Title : THE HYDROGEN ORBITALS & PHOTON WAVE PACKET

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ABSTRACT

Based on the Elastic Continuum Theory[1] a new model of photon wave packet has been proposed in this paper. In the process of computation of strain energy contained in the wave packet, the origin of Planck's constant 'h' has also been brought out. Due to a conceptual mistake[3] in the potential energy term of the Schrodinger's wave equation, Quantum Mechanics is considered unsuitable for describing the detailed dynamic behavior of individual micro particles. From the conservation of field energy and angular momentum, a detailed model of Hydrogen Orbitals has been developed for describing the instant to instant motion of the electron in elliptical orbits. The model also describes the detailed orbital transitions during photon emission. The angular momentum quantisation has been explained on the basis of photon emission recoil phenomenon.

Keywords. Photon; Planck's constant; Induced field; Orbital transitions; Momentum quantisation.

Photon : All these fifty years of conscious brooding have brought me no nearer to the answer to the question 'What are light quanta ? Nowadays every Tom Dick and Harry thinks he knows it, but he is mistaken.

Albert Einstein

1. INTRODUCTION

1.1 To develop a clear mental picture of electron orbits in Hydrogen atom, the fundamental concepts of electron must be very clear and well understood beforehand. In order to visualize the instant to instant motion of an electron orbiting a proton, we must understand as to how exactly the two charges interact to release potential energy, where the K.E. is stored and how the photon is created. Hence based on the Elastic Continuum Theory[1] our basic approach in this paper will be to first make use of some of the most fundamental concepts about electron, nature of charge, field energy and field interaction, already introduced in 'The Electron Structure and Coulomb Interaction'[2]. From the study of electron motion and motion induced fields, the concept of emitted field wave packets or photons is developed. Based on the Elastic Continuum Theory, a new model of Photon wave packet is then developed. With these revised fundamental concepts, we shall analyze the energy balance of an isolated proton-electron system and develop the electron trajectory by using the energy and angular momentum conservation principle.

1.2 We shall derive a relation from purely classical considerations that by emitting a photon at angular frequency ω, the angular momentum of orbiting electron is changed by $\hbar$ due to mechanical recoil action. This fact will form the basis for quantisation of angular momentum and hence total energy in Hydrogen orbitals. Further we shall retain the use of quantum numbers **n, ℓ, m** as usual. However on the considerations of restricting the change in angular momentum to $\hbar$, we shall associate quantum number ℓ with angular momentum of $(\ell+½).\hbar$ instead of $\sqrt{(\ell(\ell+1))}\,.\,\hbar$. This will lead to all elliptical electron orbits. During emission of photon, the elliptical orbit transitions at constant angular frequency ω will also be computed and plotted.

1.3 As per the ECT, our familiar space-time continuum, with characteristic properties of permittivity ε_0 and permeability μ_0, behaves as a perfect isotropic Elastic Continuum, with elastic constant $1/\varepsilon_0$ and inertial constant μ_0 . The equilibrium equations of elasticity written in terms of displacement vector **U** in this Continuum turn out to be identical to the vector wave equation in electromagnetic theory. These equations in vector and tensor form are given below,

$$\partial^2\mathbf{U}/\partial x^2 + \partial^2\mathbf{U}/\partial y^2 + \partial^2\mathbf{U}/\partial z^2 = \nabla^2\mathbf{U} = (1/c^2)\,\partial^2\mathbf{U}/\partial t^2 \qquad \text{.....(1)}$$

$$g^{11}u^i_{,11} + g^{22}u^i_{,22} + g^{33}u^i_{,33} = g^{jj}u^i_{,jj} = (1/c^2)\,\partial^2u^i/\partial t^2 \qquad \text{..... (2)}$$

where the displacement vector components u^i are functions of space & time coordinates referred to a coordinate system (y^1, y^2, y^3) with metric tensor components g^{ij}. The following correlation exists between displacement vector field **U** or the corresponding temporal and spatial strain components and the electromagnetic field vectors **E** and **B** ,

$$\mathbf{E} = -\,(1/\varepsilon_0).(1/c).\partial\mathbf{U}/\partial t \qquad \text{..... (3)}$$

$$\mathbf{B} = (1/c).(1/\varepsilon_0).\,(\nabla\times\mathbf{U}) \qquad \text{..... (4)}$$

That means, the electromagnetic field in the so called 'vacuum' comes out to be a dynamic stress-strain field in the corresponding Elastic Continuum. Further, as per the

ECT, one of the spherically symmetric solutions of equilibrium equations (2) represent the electron and positron strain bubbles as consisting of a small 'core' of standing strain wave oscillations, surrounded by propagating phase wave type 'strain wave field' or the 'electrostatic field'. The Coulomb interaction between two charge particles is effected through superposition of their strain wave fields. Positive interaction energy between two similar charges implies transfer of a portion of their kinetic energies to their combined field energy. Negative interaction energy between two dissimilar charges implies transfer of a portion of their combined field energy to their kinetic energies. Of course the total energy and momentum of the system is conserved in both cases. Without going into the internal details of the electron structure, let us examine the effect of motion on the overall strain wave field or the displacement vector field **U** of the electron.

1.4 Motion Induced Fields and Kinetic Energy. Let us consider uniform motion of an electron along + x axis, at velocity v . Due to finite velocity c of the phase waves ψ, the complete wave field of the electron will get deformed. This field deformation may be considered either through the concept of retarded time and retarded position vector leading to motion induced change in amplitude and direction of phase waves at any particular point. Or we may examine the transformation of field strain components through the motion induced Lorentz transformation of coordinates. Since the kinetic energy of the moving particle will be stored in its deformed field, most of the field strain components are expected to be increased. Let us say that the original field displacement vector **U**, is deformed to **U′** through Lorentz transformation of coordinates. Then $\mathbf{U'} - \mathbf{U} = \mathbf{A}$ may be defined as motion induced displacement field, which will vanish when the particle velocity becomes zero. The motion induced electric and magnetic fields of the moving particle can now be derived from the time derivative and curl of this induced displacement field by using equations (3) and (4) as,

$$\mathbf{E} = -(1/\varepsilon_0 c).\partial(\mathbf{U'}-\mathbf{U})/\partial t = -(1/\varepsilon_0 c).\partial\mathbf{A}/\partial t = (v/\varepsilon_0 c).\partial(\mathbf{U'}-\mathbf{U})/\partial x \quad \ldots\ldots\ldots (5)$$

and $$\mathbf{B} = (\mu_0 c).[\nabla\times\mathbf{A}] . \quad \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

Under certain conditions of motion, some part of the induced fields could be dissociated from the moving particle, whereas the bound field given by **U** can never be dissociated unless the particle itself gets annihilated. Normally, the induced fields are an integral part of the moving particle system and it is a matter of interpretation whether the particle motion controls the induced fields or the induced fields govern the particle motion. We shall use these concepts for developing electron orbits in Hydrogen. Due to a conceptual mistake[3] in the potential energy term of the Schrodinger's wave equation, Quantum Mechanics is considered unsuitable for describing the detailed dynamic behavior of individual micro particles.

