WAVES IN ATOMIC PHYSICS

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Abstract: As Maxwell's e/m-wave carries energy and momentum it can be the unique ingredient of the photon. The photons are not conceived here as ball-like energy-packets, (governed by an external Maxwellian E/M field), but instead. **Assumptions - Axioms:** The photon itself is assumed to be 'a linearly-polarized, micro-e/m-disturbance, of-half period-duration, propagating–in-classical no-quantized *ether*; this (λ/2)-photon don't be propagated alone usually a 'second' (λ/2)-photon is attached at the end of the 'first' one, but with opposite phase or orientation relative the 'first'; a 'third' (λ/2)-photon can be attached at the end of the 'second' (λ/2)-photon again with opposite phase or orientation relative the 'second' (λ/2)-photon and so on. This chain of the oppositely oriented (λ/2)-photons appears to form a continuous chain of linearly polarized Maxwellian wave of wavelength λ. Similar adjacent parallel chains of oppositely oriented (λ/2)-photons of the same polarization can mutually interact side-by-side:i.e. or these chains (i) can mutually attract each other in case of relative phase difference Δφ where $0 \leq \Delta\varphi < \pi/2$ (rad) or these chains (ii) can mutually repel each other in case of relative phase difference Δφ where $\pi/2 < \Delta\varphi \leq \pi$ (rad), (when $\Delta\varphi = 0$ there happens the maximum attraction among the similar (λ/2)-photon chains, when $\Delta\varphi = \pi/2$ (rad) the mutual interaction between the similar (λ/2)-photon chains becomes zero, and when $\Delta\varphi = \pi$ (rad) there occurs the maximum repulsion between the similar (λ/2)-photon chains). Above interaction leads to the explanations: 1) of the *stimulated emission* phenomenon, 2) of the *boson* behavior of photons, 3) of the *band width –coherence time* relation ($\Delta v = 1/\Delta t$) of a signal, 4) of the diffraction - interference phenomena of photons (although photons always follow classical – Newtonian –like – trajectories yet their interactions create finally a pseudo-wave behavior: "*as if the light consists of Huygens-Fresnel-type waves of wavelength λ*". Finally we prove why classical ether is not quantized and offers a mostly simple classical explanation about the existence of Planck's constant *h*; and also offers an estimation of the "angular momentum of the linearly polarized λ/2-photon" equal to $h/2\pi$.

The Weakness of the Wave-Theories in Physics

The classical real-wave-theories: (i) of Fresnel-Huygens – type, or (ii) of Maxwell-Huygens – type, explain easily the interference phenomena, but appear the classical inability to explain quantum phenomena; (iii) even the assumed combination of a quantized Maxwellian field (QMF) with the classical Huygens Principle (CHP), consists an untenable theory because CHP is enough to dilute or entirely destroy the photons.

It was thus a common but big problem among the physicists, how to conceive the picture of photon into Maxwell's-E/M-real-wave. Our hopes, to get a comprehensible picture about the so called *dual nature* of the photon, were seen to become even feeble, after Taylor's (Sir Geoffrey's) [1] announcement, of a so called "*Single Photon Interference* ".

The Copenhagen Q/M "solution" to the above classical problem, states that to each (indivisible) photon or electron has been "incorporated" a "probability-vibrating-amplitude" (PVA); this PVA, (= ψ and ψ*) a purely mathematical concept, is manipulated as a "*real*" wave, creating "*mathematical interferences*" for each individual photon or electron! (But the very question remains, from which slit -of the two in the idealized Young experiment-, the indivisible photon or electron did have been passed? But this Q/M-probabilistic-wave-theory creates and another problem: if a photon was emitted from an atom two years ago, its *probability-spherical-wave* now has a radius equal to two-light-years around the said atom; if the photon be captured, the probability instantaneously becomes unit; but by which real physics the remaining 'of-four-light-years-(in diameter) -probability-sphere' should collapse vanishing instantaneously at an infinite speed? Why and how a two (or four) light years "physical" sphere does vanish instantly?

The Existent Incompressible Ether!

