical model for the existence of the D-medium inside an atom. D-medium is more effective in between the shell and sub-shell of an atom. This medium disturbed the speed of the electron, when electron goes from one shell to another or one sub-shell to another sub-shell of an atom. When electron of a target shell get energy from external agent (photon) whose energy is greater than, the energy of target shell and less or equal than the energy of another shell which is just next of target shell. The electron take the energy and leave the shell i.e. go to another shell, and again come into its original shell. Due to Pauli exclusion principle and not sufficient energy to escape an atom or shell. In this process, the distance travel by electron take place from one shell to another through the D-medium. Due to the presence of this D-medium the speed of electron is less, which implies that electron take different time to reach from one shell to another, either directly or step wises for a same a distance. In additional, D-medium is non-homogeneous transparent medium that play an important role in time different for same distance.

**Index Terms**— D-medium, Pauli Exclusion Principle, Photon, Shell, Sub-shell, etc.

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## 1 Introduction

When the positively charged alpha particles were fired at the gold foil, most of them passed through the empty space of the gold atoms with little deflection, but a few of them ran smack into the dense, positively charged nucleus of a gold atom and were repelled straight back [1].

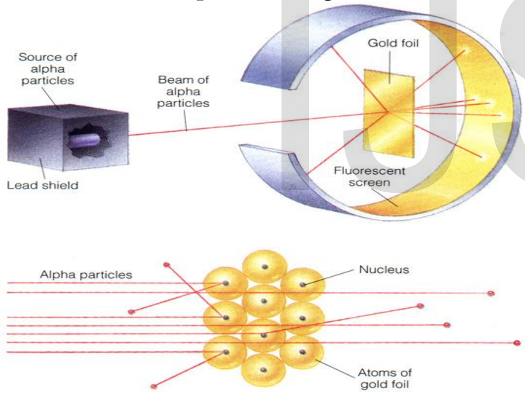


**Figure 1:** Experimental setup Rutherford alpha-Scattering (Source: https://www.iespfq.cat/moodle/mod/book/tool/print/index.php?id=6042&chapterid=292).

The experimental diagram shown in figure 1 is done by Rutherford and concluded that an atom has nucleus which concentrated approx all the mass of an atom. The scatter ray show the existence of nucleus in an atom and the straight ray passes show that atom is vacant. Atoms themselves, are mostly empty space i.e. about 99.999% of an atom is empty space was final in 1900's, most scientists came to believe in the idea that all matter was made up of tiny particles called atoms. Rutherford showed atom was mostly empty space, with mass concentrated in central atomic nucleus in 1990's, experimentally.

## 2 Review

The first model of the atom was given by a Greek philosophers Leucippus around 440 BC and his student Democritus. They believed that all matter is made of small, indivisible particles. These particles were called atoms after the Greek word for indivisible. About the 17th century, the atomic model became more important again. Further evidence came from the development of the kinetic theory of gases by Rudolf Julius Clausius, James Clerk Maxwell, and Ludwig Boltzmann in between 1800-1990's. At the end of the 19th century came the idea that the matter consists of atoms constructed, finally prevailed. Various experiments recorded a more accurate image of these atoms [2].

Investigate the angular distribution of α-particle scattering off of gold atoms, originally performed in 1909 by Geiger and Marsden under the direction of Rutherford and an experiment that shook the world of physics was carried out by Rutherford in 1910 and explained the finding by assuming that all of the mass and positive charge of an atom are concentrated in a small volume at the center, in a compact nucleus. In some experiment the counting rate in the forward direction is on the order of $10^5$ particles/hr, while in the backward direction it is of the order of $10^{-1}$ particles/hr [3], [4], [5].

In Atom history the year between 1904 and 1913 so important. J. J. Thomson, Ernest Rutherford and Niels Bohr are the scientist who first examine the origins of Thomson's mechanical atomic models, from his ethereal vortex atoms in the early 1880's, to the myriad "corpuscular" atoms he proposed following the discovery of the electron in 1897. Niels Bohr was particularly troubled by the radiative instability inherent to any mechanical atom, and succeeded in 1913 where others had failed in the prediction of emission spectra, by making two bold hypotheses that were in contradiction to the laws of classical physics, but necessary in order to account for experimental facts [6]. The hydrogen atom is the simplest two-body bound system consisting of a proton and an electron. The hypothesis of the second allotropic type of proton-electron atom, the strongly bound proton-electron atom called neutron, was suggested by Rutherford in 1920. The existence of the neutron was confirmed in 1932 by Chadwick [7].