2. THE PHOTON WAVE PACKET

2.1 Induced Field Emission. If under certain conditions, part of the motion induced fields (**E** and **B** fields) accompanying the electron tend to get separated from the electron system, the separated part of the field must independently satisfy Maxwell's field equations, vector wave equation, the boundary conditions and also satisfy the overall energy and momentum conservation. For the separated or released field designated by

$\mathbf{E_p}$ and $\mathbf{B_p}$ the field conditions will require that $|\mathbf{E_p}| \propto |\mathbf{B_p}|$ and that their strength & spatial spread will be governed by their time rates of change. This implies that provided all other conditions are met, the angular frequency $\omega = kc$ of induced / released field variation will govern the intensity as well as spatial spread of $\mathbf{E_p}$ & $\mathbf{B_p}$. The released field wave packet is the familiar photon wave packet with finite energy content which is proportional to ω.

2.2 The Photon. As an electromagnetic wave packet, the electric and magnetic field vectors within a photon must satisfy Maxwell's vector wave equation, must account for a finite energy content and must vanish at the boundaries of the packet or at infinity. In terms of displacement vector field representation for the photon, the vector field $\mathbf{U}_p$ must satisfy the above conditions. Therefore, as a tentative model based on the Elastic Continuum Theory[1], the displacement vector components of a photon wave packet propagating along +X axis may be given as,

$$u^y = a.e.k.[\exp(-k.(1+\imath).|y|) \,.\, \exp(-k.(1-\imath).|z|) \,.\, \exp(-k.(1+\imath).|x-ct|)] \quad \ldots\ldots. (7)$$

$$u^x = -a.e.k.[\exp(-k.(1+\imath).|y|) \,.\, \exp(-k.(1-\imath).|z|) \,.\, \exp(-k.(1+\imath).|x-ct|)] \quad \ldots\ldots. (8)$$

$$u^z = 0 \quad \ldots\ldots\ldots\ldots (9)$$

from which we can compute the elements of the strain tensor. Here the real and imaginary parts of the above complex solution are independently valid solutions of the vector wave equation or the equilibrium equations of elasticity. With the notation $u^x{}_y = \partial u^x/\partial y$ and $u^x{}_t = (1/c).\partial u^x/\partial t$ etc. the energy density in the photon wave packet, is given by :

$$W_{ph} = (1/2\varepsilon_0).[|u^x{}_x|^2 + |u^x{}_y|^2 + |u^x{}_z|^2 + |u^x{}_t|^2 + |u^y{}_x|^2 + |u^y{}_y|^2 + |u^y{}_z|^2 + |u^y{}_t|^2]$$

$$= (1/\varepsilon_0).8.a^2.e^2.k^4.\exp(-2k.(|x| + |y| + |z|) \quad \ldots\ldots\ldots\ldots\ldots (10)$$

2.3 Origin of Planck's constant h. Finally the total energy content in the wave packet is computed from the volume integral of W_{ph} taken over the entire region of spatial extension of photon. With $\omega = k.c$, this total energy works out to :

$$E_{ph} = 8\times a^2.e^2.k\,/\varepsilon_0 = (8/\varepsilon_0 c).a^2.e^2.\omega = \mathbf{(h/2\pi).\omega} = \boldsymbol{\hbar}.\boldsymbol{\omega} \quad \ldots\ldots\ldots\ldots\ldots (11)$$

Where the factor involving constant terms ε_0, c, a and e is equated with an important universal constant $\mathbf{h/2\pi}$. Non dimensional constant 'a' can now be evaluated from this relation and works out to be 1.167 approximately. Origin of Plank's constant **h** is thus linked with the computation of total strain energy in the photon wave packet. Although such a wave packet is emitted from the spatially extended induced field of the electron under certain characteristic conditions, this emission can not be instantaneous due to finite recoil forces exerted by finite strength fields. It can thus be seen from the spatial extension of equations (7) and (8) that the photon wave packet is essentially just a small sinusoidal pulse of displacement vector field $\mathbf{U}_p$ with exponentially decaying amplitude. In other words, the photon may be viewed as a sinusoidal pulse of electromagnetic field $\mathbf{E_p}$ & $\mathbf{B_p}$ with exponentially decaying amplitude and 'significant' spatial extension of just about one wave length in all directions.

2.4 The Photon Interaction. Here it may be appropriate to point out that just like computation of Coulomb Interaction[2], mutual interaction of two or more photons separated by distance 'd' along any Cartesian coordinate axis, can be easily computed. This is done by superposition of the strain tensor components of two interacting photons separated by distance d along any coordinate axis and referred to a common Cartesian coordinate system. The strain energy of the superposed or combined field can then be easily computed. The computation results show that the interaction energy for two photons of same frequency depends on functions of the type $2\hbar.\omega.\exp(-k.d).\cos(k.d)$. That is, any two photons of same frequency ω, will tend to get mutually coupled at certain optimum separation of the order of 'odd number of half wave lengths'. Their interaction energy will change from negative to positive if their separation along any coordinate axis is changed by about one half wave length, resulting in their mutual repulsion. This may account for the conventional interference and dispersion effects encountered in a stream of photons of the same frequency.

3. HYDROGEN ORBITALS

3.1 Isolated Proton - Electron System. Let us now consider an isolated proton - electron system with the proton located at the center of chosen coordinate system. Neglecting the motion of proton as too small, we consider the constrained motion of the electron under conservation of system energy and angular momentum. Initially when the electron is far removed from the proton, let its kinetic energy (T) and electrostatic potential energy (-V) be negligible or zero. We adopt a sign convention that all symbols like T, V, E etc. representing energy will always be positive. Conventionally the total system energy -E, with electron far removed, is considered zero (-E = -V+T = 0). But in reality we know that the total energy of the system does include the mass energies of the two particles as discussed earlier. When the electron is brought to a finite radial distance r from the proton, without any external work, the conventional -ve potential energy (-V) of the system (not of electron alone) gradually changes from zero to $-e^2/4\pi\varepsilon_0 r$ or say $-\eta/r$ where $\eta=e^2/4\pi\varepsilon_0$ is a constant. Simultaneously the kinetic energy T of the electron increases from zero to η/r. That is, the interaction energy released by the system, keeps getting converted to kinetic energy of the electron on instant to instant basis. Henceforth we shall no longer use the term negative potential energy (-V) but only refer to field interaction energy released (V) by the system. If a small part (E_n) of this energy is now radiated out as a photon, then system total energy will become $-E_n$ and remaining K.E. of the electron given by $T = V - E_n$.