Almost four centuries ago, Newton had conceived the light as a steam of corpuscles and he thought that diffraction and interference occurred because of the attractive forces exerted on them by the obstacles of matter. Of course we have got today sufficient knowledge to reject the "corpuscle" model; at least we know today that Newton's light had to travel into an entirely empty space, (although Newton was acquainted of the classical ether). Since Newton's "corpuscles" needed not any ether medium, for that reason they had to acquire variable velocity when the source was moving, (which is, of course, opposite to our present experience). Today, we know, that electromagnetic energy is indeed generated, emitted, propagated and received in the form of quanta, and we also know that these quanta maintain their own speed of propagation constant *c* no matter if the source stops or be moving [2,3]; Michelson [3] had explained this as meaning that light is waves into Maxwell's - Fresnel *unified ether*. (We have to remind first the existence of the optical light-waves propagating into Huygens-Fresnel ether -with speed *c*-, and second the existence of Maxwell's E/M – waves propagating in Maxwell's *electromagnetic ether* –with speed $\sqrt{1/\mu_0 \cdot \varepsilon_0}$ -, and the fact that it was found that $c = \sqrt{1/\mu_0 \cdot \varepsilon_0}$ it leaded to Maxwell's unification of the two above kinds of ether and also verified the electromagnetic nature of light waves). The Maxwell's-Fresnel *unified ether* is really present in space. {Of course after his failure to measure Earth's velocity in space (through Michelson-Morley experiment), Michelson, -disagreeing to Einstein- had accepted and believed that ether was dragged and carried totally by Earth in its translation in space [4]; the 'annual starlight abberation' was explainable by '*Stokes' ether-abberation model*' (1845) [5]; meanwhile before the good experimental testing of Special Relativity Theory, first Sagnac (1913) and later (1925) Michelson-Gale [6] had found the Galilean variation of the velocity of light, relative to slowly moving parts of the optical arrangement through the nearly stationary and non-rotating Earth's ether around Earth's axis (this immobilization is due to the tidal

forces of Sun and Moon [7,8])}. The classical thus explanations of Sagnac and Michelson-Gale experimental results have offered the additional evidences for the existence of the Maxwellian – *unified luminiferous ether* in our laboratories. Of course present author managed to prove the existence of the ether by modern experiments and to reproduce entire the so called "relativistic –SRT & GRT-experimental menu" simply from classical pre-relativistic physics [9]. The ether is assumed as an elastic medium of constant density i.e. incompressible.

Here it is necessary to open a historical parenthesis: after the above mentioned Sagnac effect, genius Einstein had abandoned –tacitly- his own original SRT and had been interested to construct a more general theory –GRT- where the speed of light is permitted to be combined (by the classical Galilean addition) with the velocity of observers or their frames!! (Unfortunately for him, his own "new GRT" was based on the so called relativistic *"space-time metric invariance"* $(dS)^2 = (dS')^2$.

This *"property"* of *"space-time invariance"* had its own origin from the experimentally disproved Lorentz-transformations -adopted in the abandoned SRT!-….).

Why a non Quantized Ether?

In a universe of propagating quanta it sounds very curious a non-quantized ether! The reasons for the non-quantized ether are the following:

(1). The emitted quanta are easily recognized as such because accurately ether is non-quantized otherwise in ordinary spectra we should find and the concrete-definite permitted lines of the ether.

(2). The ether of today belongs to the "dark matter of universe" not emitting and not absorbing but only apparently propagating the radiation; yet any quantization inherent in ether should create unexpected changes in the intensities of some very definite lines present in all the spectra.

(3). The existence of quantization of ether should complicate and should change Planck's 'black-body radiation law'.

(4). During our long studies on Doppler effect, (where we do find any change in the frequencies coming from a great range of variations in the velocities of the sources), we necessarily should meet any "quantization" if it was really present in ether; i.e. a non-quantized ether is compatible to the existence of continuum Doppler effects even due to very small speeds of the sources.

Why a "(λ/2) – Photon"?

1. We know that Planck's law for the 'black body radiation spectrum' contains, except its exponential factor, the function expressing of the number of *'standing waves'* existing continually inside a given enclosure. This number of the 'standing waves' had calculated by Rayleigh and of course it denotes how many standing waves of a given wavelength (or frequency) - are continually present into the cavity. The smallest quantity of radiation being in equilibrium in thermal cavity is a half-wavelength -this is the least wave that forms standing waves-; Rayleigh's thus calculation had gave at me the idea to propose the (λ/2)-photon.

2. Reasons of economy in Physics and in Nature impose the existence of the shortest formation: a (λ/2)-Maxwellian-sinusoidal photon i.e. of phase range from φ=0 to φ=π (instead of use of an indeterminate number of sinusoidal periods). The (λ/2)-Maxwellian-sinusoidal photon has a definite start and end (i.e. before it and after it the Maxwellian field is zero); and of course it can act -by its own Maxwellian field- as a "photon-particle" on a "real-particle" (especially as the wavelength λ becomes shorter and sorter).

3. Between node points φ=0 and φ=π there exist the E field which acts on photographic plates when *'standing waves'* are formed.

4. As it will be stated bellow the (λ/2)-photons form chains of oppositely oriented fields ("up", "down", "up"…) which are propagated without changing of their orientations except in case of the reflection on a "mirror".

5. One more reason which imposes the "λ/2-photon" is the following: As the λ/2-photons are alternating as "up", "down", "up", "down" their own "angular momentum vectors", calculated relative to their own middles, are anti-parallel (see and bellow), yet at their connections (of photons) the molecules of ether are co-vibrating without phase differences.