Earnest Rutherford, a nuclear scientist who worked around the same time as Thompson, carried out experiments to further understand the nature of the atom. Under the direction of Rutherford, Hans Geiger and Earnest Marsden performed an experiment in 1909 that helped disprove the plum pudding theory of the atom. The result of the experiment had most of these α-particles going through unaltered, while some were scattered backwards at angles above 90 degrees. In 1913 this model was further refined by scientist Niels Bohr. Using advanced combinations of classical and quantum mechanics he was able to provide an accurate model of the way that electrons would be able to orbit this massively charged nucleus and not decay [8].

## 3 METHODOLOGY

**3.1. D-Medium (Dhobi-Medium):** D-medium is transparent medium presence in an atom through which an electron, photon and atom of suitable size can passes through it. When the particle of suitable size passes through it without interacting with electron and nucleus of an atom, the velocity of the particle goes to changes. This phenomena is similar to the refraction of light, when passes from one medium to another medium. It can be also observed more clearly in between the shells or sub-shells of an atom because the time taken of an electron for same distance in an atom is different. This medium is not only transparent but also non-uniform, and because of this non-uniform the time taken for same distance and same velocity is different.

**3.2. Mathematical Model for the existence Dhobi-Medum inside an atom:** Let us consider $r_n$ and $r_{n+1}$ distance of an electron on shell-$n^{th}$ and shell-$(n+1)^{th}$ (Here shell is energy level), with energy $E_n$ and $E_{n+1}$ of an consider atom. The visualized in diagram are shown in figure 2.

Now from Bohr's theory of hydrogen atom, we have energy for a consider energy level or shell of an atom is given by

$$E_n = \frac{-1}{n^2}\frac{me^4 z^2}{8\varepsilon^2 h^2} = \frac{-z^2 R_H}{n^2} \text{.............}(1a)$$

$$E_n = \frac{-1}{n^2}\frac{me^4 z^2}{8\varepsilon^2 h^2} = \frac{-z^2 13.6 eV}{n^2} \text{..........}(1b)$$

i.e. the quantization of orbital angular momentum leads to quantization of orbital energy and $R_H$ = 13.6eV is called Rydberg constant and distance at which the electron revolved around the nucleus is called radius or the distance between electron revolving around the nucleus on specific shell or energy level is given by

$$r_n = \frac{n^2 h^2}{4\pi^2 z m e^2} = 0.529\frac{n^2}{z}A^o \text{..........}(2)$$

for z=1 and n=1

$r_0 = 0.529 A^o$ This is called Bohr's radius.

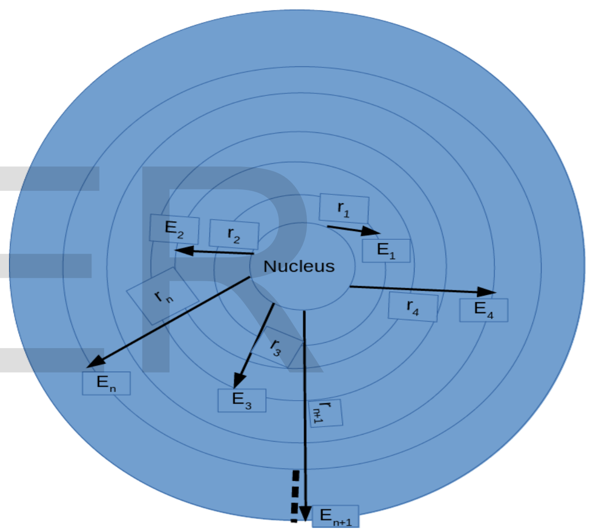


**Figure 2:** Sketch of single atom having energy level, nucleus and distance of nucleus from shell contain electron.

Let us consider, a photon of energy is hf before enter in an atom and after enter into an atom the energy of the photon become hf', which is suitable to push or kick an electron of one shell to another shell as shown in figure 3. When electron is pushed from one shell to another shell in an atom it carry kinetic energy which is given by

$$K.E_e = \frac{m v_e^2}{2} \text{................}(3)$$

where, m = mass of electron and $v_e$ = velocity of an electron when electron goes from one shell to another.