3.2 Time Invariant Orbital Parameters. Corresponding to conventional total energy of $-E_n$, let d_n be the radial distance at which K.E. of the electron (mass m_e) becomes zero (i.e. $V= E_n$), as shown in figure 1. A sphere of radius d_n may be referred as the bounding sphere for the electron and all possible electron orbits for angular momenta $k.\hbar$, must be located well within this sphere characterized by principle quantum number **n**. Let us therefore examine the shape and size of all possible orbits for given orbital quantum numbers **n** and ℓ . There is one unique circular orbit of radius $a_c= d_n/2$, angular momentum $L_c = \mathbf{n}.\hbar$, with following other main parameters,

$T_c = V - E_n = \eta.(1/a_c - 1/d_n) = \eta/d_n = E_n$ ..... (12)

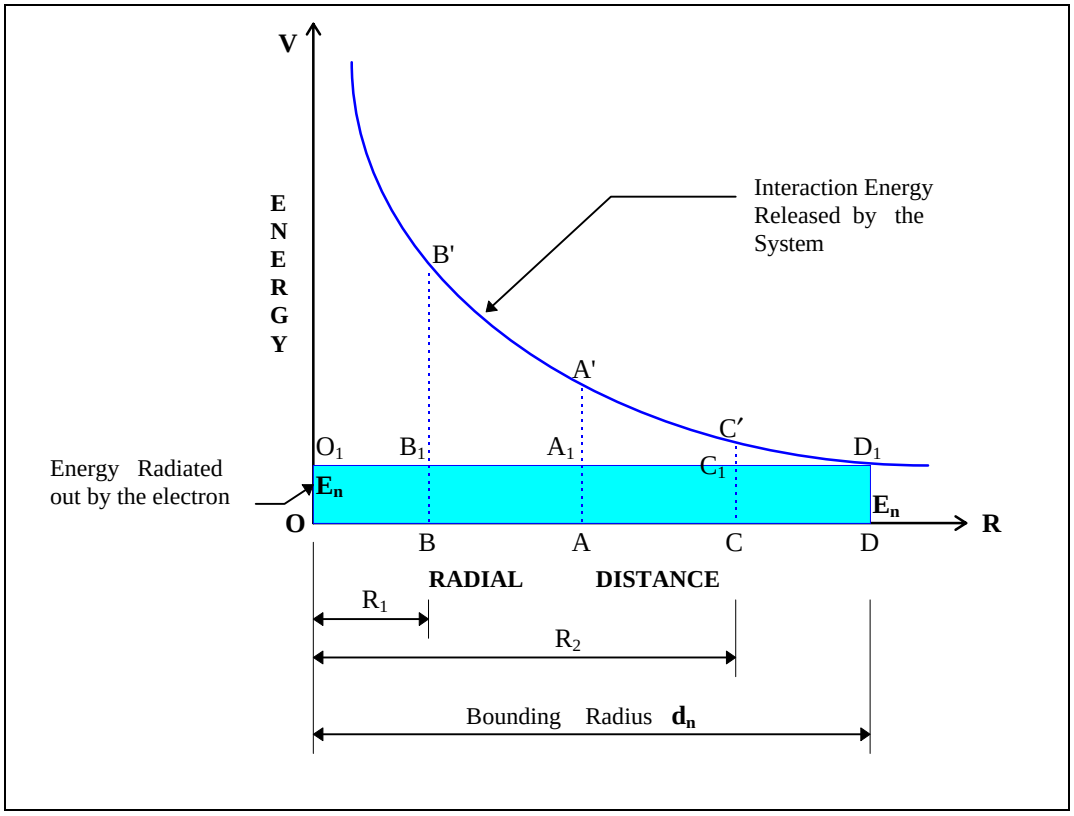
$L_c^2 = (m_e.v_c.a_c)^2 = 2m_e.a_c^2.T_c = 2m_e.a_c^2.E_n$ ..... (13)

$v_c = 2T_c/m_e v_c = (\eta/\hbar\mathbf{n})$ & also $v_c = L_c / m_e.a_c = (\mathbf{n}.\hbar/a_c m_e)$ ..... (14)

which give $a_c = \mathbf{n}^2.(\hbar)^2/m_e\eta$ and $\mathbf{E_n} = \eta/2a_c = \mathbf{(m_e/2n^2).(\eta/\hbar)^2}$ ……..... (15)

Figure- 1.

Interaction energy released (V) by the Electron - Proton system vs. their relative radial distance R. In the elliptical orbital motion of the electron, the relative radial distance oscillates between OC and OB with corresponding K.E. varying between C_1C' and B_1B'.



3.3 However with the same total energy, there could be many elliptical orbits with their angular momentum $L_e = k.\hbar < L_c$ and differing from each other in steps of $\hbar$. Since $L_e=0$ will correspond to head on collision and annihilation of electron, it can't correspond to any valid orbit. Therefore as mentioned earlier, we shall take $k=(\ell+½)$ instead of $(\ell(\ell+1))^{½}$. Let the two vertices B and C (fig. 2) of the ellipse be identified by subscripts 1 and 2 e.g. radius R_1, R_2 etc. Then, at the vertices

$L_e = k.\hbar = m_e.v_i.R_i$ (for i = 1, 2 and no summation on i)

$T_i = ½ .m_e .v_i^2 = \eta.(1/R_i - 1/d_n) = E_n.(d_n/R_i - 1)$ which gives

$R_i = E_n.d_n/(T_i+E_n) = 2\,a_c.E_n/(T_i+E_n)$ ..... (16)

and $L_e^2 = 2m_e.T_i.R_i^2 = 8m_e.a_c^2.E_n^2.T_i/(T_i+E_n)^2 = 4L_c^2.E_n.T_i/(T_i+E_n)^2$

which after substituting $L_e/L_c = k/\mathbf{n}$ simplifies to a quadratic in T_i as

$$T_i^2 - 2[2(\mathbf{n}/k)^2-1].E_n.T_i + E_n^2 = 0 \qquad \text{.....} \qquad (17)$$