Chains of Oppositely Oriented (λ/2)-Photons

Let's "visualize" the propagation of Maxwellian (λ/2)-photons, let us consider on propagation axis a "rigid sinusoidal line" (RSL) (including phases from 0 until Nπ). This RSL can move along the propagation axis; its rigid parts don't alter during the motion. This example is to denote that the "up" and "down" photon do not "vibrate" at all but if this moving RSL be passed through a narrow but stationary slit then a local photographic recorder can see a "harmonic vibration" of the RSL at this narrow slit.

During the propagation (and before any reflection) the 'up'-(λ/2)-(Maxwellian)-photon (or the 'down'-one) don't change its orientation it can continuously be propagated with the original orientation until the moment of the reflection on a mirror where there can inversed the above said orientations of (λ/2)-(Maxwellian)-photons.

Conclusively: Due of the above definition of photon the first basic property of the (λ/2)-(Maxwellian)-photons is to form continuous propagating chains consisting of oppositely oriented (λ/2)-(Maxwellian)-photons (of the same frequency), -the chains may have a variety of total lengths-.

Except of the strong tendency of (λ/2)-(Maxwellian)-photons the one to *attach* the end of the other, -but with opposite orientation in their fields-, we have and another strong tendency of (λ/2)-(Maxwellian)-photons to *attract* or to *repel* each other by means of -side-by-side interactions.

Why and How the (λ/2)-Photons Should Mutually Interact?

At least every "elementary" entity or "particle"- usually exposes some king of interaction forces, why the (λ/2)-photons should not interact too among them?

Fig. 1(a) briefs our experience about the behavior of the electric and magnetic fields; the attraction and the repulsion of these fields obey the following two rules: (I) The "attraction of the fields" or the same thing the "tendency of the fields to overlap partially each other" occurs when these fields (electric or magnetic) have their own closest areas with roughly parallel dynamical lines and (II) The "repulsion of the fields" or the same the "tendency of the fields to avoid each other" occurs when the fields (electric or magnetic) have their own closest areas with roughly anti-parallel dynamical lines. These two rules (I),(II) have to govern and the behavior of the photons to each other and the behavior of the photons relative to the macroscopic electric or magnetic fields as well

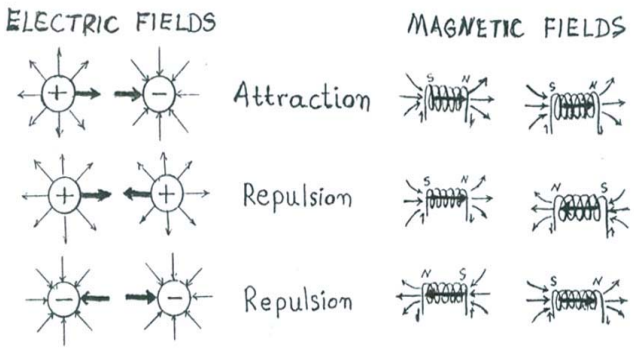


Fig. 1

We saw first the given interaction between the (λ/2)-photons: this occurs in the sequence of 'up'-'down'-'up'-'down'-… between the (λ/2)-Maxwellian-photons. In this sequence, during the propagation – with absent reflections-, the (λ/2)-photons don't "vibrate" neither change to each other (an 'up' photon don't changes into a 'down' one neither a 'down' turns into 'up') but only they propagate as rigid

formations – remember "glass tube" above- (of course under the presupposition that mirrors and reflections are absent); the "vibration" becomes "perceptible" locally only by the vibrating "molecules' of the propagating medium (ether).

The above interaction of (λ/2)-Maxwellian-photons to form "up"-"down"… chains becomes by "permission" by both above (I) and (II) rules; because the "up" and "down" fields don't "see" directly each other and the middle between them has "zero" field this is accurately the point of permitted attachment between the "up" and "down" (λ/2)-photons.

Rule (I) permits two similarly oriented (λ/2)-photons, propagating side-by-side parallel (or nearly parallel) along the OX-axis [and normally to the ΨOZ-plane (Fig.2ab)] to attract with the greater force each other when their own local fields have a complete parallelism of their orientations with the *overlapping lengths* of photons equal to: λ/2 (they have then zero "phase"-difference).