Since we have

$$hf' = hf_0 + K.E_e \text{............}(4)$$

where f' =energy of incidence photon on an electron in an atomic shell.

where $f_0$=minimum amount of energy of a shell, of an atomic shell.

Now putting the value of (3) in (4) we get

$$hf' = hf_0 + \frac{mv_e^2}{2}$$

$$\frac{mv_e^2}{2} = hf' - hf_0 \quad \text{.............(5)}$$

Let L is the distance between two shell, travel by electron from one shell to another with velocity $v_e$ after kick out from consider shell in time T. Then from equation (3) we can write,

$$\frac{2K.E_e}{m} = v_e^2$$

$$v_e = \left(\frac{2K.E_e}{m}\right)^{\frac{1}{2}}$$

$$\frac{dL}{dt} = \left(\frac{2K.E_e}{m}\right)^{\frac{1}{2}}$$

$$dL = \left(\frac{2K.E_e}{m}\right)^{\frac{1}{2}} dt \quad \text{....................(6)}$$

Integration, dL from 0 to L and dt from 0 to T of equation (6)

$$\int_0^L dL = \int_0^T \left(\frac{2K.E_e}{m}\right)^{\frac{1}{2}} dt$$

$$L = \left(\frac{2K.E_e}{m}\right)^{\frac{1}{2}} T \quad \text{...................(7)}$$

This equation (7) represent the distance travel by electron in time T, from one shell to another shell when suitable amount of energy is incidence on consider electron, in general. Example, the representation of the distance L is shown in figure 3.

$$T = \frac{L}{\left(\frac{2K.E_e}{m}\right)^{\frac{1}{2}}} \quad \text{...................(8)}$$

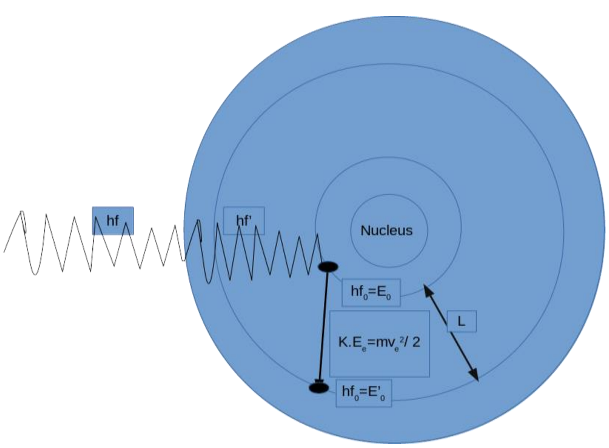


**Figure 3 :** Electron goes from one energy level to another after absorption energy.

**3.2.1. Case I: Double or two step electron pushes from shell-1 to shell-2 then shell-3:** Let us consider, a photon of energy is $hf_1$ before enter in an atom and after enter into an atom the energy of the photon become $hf_2$, which have is suitable to push or kick an electron of one shell ($E_1$) to another shell ($E_2$) inside ana atom as shown in figure 4, whose distance travel is $L_{12}$.

Now from equation (2), if we consider n=1 and n=2 that is, after taking energy electron of shell-1 goes to shell-2. If we consider this for hydrogen and hydrogen like atom then the distance between shell-1 and shell-2 is given by

$$r_2 - r_1 = L_{21} \quad \text{..............(9)}$$

Now from equation (2) and (9) we can write,

$$L_{21} = 0.529\frac{(4-1)}{1} \quad \text{(for Hydrogen atom )}$$

$$L_{21} = 0.529 \times 3 = 1.587\,A^O \quad \text{..................(10)}$$

Putting the value of (10) in (8) we have,

$$T_{21} = \frac{L_{21}}{\left(\frac{2K.E_e^{21}}{m}\right)^{\frac{1}{2}}} = \frac{1.587\,A^o}{\left(\frac{2K.E_e^{21}}{m}\right)^{\frac{1}{2}}} \quad \text{..........(11)}$$

This is the time take to reach the electron from shell-1 to shell-2.