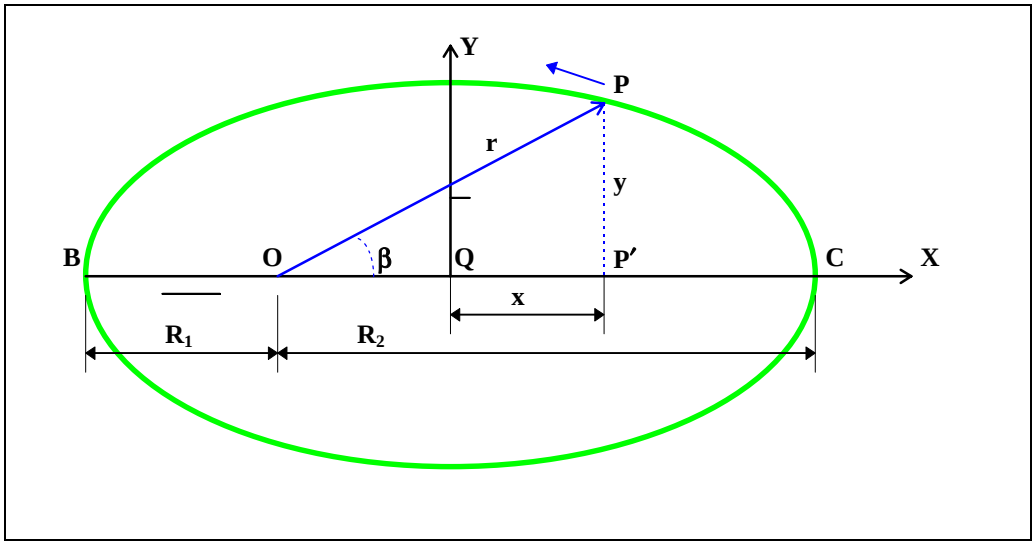
that yields two values of T_i, that is T_1 and T_2 as given below

$$T_1 = E_n.[(2(\mathbf{n}/k)^2-1) + 2(\mathbf{n}/k).((\mathbf{n}/k)^2-1)^{½}] \qquad \text{.....} \qquad (18)$$

$$T_2 = E_n.[(2(\mathbf{n}/k)^2-1) - 2(\mathbf{n}/k).((\mathbf{n}/k)^2-1)^{½}] \qquad \text{.....} \qquad (19)$$

and from equation (16), R_1 & R_2 can now be computed. Further from these values of R_1, R_2, T_1, T_2 we can easily compute maximum and minimum values of velocity (v_1, v_2) and angular frequency $\omega_1 = v_1/R_1$, $\omega_2 = v_2/R_2$. It can also be easily shown that ellipse major diameter = $R_1+R_2 = d_n$ and that eccentricity of the ellipse is $e_k = (R_2 - R_1)/d_n$.

Figure - 2. In the orbital motion of the electron as its relative radial distance from the Proton O varies from OC to OB the angle β increases from 0 to π radians. Major dia. $d_n = R_1 + R_2$ of the ellipse is governed by quantum number **n** and the eccentricity by the quantum number ℓ .



3.4 Dynamic Orbital Parameters. After determining the major diameter $2a_c$ the eccentricity e_k & R_2, v_2, ω_2 etc. as above for the given quantum numbers **n**, ℓ , we are now in a position to compute the instant to instant motion of the electron on this orbit. For this purpose let us superimpose a Cartesian coordinate system X-Y with origin Q at the center of major dia BC as shown in fig.2. Of course the radial position vector **r** will still be measured from O, the principal focus of the ellipse (proton location). At time t =0 let us start from the outer vertex C where $r = R_2$, $x = a_c$, $y = 0$, $\beta = 0$, $v_\beta = v_2$, $v_r = 0$ and $\omega = \omega_2$. For numerical computations with the aid of a digital computer, we may divide the major diameter BC into N (say 1000) equal parts such that $\delta x = d_n/N$. To compute the next position (subscript n) parameters from the old position (subscript o) following relations could be used.

$$x_n = x_o - \delta x \qquad r_n = a_c + e_k.x_n$$

$$y_n = (1 - e_k^2)^{½}.(a_c^2 - x_n^2)^{½} \qquad \beta_n = \mathrm{Sin}^{-1}(y_n/r_n)$$

$$v_\beta = (k.\hbar)/m_e r_n \qquad \omega_n = v_\beta/r_n = (k.\hbar)/m_e r_n^2$$

$$\delta\beta = \beta_n - \beta_o \qquad \delta t = \delta\beta/\omega_n$$

$$t_n = t_o + \delta t \qquad v_r = e_k.\ \delta x/\delta t$$

$$v = (v_r^2 + v_\beta^2)^{½} \qquad \text{..... (20)}$$

3.5 Repeating these computational steps, we can obtain instant to instant variation of all dynamic parameters like v, β, ω, r, etc. and plot them against time. For convenience in computations, it is preferable to use non-dimensional form of these parameters by dividing with corresponding parameters of first circular Bohr orbit. A few typical curves showing v and ω verses time for certain elliptical orbits are placed at appendix 'A'. The results show the variation of these parameters to be far from sinusoidal and hence indicate the necessity of reviewing our concepts about orbital stationary states in Quantum Mechanics. By assuming separable temporal part $\exp(-i\, E_n.t/\hbar)$ in the wave function, basically circular electron orbits get implied in the concept of stationary states, whereas in reality the quantum numbers **n** and ℓ yield all elliptical orbits. Salient orbital parameters for Hydrogen are given below at Table - 1. One very important parameter to be noted from this table is the time period of the orbital motion, which is independent of ℓ. That is for a given **n** the time period of all elliptical orbits is the same as that of a corresponding circular orbit. This may explain why equivalent circular orbits could be implied in the concept of stationary states.

Table - 1. Salient Orbital Parameters

Orbit No.	Total Energy	Eccen-tricity	Time Period	Vertex - Radii Min.	Max.	K.E. at Vertices Max.	Min.	Angular Frequency Max.	Min.
	ev		$\times 10^{-15}$ s	$\times 10^{-10}$ m		ev		$\times 10^{15}$ rad/s	
1s	- 13.60	0.866	0.1520	0.071	0.988	189.44	0.977	1151.15	5.93
2s	- 3.40	0.968	1.2164	0.067	4.167	210.77	0.055	1280.73	0.33
2p	- 3.40	0.661	1.2164	0.717	3.518	16.69	0.693	33.80	1.40
3s	- 1.51	0.986	4.1052	0.067	9.461	214.59	0.011	1303.95	0.06
3p	- 1.51	0.866	4.1052	0.638	8.889	21.05	0.109	42.64	0.22
3d	- 1.51	0.553	4.1052	2.130	7.397	5.25	0.435	6.38	0.53
4s	- 0.85	0.992	9.7308	0.066	16.871	215.92	0.003	1312.03	0.02
4p	- 0.85	0.927	9.7308	0.618	16.319	22.45	0.032	45.47	0.07
4d	- 0.85	0.781	9.7308	1.858	15.080	6.90	0.105	8.39	0.13
4f	- 0.85	0.484	9.7308	4.369	12.569	2.45	0.296	2.12	0.26

3.6 Photon Emission - General Conditions. As per the discussions of paras 1.4 to 2.2 above, we may visualize the emission of a photon wave packet from the vicinity of orbiting electron, under following general conditions.