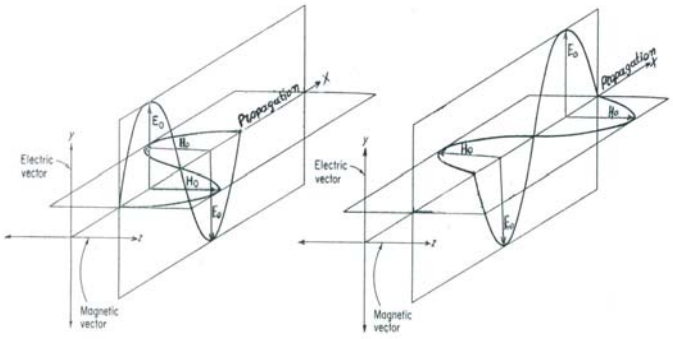


Fig. 2a Maxwell's e/m micro-fields representing two propagating –in-parallel chains of linearly polarized photons; these chains contain alternatively photons of opposite orientation. These chains of photons are attracted side-by-side between them (since the 'second photon' of the chain at right is co-parallel i.e. in "phase" with the 'first photon' of the chain at left).

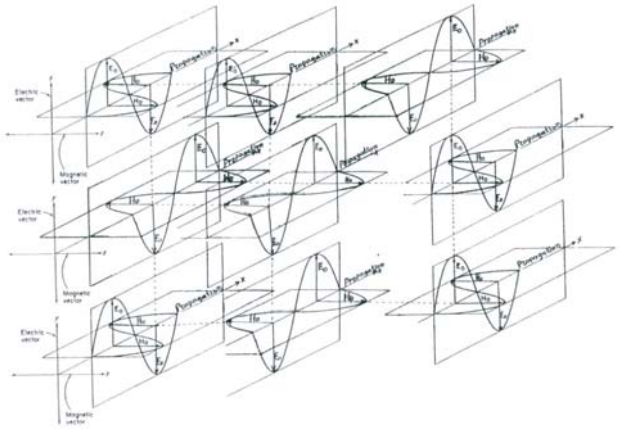


Fig. 2(b) explains how, by λ/2 overlapping, the coherently vibrating in line(s) photons can attract side-by-side tightly the adjacent ones (either along the H-fields or along the E-fields) forming a tightly coherent 3D-bunch of (λ/2)-photons.

Thus we managed to present the "hard action" of (λ/2)-photons without probability ψ amplitudes; we also managed to present the light as a bunch of small (λ/2)-Maxwellian-photons (the least e/m "entity") which can act on a particle while a bunch of such coherent (λ/2)-photons (Fig. 2b) do really behaves as a Fresnel-Huygens pseudo-wave.

In verifying Rule (II); when it be happen, after different optical paths, two rays to follow parallel paths and is to be meet at the same point of space one "up" (λ/2)-photon and a "down"-one then if their theoretical overlapping of these oppositely oriented photons is λ/2 they repel strongly each other; rule (II) forces two similarly polarized photons to repel fully each other when their local oscillation phase-difference is π (rads) (of course the photons show not any attraction or repelling when their local phase-difference is π/2 accurately).

Properties of (λ/2)-Photons

Additionally we made the following assumptions**:**

1)**.** The (λ/2)-photons cannot be vanished by any interference (=energy conservation).

2). The (λ/2)-photons don't be dissolved outwards (i.e. the photon might not be transformed or be dissolved into any Huygens wavelet), but instead the chains of photons are propagated or better can be spread along Newtonian-like trajectories forming (macroscopically) a kind of pseudo-Huygens wavelet; this pseudo-Huygens wavelet which accurately is an open beam of Newtonian trajectories of (λ/2)-photons is compatible with the existence of these photons.

3). The (λ/2)-photons can interact mutually only with those similar (λ/2)-photons (of the same polarization) which are propagating along crossing Newtonian-like paths forming only slight angles between them. At this point we are close to Newton's ideas properly because these dynamical - Maxwellian photons are conceived as propagating along Newtonian-like trajectories.

4). From the cases exposed above we deduce that the forces acting between the (λ/2)-photons have a cosine dependence from their relative "orientation-phase" Δφ . When it is $0 < \cos(\Delta\varphi) \le 1$ the (λ/2)-photons are attracting each other and when it is $-1 \le \cos(\Delta\varphi) < 0$ the (λ/2)-photons are repelling each other (with Δφ=0 in case of identical orientations of adjacent (λ/2)-photons and (λ/2)-mutual overlapping, they attract each other with maximum strength; with Δφ=π in case of opposite orientations of adjacent (λ/2)-photons and anti-parallel full overlapping they repel each other with maximum strength and when Δφ=π/2 we have no force between the (λ/2)-photons.

5). As a general remark, referred to the kind of the above mentioned forces acting between the photons, we can say that what is called 'attractive force' between the photons in reality reflects to the 'love' or 'permission' of the *vibrating ether* to contain in a concrete region only coherently vibrating photons, and the 'repulsive forces' between the photons expresses essentially the "non-permission" of the vibrating ether, or its 'prohibition', to contain into the same region non-coherently vibrating photons.

6). The action of the 'attraction force' between the photons should bring them closer and closer, permitting strong intensities (lasers).

7).When there exists a slight variety among the frequencies of photons (i.e. non-absolute equality), soon increase their relative vibration phase-differences Δφ>π/2 and they start to repel each other spreading themselves outwards (increase of the entropy).