Again, when same electron i.e. shell-2 electron which come from shell-1 get simultaneously or frequently observed energy of a photon and goes from shell-2 to shell-3. Then similar as above. Let us consider a photon of energy $hf_3$ before enter in an atom and after enter into an atom of the photon become $hf_4$, which have is suitable to push or kick an electron of one shell ($E_2$) to another shell ($E_3$) as shown in figure 4, whose distance travel is $L_{32}$ with kinetic energy $K.E^{32}_e$.

Then again from equation (2), if we consider n=2 and n=3 that is after taking energy electron of shell-2 goes to shell-3, for hydrogen and hydrogen like atom then the distance between shell-2 and shell-3 is given by

$$r_3 - r_2 = L_{32} \quad \text{.......(12)}$$

Now from equation (2) and (12) we can write,

$$r_3 - r_2 = 0.529\frac{(3^2-2^2)}{z} = L_{32}$$

$$L_{32} = 0.529\frac{(9-4)}{1} \quad \text{(for Hydrogen atom )}$$

$$L_{32}=0.529\times 5=2.645A^{O}.......(13)$$

Putting the value of (13) in (8) we have

$$T_{32}=\frac{L_{32}}{\left(\frac{2K.E_e^{32}}{m}\right)^{\frac{1}{2}}}=\frac{2.645A^{o}}{\left(\frac{2K.E_e^{32}}{m}\right)^{\frac{1}{2}}}...........(14)$$

Now, total distance travel by an electron with kinetic energy $K.E^{21}_e$ and $K.E^{32}_e$ is given as

$$L_{Total}=L_{32}+L_{21}.........(15)$$

Putting the value from (13) and (10) in (15) we have,

$$L_{Total}=4.232A^{o}.........(16)$$

Also the total time taken to travel total distance $L_{total}$ is

$$T_{Total}=T_{32}+T_{21}.............(17)$$

Putting the value from (11) and (14) in (17) we have,

$$T_{total}=\frac{2.645A^{o}}{\left(\frac{2K.E_e^{32}}{m}\right)^{\frac{1}{2}}}+\frac{1.587A^{o}}{\left(\frac{2K.E_e^{21}}{m}\right)^{\frac{1}{2}}}.............(18)$$

This is the total time take to reach the electron from shell-1 to shell-2 and finally shell-3 in hydrogen atom.

$$T_{total}=\left(\frac{m}{2}\right)^{\frac{1}{2}}\left[\frac{2.645A^{o}}{(K.E_e^{32})^{\frac{1}{2}}}+\frac{1.587A^{o}}{(K.E_e^{21})^{\frac{1}{2}}}\right]$$

$$T_{total}=K\left[\frac{2.645A^{o}}{(K.E_e^{32})^{\frac{1}{2}}}+\frac{1.587A^{o}}{(K.E_e^{21})^{\frac{1}{2}}}\right]............(19)$$

Where $K=(m/2)^{1/2}$ which is dimension of mass.

Equation (19) is the equation for hydrogen atom, when an electron get an energy from incidence photon in two or double step (one on shell-1 and goes to shell-2 and after then the same electron get and energy on shell-2 and goes to shell-3) with in an hydrogen atom.

This equation (19) show that kinetic energy play an important role for an electron to travel from one shell to another.