(a) The angular frequency $\omega = kc$, will govern the spatial extension as well as the energy content of the photon wave packet.

(b) The angular frequency ω should remain constant throughout the spatial and temporal extension of the wave packet.

(c) A photon of angular frequency ω_p may be emitted from the induced field of orbiting electron when the instantaneous angular frequency ω of the orbital motion matches ω_p and remains constant throughout the emission process.

(d) The photon may be emitted from a finite region around the middle of the relative position vector **r** of the orbiting electron.

(e) The photon will be emitted in the orbital plane of the electron and along a line perpendicular to the relative position vector **r**.

(f) The strength and time rate of change of induced **E** and **B** fields must be above certain minimum values, to enable the emission of a photon wave packet of certain minimum energy content.

(g) The strength of induced **E** and **B** fields in the region around **r**/2, will be governed by $\mathbf{v_r}$ and $\mathbf{v_\beta}$ components of the electron velocity respectively. The time rate of change of these fields may be governed by instantaneous angular frequency ω of the orbiting electron.

(h) The direction of emission of the photon may get reversed if the relative phase of induced **E** field is opposite at the time of emission. That is, the photon will be emitted in the direction of v_β if the electron is approaching the nucleus (v_r -ve) and in a direction opposite to v_β if the electron is receding (v_r +ve) from the nucleus at the time of emission.

(i) During the photon emission process, the conservation of overall system energy and momentum must be ensured at every instant.

3.7 Photon Emission - Recoil. Let us consider a body A with kinetic energy E and another body B with negligible K.E., both located on and moving along X-axis. Let the body A act on body B for a small distance δs to transfer a small fraction δE of its K.E. to body B. We may assume that the action force **F** exerted by body A and the reaction force **-F** exerted by B, remains constant throughout this energy transfer interaction between A and B. Then the energy transferred from A to B will be given by $\delta E = F.\delta s$. If this interaction process lasts for a very small interval of time δt, then a momentum impulse of $I_p = F.\delta t$ will be imparted to both A and B in opposite directions along X-axis. This momentum impulse will imply a small change in momentum δp such that,

$$\delta p = I_p = F.\delta t = (\delta E/\delta s).\delta t = \delta E / (\delta s/\delta t) \quad \text{.....} \quad (21)$$

Now, let us imagine that the body A mentioned above is the orbiting electron and body B is the photon being emitted. The recoil impulse experienced by the electron while transferring a small fraction δE of its K.E. to the photon is therefore given by equation (21). Since, as mentioned above, the photon is emitted in a direction perpendicular to the

position vector **r**, the distance traveled by the electron δs may be given by $r.\delta\beta$ so that $\delta s/\delta t = r.\omega$. The corresponding change in angular momentum of the orbiting electron is therefore given by $|\delta L| = r\times\delta p = r.\delta E/r\omega = \delta E / \omega$. Hence the total change in angular momentum ΔL, when a photon of total energy content $\Delta E = \omega.\hbar$ is emitted, will be

$$|\Delta L| = \Delta E / \omega = \omega.\hbar/ \omega = \hbar \qquad \text{.....} \qquad (22)$$

3.8 This is an important result which forms the basis of angular momentum quantisation and hence total energy quantisation in sub-atomic phenomena. The photon emission recoil phenomenon is unique in two respects. Firstly the actual recoil interaction between the electron and the photon is effected through the action of released photon fields $\mathbf{E}_p$ and $\mathbf{B}_p$ on the bound -ve electrostatic field of the moving electron. At the same time the released photon fields $\mathbf{E}_p$ and $\mathbf{B}_p$ will act on the bound +ve electrostatic field of the nucleus to produce an opposite linear momentum change. The presence of the nucleus will thus ensure that a total momentum of $\Delta p = \Delta E/r\omega$ is not carried by the photon but only a small fraction $\Delta E/c$ is carried off. Secondly, the emission phenomenon is unique in the sense that depending on the relative phases of $\mathbf{E}_p$ and $\mathbf{B}_p$ fields, the photon may be emitted by the moving electron either in forward direction or in rearward direction. The photon will be emitted in forward direction when at the time of emission, the electron is approaching the nucleus on its elliptical orbit and the total angular momentum of the electron will reduce by $\hbar$. The photon will be emitted in rearward direction when the electron is receding from the nucleus and the total angular momentum of the electron will increase by $\hbar$.

4. Orbital Transition Parameters

4.1 Let us consider the electron transition from orbit A specified by ($\mathbf{n}_1$, ℓ_1) to orbit B specified by ($\mathbf{n}_2$, ℓ_2), such that $\mathbf{n}_1 > \mathbf{n}_2$ and $\ell_2 = \ell_1 - 1$, then $E_1 = (m_e/2n_1^2).(\eta/\hbar)^2$, $d_1 = \eta/E_1$, $E_2 = (m_e/2n_2^2).(\eta/\hbar)^2$, $d_2 = \eta/E_2$ and the angular frequency of the photon to be emitted is $\omega_p = (E_2 - E_1)/\hbar$. Angular momentum for orbit A is $L_a = (\ell_1 + ½).\hbar$ and for B is $L_b = (\ell_2 + ½).\hbar$. The emission will take place when the electron is approaching the nucleus. Complete orbital parameters for 'A' and 'B' can be worked out as per procedure outlined at paras 3.3 and 3.4 above. The radius R_a in orbit 'A', at which the photon emission process will commence, can be computed from the condition

$$\omega = \omega_p = L_a/m_eR_a^2$$

$$\text{or} \quad R_a = (L_a /m_e\omega_p)^{½} \quad \text{and similarly} \quad R_b = (L_b /m_e\omega_p)^{½} \qquad \text{.....(23)}$$