8). The forces among the (λ/2)-photons, as have exposed in the above cases, are assumed to be in rule only for (λ/2)-photons of the same frequency and of identical (parallel) polarization, while these are propagating along trajectories forming zero angles or very small angles among them; the smallness of the angles between the photon-trajectories is a necessary condition in order an interaction between the photons to takes place; this condition is fulfilled in the diffraction and interference of photons (see below). Interaction of the photons also occurs when their trajectories are coincident in space but their polarizations are not identical; then (i) circularly polarized photons are created if an equal number of photons of "vertical" polarization is in immediate vicinity with an equal number of "horizontal" polarization, but in case (ii) of inequality of these numbers photons we are confronted with the generally elliptically polarized light.

9). The experiment can show that the photons do not interact between them when they have parallel polarizations and their trajectories form large angles between them.

10). We have to dissolve and another usual misinterpretation: In this paper the photon is not a point-like energy packet having an "indeterminacy" of its position equal to *λ/2*, but instead, it is a disturbance in ether of total length, *λ/2*, of concrete speed c of propagation, of concrete energy *hν* and of concrete momentum *hν/c* The photon is defined as an-"up" (or "down")- e/m-disturbance-of-half-period-propagating-in-ether'.

The fact that the energy of photon ($h\nu$) is proportional of the frequency, it means that the -elementary- e/m fields inside the individual photon obey or are compatible with Maxwell's equations. Maxwell equations mean that high frequency ν has as a consequence also the appearance of high values of the propagating in ether – elementary fields $\vec{E}$ and $\vec{B}$ inside photon-; {high frequency ν means and high time-derivatives, $\partial\vec{E}/\partial t$ and $\partial\vec{B}/\partial t$ of the elementary e/m field of photon, which finally leads to the high values of $\overline{E}$ and $\overline{B}$ inside the photon}.

11). The form of (λ/2)-photon as '*an "up (or "down") propagating e/m-disturbance of half-wavelength extension*' is imposed from the following reasons: (1) the half sinusoidal harmonic vibration (from φ=0 until φ=π) seems to be the most natural disturbance propagating in ether. (2) It seems to be the more economical form of disturbance in the ether; it starts from resting ether and also lefts behind it resting ether. (3) It has been found theoretically after the solution-presentation of Maxwell's wave, -corresponding to the passing of two or more sequential "up"-"down" photons. (4) Each chain of "up" – "down" (λ/2)-photons is more or less sufficiently long containing thus "neutral" volumes of 'up'-'down' electric fields and "neutral" volumes of 'north'-'south' magnetic fields as well. Our ordinary experimental electric and magnetic apparatuses obtain only the turning of the level of vibration but not the "separation" of the "up" and "down" photons (such a "separation" of (λ/2)-photons should mean the destroying of the ether itself). (5) All the interference phenomena are in favor of the 'sinusoidal' form, 6) Wiener at 1890 had experienced with his semi-transparent photographic film, forming a small angle (one degree), with a reflecting mirror. Wiener has found "a system of parallel arrays of nodes and anti-nodes" (after the perpendicular reflection of light forming standing waves with the film -obscured it at the positions of the antinodes-). Wiener's observation does not exclude the "half-wavelength-sinusoidal photon".

Existence of Planck's constant.

According to Planck's ideas quantization occurs only in the energy-exchanges between matter-vibrators (atoms); there is not any need to introduce any quantized ether (see). A quantized ether on the other hand should do more difficult Planck's above idea.

The photon as 'half-wavelength wave'
of mechanically vibrating 'molecules' of ether.

The sinusoidal form of the e/m field into the photon means of course the transverse harmonic vibration of the ether "molecules". The total energy (potential and kinetic) per one vibrating ether molecule (of mass m) is classically calculated by means of the maximum kinetic energy at the center of the vibration:

$$W_{per-ether.molecule} = \frac{1}{2}\cdot m\cdot(a\cdot\omega)^2 \qquad (1)$$

Where the circular frequency is ω=2πν and a is the vibration amplitude (here the vibration amplitude a will be assumed constant for any frequency ν); since the photon is assumed to have extension equal to half-wavelength into ether and if to each ether molecule corresponds a cell of space of diameter ℓ then into a half-wavelength there are $\lambda/2\ell$ ether molecules (liquid ether). Thus the energy of the photon must be:

$$E_{(\lambda/2)} = \frac{1}{2}m\cdot(a\cdot\omega)^2\frac{\lambda}{2\ell} = \left[\frac{m}{\ell}\cdot a^2\cdot\pi^2\cdot c\right]\cdot\nu = h\cdot\nu \qquad \mathbf{(2)}$$

From this equation we have do found the meaning of Planck's constant in terms of the ether constants or at least we see why Planck' constant exist.