Since, we have energy level equation from (1) Bohr' s theory of hydrogen atom, for n=1 and n=2 (shell-1 and shell-2 ) is

$$E_1=\frac{-1}{1^2}\frac{me^4 1^2}{8\varepsilon^2 h^2}=\frac{-1^2 R_H}{1^2}$$

(for n=1, z=1)

Where, Rydberg constant for hydrogen $R_H$ given by

$$R_H=\frac{me^4}{8\varepsilon_o^2 h^2}=1.097\times 10^7 m^{-1}$$

[9], [10].

$$E_1=-R_H.............(20)$$

$$E_2=\frac{-1}{2^2}\frac{me^4 1^2}{8\varepsilon^2 h^2}=\frac{-1^2 R_H}{2^2}$$

(for n=2, z=1)

$$E_2=\frac{-R_H}{4}................(21)$$

Now,

$$E_2-E_1=\left(\frac{1}{2}-\frac{1}{4}\right)R_H=\frac{R_H}{4}.................(22)$$

This is the amount of kinetic energy need to travel from shell-1 to shell-2, depending upon the incidence energy of photon and minimum bounded energy of electron in shell-1 (work function of shells).

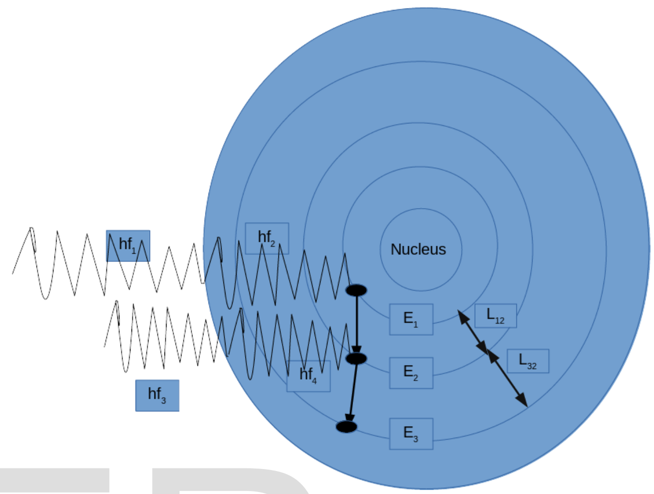


**Figure 4:** Electron get energy in two step and reach from $E_1$ to $E_2$ and then $E_3$, and travel $L_1$ and $L_2$ distance.

Let remaining energy of incidence photon after pushing the electron from shell-1 to shell-2 is equal to $E_2-E_1$, on the other hand we can also say that $E_2-E_1$ is the amount of kinetic energy of an electron carried from incidence photon to reach from shell-1 to shell-2.

Then $K.E_e$ of an electron from shell-1 to shell-2 is

$$K.E_e=E_2-E_1=\frac{R_H}{4}.......(23)$$

[from equation (22)]

Similarly we can obtain an relation of kinetic-energy of electron, when electron push from shell-2 to shell-3 by carried energy from another incidence photon $hf_4$ as shown in figure 4.

Then $K.E_e$ of an electron from shell-2 to shell-3 for same electron is

$$K.E'_e=E_3-E_2=\left(\frac{1}{4}-\frac{1}{9}\right)R_H=\frac{5R_H}{36}.........(24)$$

On putting the value of kinetic energy of electron from one shell to another shell, from (23) and (24) in (19) we have,

$$T_{total}=K[\frac{2.645A^o}{(\frac{5R_H}{36})^{\frac{1}{2}}}+\frac{1.587A^o}{(\frac{R_H}{4})^{\frac{1}{2}}}]$$

$$T_{total}=K[\frac{6\times 2.645A^o}{(5R_H)^{\frac{1}{2}}}+\frac{2\times 1.587A^o}{(R_H)^{\frac{1}{2}}}]$$

$$T_{total}=K[\frac{15.87A^o}{(5R_H)^{\frac{1}{2}}}+\frac{3.174A^o}{(R_H)^{\frac{1}{2}}}]..........(25)$$

Since we have, $R_H$=13.6eV=13

$$R_H=13.6eV=13.6\times 1.6\times 10^{-19}joule$$

$$R_H=21.76\times 10^{-19}joule=2.176\times 10^{-18}kgm^2s^{-2}.....(26)$$

Putting the value of RH from (26) in (25) we have.