While computing the dynamic parameters of orbit 'A', we may extract the values of salient parameters at the instant when $r = R_a$ and designate them with subscript 'o' as β_o, T_o and $t_o=0$, $r_o = R_a$, $L_o = L_a$ and $E_o = E_1$. Similarly from orbit 'B' we may extract β_b when $r = R_b$. To compute the transition trajectory from 'A' to 'B' we may divide this path into N (say 1000 or more) equal steps. With $\delta L = \hbar/N$ and $\delta E = (E_2 - E_1)/N$, following relations may be used for step by step computation of transition trajectory.

$$L_n = L_o - \delta L \qquad\qquad E_n = E_o + \delta E$$

$r_n = (L_n / m_e\omega_p)$ $\quad T_n = \eta/r_n - E_n$

$v_\beta = r_n.\omega_p$ $\quad v = (2T_n/m_e)^{½}$

$v_r = (v^2 - v_\beta^2)^{½}$ $\quad \delta r = r_n - r_o$

$\delta t = \delta r/v_r$ $\quad t_n = t_o + \delta t$

$\delta\beta = \omega_p.\delta t$ $\quad \beta_n = \beta_o + \delta\beta$ ..... (24)

After repeating these steps N times, let the final values of t_n and β_n be t_f and β_f respectively. For plotting the transition trajectory along with orbits 'A' and 'B', the major axis of orbit 'B' will have to be rotated through $\Delta\beta = \beta_f - \beta_b$. A few plots of some typical orbital transitions are placed at appendix B, showing original & new orbits in the same plane and the direction of photon emission. The photon emission time for various transitions is generally found to be of the order of 10^{-16} seconds which appears to be too small for the actual spatial extension of the photon. This is due to the fact that the photon is not 'created' from a single point in space, but 'released' from the spatially extended induced field of the electron and 're-forms' to its characteristic shape in accordance with the vector wave equation.

5. SUMMARY & CONCLUSION

5.1 In this paper we have attempted to develop a new model, a new methodology, to compute the detailed instant to instant motion of individual electrons in Hydrogen atom, based on the principle of conservation of energy and momentum. For this a number of new basic concepts have been used to develop a better insight and fundamental understanding of the sub-atomic phenomenon. The new concepts include the structure of the electron[2] , Coulomb interaction, potential energy etc. In the process a few of our fundamental concepts about the Photon wave packet and Planck's constant **h** have also been explained. We have also shown that whenever a photon is emitted from an orbiting electron the angular momentum of that electron is changed by $\hbar$. This may be seen as the origin of various quantisation rules. After introducing several new fundamental concepts, the electron trajectories in the form of elliptical orbits, have been developed and their transitions plotted. The linear velocities, angular velocities, K.E., radial distance **r** and angle β have been computed for the instant to instant motion of the electron in various Hydrogen orbitals. It is hoped that the procedure for computation of electron trajectories outlined in this paper, will pave the way for large scale computer simulations of the sub-atomic phenomenon.

References

[1] Elastic Continuum Theory of Electromagnetic Field & Strain Bubbles by the Author

[2] The Electron Structure and Coulomb Interaction ,,

[3] A Fresh Look at Fundamental Concepts of Quantum Mechanics ,,

Appendix A

Figure - A1

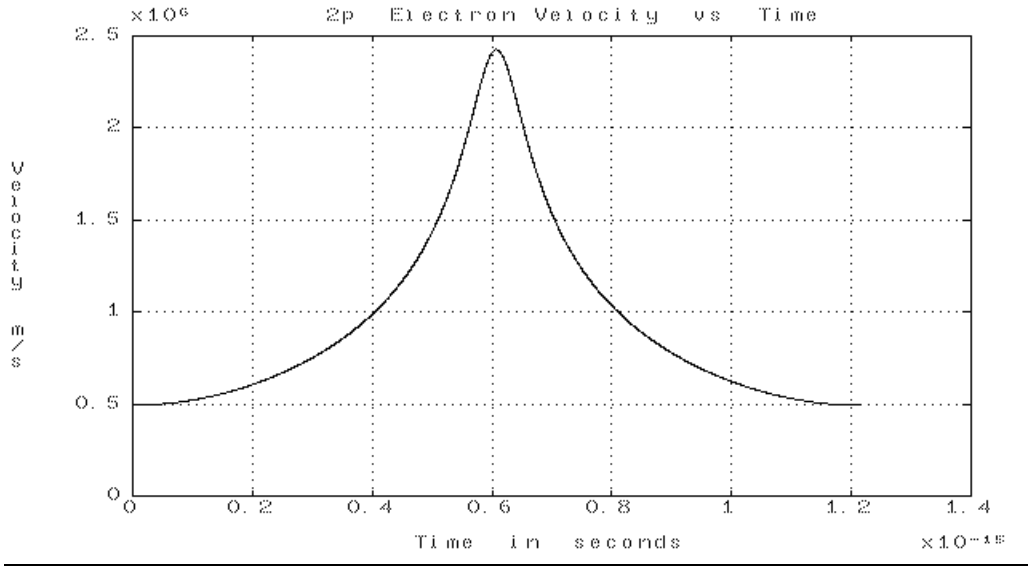
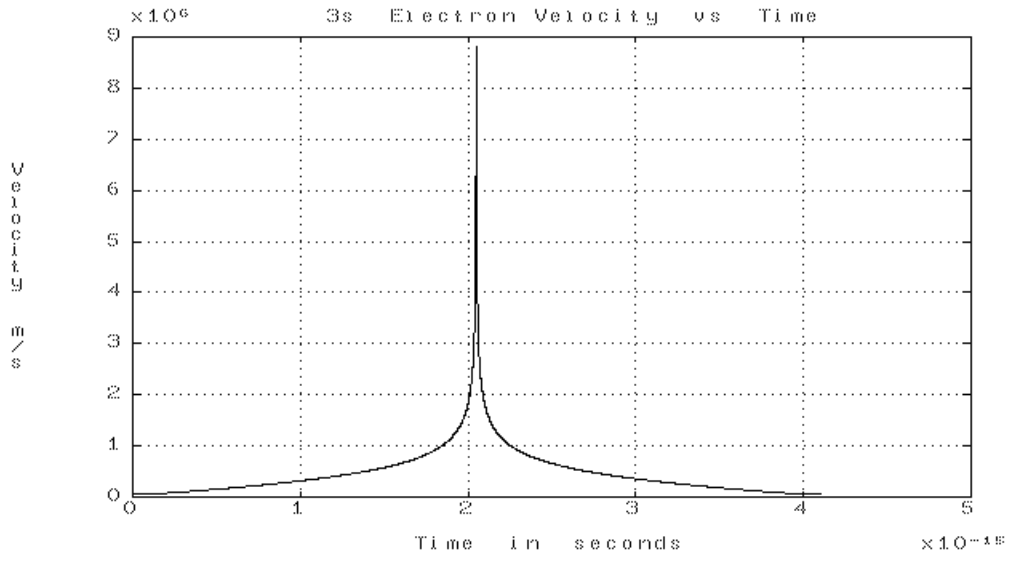