$$h = \pi^2\cdot a^2\cdot c\cdot\frac{m}{\ell} \qquad (3)$$

From equation (2) we get by division by ω

$$\frac{E_{(\lambda/2)}}{\omega} \equiv \hbar = \pi\cdot\frac{c}{2}\cdot\frac{m}{\ell}\cdot a^2 \qquad (4)$$

Equation (4) gives us the "angular momentum" $\hbar$ of the linearly polarized (λ/2)-photon; really in the linearly polarized λ/2- (up, or down) photon there is an angular momentum around the center of photon, (-placed at λ/4 or at phase π/2-) the vector of this momentum is normal to both: the direction of propagation and the direction of vibration:

$$M_{LP-ph} = 2\cdot\int_0^{\lambda/4}\frac{m}{\ell}\cdot(a\omega)\cdot\cos\left(\frac{2\pi}{\lambda}\cdot x\right)\cdot a\cdot\cos\left(\frac{2\pi}{\lambda}\cdot x\right)\cdot dx =$$

$$= 2\cdot\frac{m}{\ell}a^2\omega\cdot\frac{\lambda}{2\pi}\cdot\int_0^{\pi/2}\cos^2\Theta\cdot d\Theta = \pi\cdot\frac{c}{2}\cdot\frac{m}{\ell}a^2 = \hbar \qquad (5)$$

Consequences of the Theory

Stimulated Emission, Bandwidth - Coherence Time* and *Boson Behavior

The existence of the relatively strong (e/m) attractive forces acting between the coherently propagating and linearly polarized Maxwellian photons could explain the appearance of the *stimulated emission* phenomenon. The *stimulated emission* is a fundamental property of photons it occurs of course in the function of lasers as well as in the emission from 'Gaussian ordinary light sources' too (the great number of the atoms in a 'point-like' source, ensures the action of the '*stimulated emission*' to create coherent light bunches from Gaussian sources). This explains practically how the pre-supposition for Fourier-analysis is realized: i.e. (how) the infinite-in-number frequencies "decide to start vibrating" in such a simultaneous manner so to create a pulse in time of some definite form. The nearly in parallel propagating photons, have the time to attract those similar photons (of the same spectral line) with which they have nearly the same propagation phases {*cos(Δφ)>0*} and at the same time to repel away the photons that are propagating generally with opposite phases {*cos(Δφ)<0*}.

Let us assume a spectral line of central frequency ν_o has a line-width (at mid) $\pm\Delta\nu/2$. The two corresponding photons, at the mid right and at the mid left of the spectral ray, have wavelengths:

$$\lambda_- = \lambda_o\cdot\left(1-\frac{\Delta\nu/2}{\nu_o}\right) \quad \text{and}$$

$$\lambda_+ = \lambda_o\cdot\left(1+\frac{\Delta\nu/2}{\nu_o}\right)$$

We ask about the distance L, after which, these two photons will have entirely been repelled away from each other:

$$\frac{L}{\lambda_-}\cdot 2\pi - \frac{L}{\lambda_+}\cdot 2\pi \le 2\pi \qquad \text{it gives}$$

$$\frac{L}{c}\cdot\Delta\nu = \Delta t\cdot\Delta\nu \le 1$$

i.e. we have found, without any Fourier analysis, the relation which determines the time-duration *Δt* of a signal to its band-width *Δν*; Here the term "signal" is synonymous to term "*coherently vibrating photon-bunch*" and the "time-duration" synonymous to "*coherence time*".

The *'stimulated emission'* mechanism is responsible for a somewhat new aspect regarding the emission of light from the conventional light-sources like flames, gas discharge tubes, or resistance heating-wire lamps. A point-like element from the above sources, –consisting essentially from a very large number of emitting atoms-, emits each time a coherent bunch of photons only to some concrete but random directions in space. Thus the point-like source emits "momentarily"

relatively narrow bunches of coherent photons, only to some random directions; of course the said random directions of 'bunches of coherent photons' will complete statistically the entire 'unit sphere' around the point-like source. {The situation can be parallelized with that one of a nightclub stroboscope pulsing out ultra sort laser light, as the time passes the pulsed beams cover statistically the entire surface of the room with bunches of locally coherent photons}.

The existence of the strong (e/m) attractive forces between the coherently vibrating and linearly polarized Maxwellian photons (CoVLPMPs) explains the reason for which, the photons expose their own *boson behavior*. This *boson-behavior* of photons is owed in the fact that as more and more CoVLPMPs are in the same state of the vibrating ether, the greater becomes the resultant of their fields and this makes this resultant to become more and more effective to "its task" i.e. to catch more and more coherently vibrating photons.

Reflection of Light

It easily be explained the reason for which the photon-bunches are reflected by a mirror obeying the known law. In this case we have both: the inversion of the normal momentum component of photons by the mirror, as well as, the conservation of the relative vibration-phases between the photons, permitting to them to be reflected coherently vibrating also.