$$T_{total}=K[\frac{15.87A^o}{(5\times 2.176\times 10^{-18}kgm^2s^{-2})^{\frac{1}{2}}}]+$$

$$K[\frac{3.174A^o}{(2.176\times 10^{-18}kgm^2s^{-2})^{\frac{1}{2}}}]$$

$$T_{total}=K[\frac{15.87A^o}{(10.88\times 10^{-18}kgm^2s^{-2})^{\frac{1}{2}}}]+$$

$$K[\frac{5\times 3.174A^o}{(5\times 2.176\times 10^{-18}kgm^2s^{-2})^{\frac{1}{2}}}]$$

$$T_{total}=K[\frac{15.87A^o}{(10.88\times 10^{-18}kgm^2s^{-2})^{\frac{1}{2}}}]+$$

$$[\frac{15.87A^o}{(10.88\times 10^{-18}kgm^2s^{-2})^{\frac{1}{2}}}]$$

$$T_{total}=K[\frac{2\times 15.87A^o}{(10.88\times 10^{-18}kgm^2s^{-2})^{\frac{1}{2}}}]$$

$$T_{total}=K[\frac{31.74A^o}{(10.88\times 10^{-18}kgm^2s^{-2})^{\frac{1}{2}}}]$$

$$T_{total}=K[\frac{31.74A^o}{(10.88\times 10^{-18}kgm^2s^{-2})^{\frac{1}{2}}}]...........(27)$$

$$Since, K=(\frac{m}{2})^{\frac{1}{2}}=(\frac{9.10938356\times 10^{-31}kg}{2})^{\frac{1}{2}}$$

$$K=(4.55469178\times 10^{-31}kg)^{\frac{1}{2}}$$

$$Therfore, K=(45.5469178\times 10^{-30}kg)^{\frac{1}{2}}$$

$$K=6.748845664\times 10^{-15}kg^{\frac{1}{2}}...............(28)$$

On putting the value of K from (28) in (27) we have

$$T_{total}=6.748845664\times 10^{-15}\times\frac{31.74A^o}{(10.88\times 10^{-18}m^2s^{-2})^{\frac{1}{2}}}$$

$$T_{total}=6.748845664\times 10^{-15}\times\frac{31.74\times 10^{-10}}{3.2984845\times 10^{-9}s^{-1}}$$

$$T_{total}=64.94144853\times 10^{-15-10+9}s$$

$$T_{total}=64.94144853\times 10^{-16}s.................(29)$$

This is the total time $T_{total}$ required to move the total distance $L_{total}$ by an electron in two step, one from n=1 to n=2 then from n=2 to n=3 as shown in figure 4.

**3.2.2. Case II: Single step electron pushes from shell-1 to shell-3:** Let us consider a photon of energy is $hf_5$ before enter in an atom and after enter into an atom of the photon become $hf_6$, which have is suitable to push or kick an electron of one shell ($E_1$) to another shell ($E_3$) as shown in figure 5, whose distance travel is $L_{31}$.

Now from equation (2), if we consider n=1 and n=3 means that after taking energy electron of shell-1 goes to shell-3, for hydrogen atom and hydrogen like atom then the distance between shell-1 and shell-3 is given by

$$r_3-r_1=L_{31}..................(30)$$

Now from equation (2) and (30) we can write,

$$r_3-r_1=0.529\frac{(3^2-1^2)}{z}=L_{31}$$

$$L_{31}=0.529\frac{(9-1)}{1}\quad\text{(for Hydrogen atom )}$$

$$L_{31}=0.529\times 8=4.232A^O..............(31)$$

Here $L_{31}$ is the distance travel by electron after getting energy from $hf_6$ photon with kinetic energy $K.E^{31}_e$. putting the value of (31) in (8) we have

$$T_{31}=\frac{L_{31}}{(\frac{2K.E_e^{31}}{m})^{\frac{1}{2}}}=\frac{4.232A^o}{(\frac{2K.E_e^{31}}{m})^{\frac{1}{2}}}.............(32)$$

This is the time take to reach the electron from shell-1 to shell-3 in a single step as shown in figure 5.