Figure - A2



Appendix A

Figure - A3

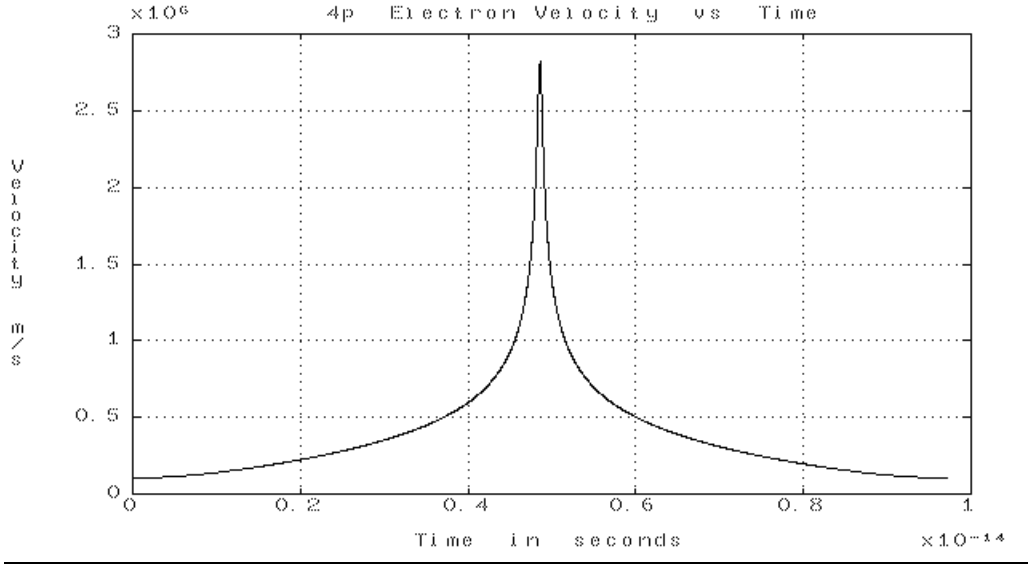
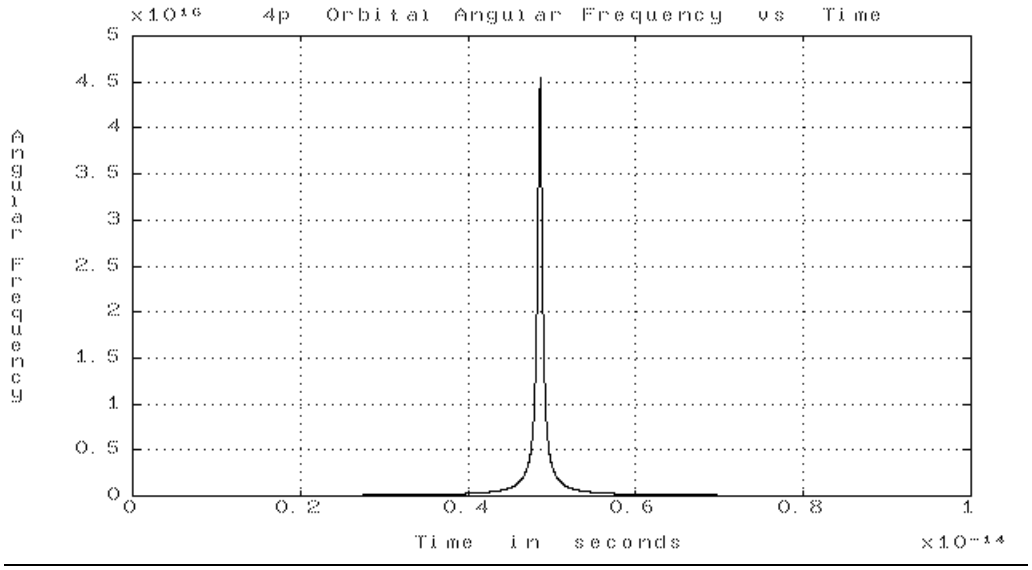