Refraction of Light

It easily be explained the reason for which the photon-bunches are refracted by the known law. This happens because due of the difference of the speed of light in the second medium, the photons change the wavelength of their own internal vibration, and thus if a different angle of refraction (than the observed), should be observed, this should change the relative vibration-phases of the refracted photons. To say it in other words**:** our graphical constructions about the reflection and refraction (found in the Wave-Optics textbooks) satisfy the condition of the coherent vibration in the emerging photon-bunches.

Fraunchofer Diffraction Through a Slit

It easily be explained the reason for which the Fraunchofer diffraction takes place. The diffraction through a slit is calculated by the usual graphical method of closed multi-polygons of *phasors* [9]. We remind that a closed "circle" of the phasors corresponds to zero intensity to this direction (a complete circle of phasors corresponds to a 2π-phase-change between the extreme phasors –which mean that the extreme points of the beam have one wavelength path difference to the said direction-). The first maximum is at the direction where the phasors complete 1,5 circumference. The second and third etc maximum are at the directions where the phasors complete 2,5 and 3,5 etc circumferences, While the zero intensities are at the directions where the phasors complete 1, 2, 3, etc circumferences. Here the term *phasors* is not referred to the classical – wavelets, (propagating outwards from the slit), but to the phases of the numerous adjacent coherently vibrating photons, which are not spreading randomly behind the slit. The interaction forces between the photons play an important role (for example the zero-intensities are to those directions where a number photons repel mutually an equal number of oppositely vibrating photons).

In this model of light, the vibrating but elementary $\vec{E}_o$ and $\vec{B}_o$ - vectors of photons, create the final resultants of the Maxwellian field $\left(\sum \vec{E}_o\right)$ and $\left(\sum \vec{B}_o\right)$. According to Maxwell's theory the quantity

$$\frac{1}{2}\left[\left(\sum \vec{E}_o\right)^2 + \left(\sum \vec{B}_o\right)^2\right]$$

is analogous to the energy-flux i.e. the flux of photons. The classical Wave-Optics calculations maintain their meaning! Here we have not any difficulty to conceive how the photons travel; these are traveling along Newtonian-like trajectories determined by Maxwell's theory.

Fraunchofer Diffraction through a Rectangular Aperture

It easily be explained the reason for which, the known Fraunchofer diffraction of light through a rectangular slit, takes place.

As the bunches of the coherently vibrating photons spread behind the rectangular slit, and due to the 'orthogonal "crystalline – like" - connection' of photons inside the *photon bunch*, the photons can be rearranged (interacting mutually) behind the two axes of the slit, creating coherently vibrating photon bunches to those directions (secondary maxima) where the *phasors* complete $m+½$ and $n+½$ circumferences respectively. The result of the two-degree diffraction is due to the two dimensional 'orthogonal connection' of photons inside the coherent incident and diffracted bunches of photons.

The diffraction is independent of the kind of polarization of photons relative to the axes of the rectangular slit. We again have not any difficulty to conceive how the photons travel to form the diffraction pattern; the photons are simply moving along Newtonian-like trajectories which statistically are found where the calculations of the classical Wave-Optics dictate.

Wave-like "Interference" of Photons

Due to the said kind of attractive and repulsive forces between the LPMPs it can also be explained the way by which, the coherently vibrating photon-bunches create *interference effects* when these are passing through the two-slits, pseudo-simulating the case of the classical waves of wavelength λ. We can describe technically the "*two-slit interference of photons*" into four stages.

First stage. As the coherently vibrating and of -'square connection'- linearly or elliptically polarized bunches of photons are arriving at the two slits, these are diffracted behind each one of the two slits, obeying the rules of the *diffraction through a single slit* of photon-bunches exposed before.

Second stage. As now, the two diffraction-patterns of the photon-bunches are overlapping side-by-side behind the two slits; there are photon-chains, (belonging to coherent photon-bunches), moving linearly and spreading to all the directions of space dictated by the diffraction phenomenon. At this stage the linear path of each one photon-chain from the '1-slit' cross every other photon-chain from the '2-slit'; the formed angles between the crossing photon-chains extend from 0^o to 90^o and more degrees.