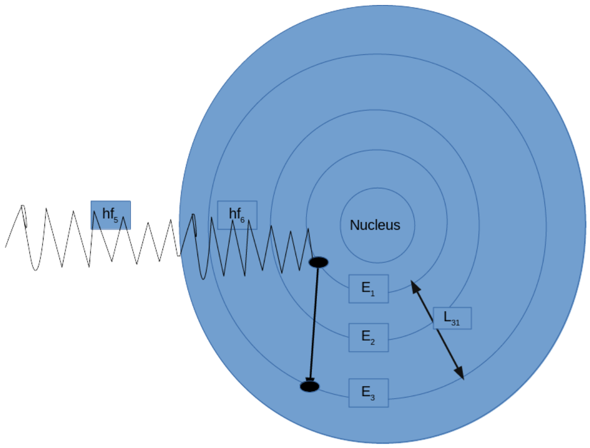


**Figure 5:** Electron get energy in single step and reach from $E_1$ to $E_3$, and travel $L_{31}$ distance.

Now similarly as equation (23) we have kinetic energy

$$K.E_e^{31}=E_3-E_1=(\frac{1}{1^2}-\frac{1}{3^2})R_H=\frac{(9-1)}{9}R_H$$

$$K.E_e^{31}=\frac{8R_H}{9}..................(33)$$

Now putting the value of kinetic energy of electron which goes from shell-1 to shell-3 after taking the energy from photon, from (33) in (32) we get,

$$T_{31}=\frac{4.232A^o}{(\frac{2\times 8R_H}{9\times m})^{\frac{1}{2}}}=\frac{4.232A^o}{(\frac{16R_H}{9m})^{\frac{1}{2}}}...........(34)$$

Since we have $R_H$=13.6eV and putting these on (34)

$$T_{31}=\frac{4.232\times 10^{-10}}{(\frac{348.16\times 10^{-19}}{81.98445204\times 10^{-31}})^{\frac{1}{2}}}s$$

$$T_{31}=\frac{4.232\times 10^{-10}}{(4.246658864\times 10^{-19+31})^{\frac{1}{2}}}s$$

$$T_{31}=\frac{4.232\times 10^{-10}}{2.060742309\times 10^{6}}s$$

$$T_{31}=2.053628919\times 10^{-16}s...............(35)$$

This is the total time taken when electron get energy on shell-1 and push to shell-3 in single step. Since the length or distance travel by electron in two step and single step is same i.e. length from single step $L_{31}=L_{total}=4.232A^o$ and in two or double step is $L_{total}=L_{12}+L_{32}=4.232A^o$. Also, on other hand the total resultant amount of energy supply to an electron in single and two step is same.

Then the time travel by electron should be equal i.e. $T_{31}=T_{total}$ but from equation (35) and (29) the time take are totally difference. This difference is due to presence of non homogeneous transparent medium inside an atom.

## 4 Result and Discussion

As we calculated the total time take for an electron in single step (shell-1 to shell-3) and two step (shell-1 to shell-2 and then after shell-2 to shell-3) for same distance

$$L_{31}=L_{total}=4.232A^o,$$

is in single step is $T_{31}=2.053628919\times 10^{-16}s$ and in two step (shell-1 to shell-2 and then in shell-3) is $T_{total}=64.94144853\times 10^{-16}s$.

Here we clearly seen that the time in single step is less than two step. This is due to the presence of D-medium, which is non-homogeneous in nature. If the D-medium is homogeneous then the time for the electron, for same distance is same. The difference of the time for single step and two step is

$$T_{diff}=64.94144853\times 10^{-16}-2.053628919\times 10^{-16}s$$

$$T_{diff}=(64.94144853-2.053628919)\times 10^{-16}s$$

$$T_{diff}=62.88781961\times 10^{-16}s.$$

This is the delay time for two step i.e. electron push from shell-1 to shell-2 after taken energy from $hf_2$ photon as shown in figure 3 and then again taken energy from photon $hf_4$ simultaneously on shell-2 and push to shell-3 as shown in figure 3.

This time delay is due the presence of non-homogeneous medium in an atom. Similarly we can also say that the energy of the photon is changed when it enter in a D-medium of an atom.

## 5. CONCLUSION

Hence, difference in the time of single and two or double step is found to be $62.88781961\times 10^{-16}s$ in hydrogen atom, which indicate the presence of non-homogeneous medium in an atom called d-medium.

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