Figure - A4



Appendix A

Figure - A5

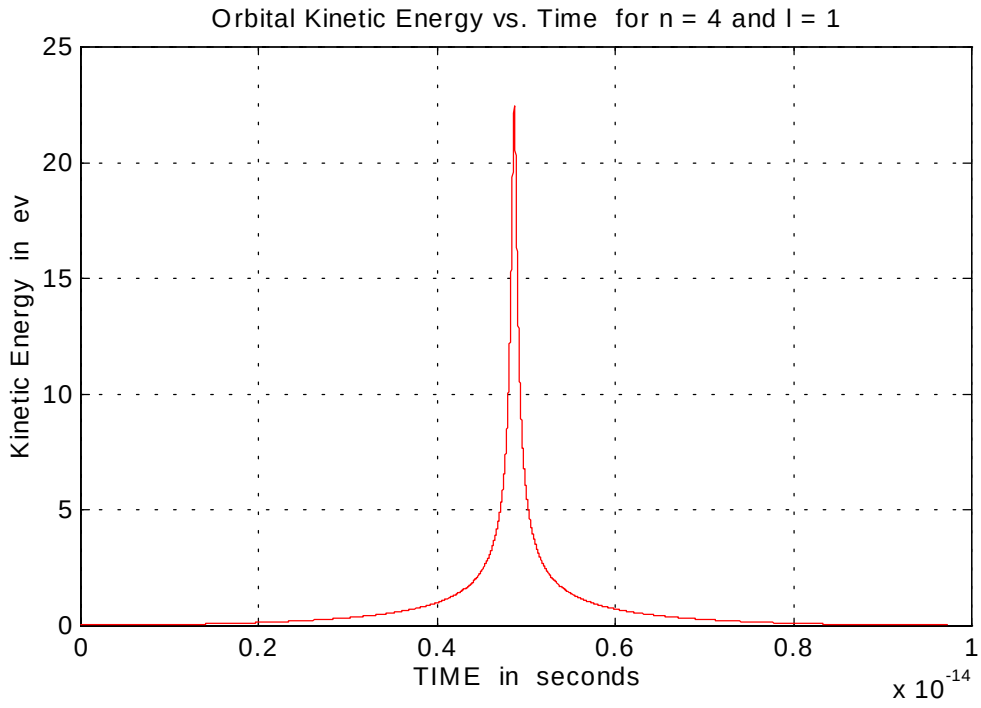
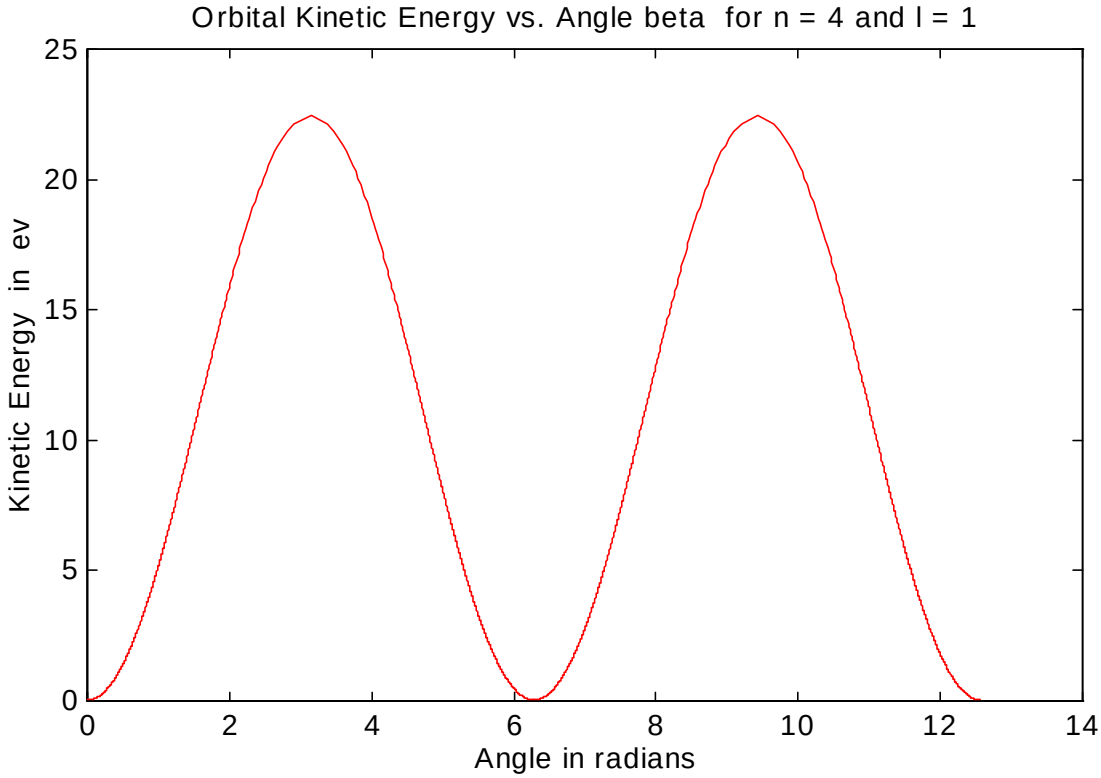


Figure - A6



Appendix B

Figure - B1

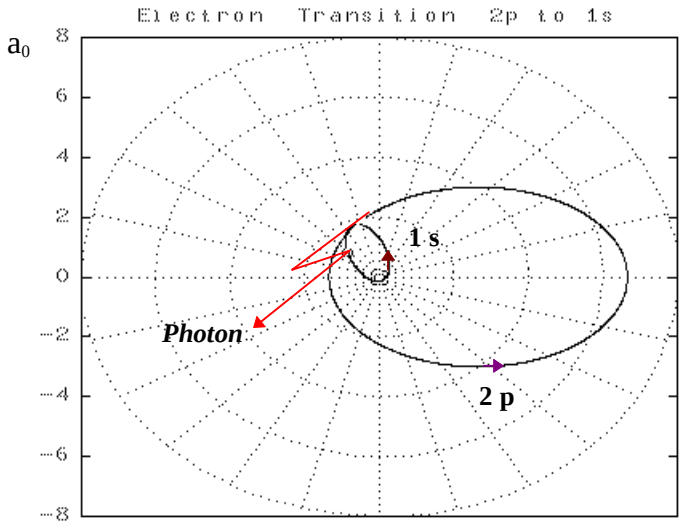
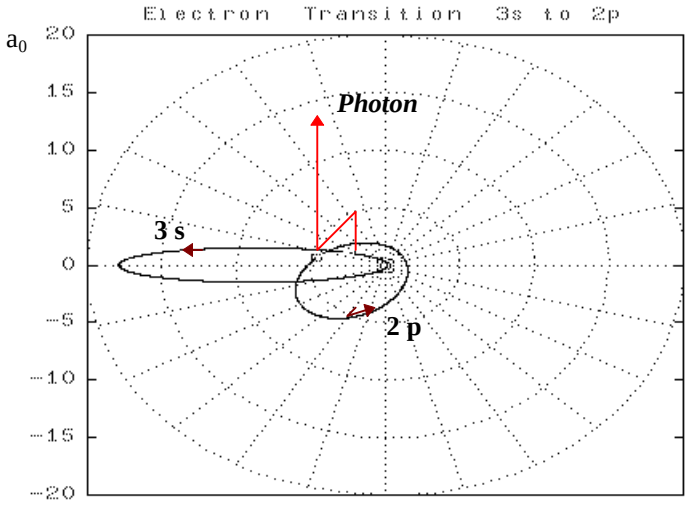


Figure - B2



Appendix B

Figure - B3

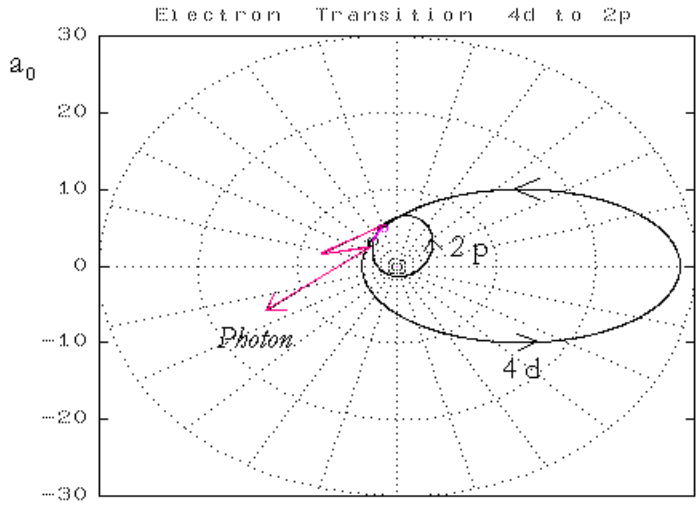


Figure - B4