Third stage. In this stage the interference takes place (Fig.5). The photon-chains, which are crossing other ones at large angles, do not interact with them. Only the photon-chains, which meet other photon-chains at very small angles, are mutually interacting. Finally during the coherence time, (not simultaneously), all the "1"-photon-chains –coherently vibrating- will cross, the corresponding, "2"-photon-chains, at small angles in the interference field. We know that geometrical loci of photon-chains (or rays) exposing some concrete phase-difference are the Fresnel's hyperbolas; and the

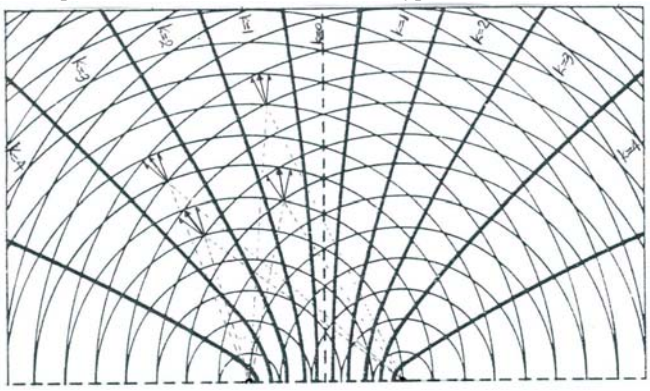


Fig. 4 Interference: by means of Newtonian trajectories and coupled photons

interacting coherent photon-chains attract each other when their phase difference is $2k(\lambda/2)$ and repel each other when their phase-difference is $(2k+1)(\lambda/2)$. This mean that the repelled photon-chains of the "$(2k+1)(\lambda/2)$-phase difference hyperbola" do "jump" away from this

geometrical locus and an equal number goes to the adjacent "(2k)(λ/2)-phase difference hyperbola" and another equal number goes to the "(2k+2)(λ/2)-phase difference hyperbola";
The "even phase-difference-hyperbolas" -at some suitable distance- (so the slits to be seen having small angular distance), are the much more stable loci to be found the attracted photons.
Stage four. The attracted photons which are 'co-moving' in narrow-angle crossing trajectories move about the known "even"-Fresnel's-hyperbolas; this is physically possible because of the property of the hyperbola to divide accurately in two (equal halves) the angles of the momentum vectors of the attracted photons. Thus the joined-by-attraction photons move continually in joined pairs far away from the slits along the "even" –Fresnel's hyperbolas.
That is why we find no photons at the directions

$$d \sin\theta = (2k+1)\,\lambda/2$$

and have double intensity at the directions

$$d \sin\theta = (2k)\,\lambda/2$$

where k = 0,1,2,3,..; d is the distance of the two slits, λ is the wavelength of the photon bunch, and θ is the angle measured from the frond direction.
The 'even' –light- hyperbolas and the 'odd'-dark-ones are not separated abruptly the one from the other but their intensities vary gradually; this is due: 1) in the cos(Δφ)-variation of forges acting between photons, 2) in the smooth spreading of the photons inside each one of the diffraction lobes, and 3) in the development (as the time passes) of repulsive forces between the photons of an 'even' hyperbola ($\Delta\varphi > \pi/2$).
It is self-evident: these relations rule the "interference"-fringes-formation for any kind of polarized light. We note that this mechanism for the "interference"-fringes- formation presupposes a rather great number of photons to be spread behind the two slits and each one of the fringes is formed from the arriving of coherently coupled photons. The great number of coherently vibrating photons, which is necessary to be found, before the two slits, is offered by the stimulated emission mechanism discussed previously. The emitted photon vibrates mostly coherently to its nearby vibrating photon propagating along crossing Newtonian-like paths forming very small angles between them (no matter if the photons are moving co-flying or flying in opposite directions), of course due of the phase symphony (Δφ =0) or more accurately when cos(Δφ)>0 the coming back photon keeps its position close to the preceding one. Otherwise when cos(Δφ)<0 the photons partially repel each other and both the photons fly away the one from the other, or at least the coming back photon flies away from the preceding one.

X- Ray Bragg's Law

It easily be explained the reason for which, the Bragg's law for the "reflections" (interferences) of the X-photons is in rule. The X-photons, which are falling on a crystal level, are coherently vibrating and have their own 'square crystal-type connection'. The equality of the angle of incidence to that one of the reflection, is due in the simultaneous fulfillment of both conditions: (i) the inversion of the normal momentum component of X-photons by the crystal levels and (ii) the preference of photons, among the numerous orientations of the crystal levels, to those levels for reflection, for which the photons are rearranged by their mutual re-overlapping so that to attract each other or to vibrate coherently i.e.

$$2d \sin\theta = n\,\lambda$$

where n =1,2,3,… and θ is the angle of incidence (and of reflection), formed between the reflecting crystal levels and the ray.

"Huygens Principle" and Fresnel's Zones Plates

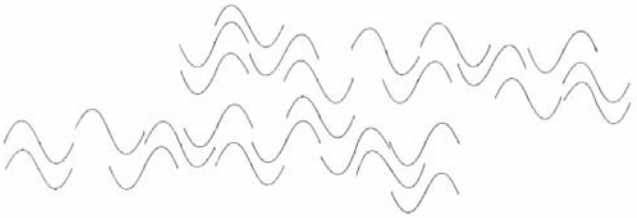
It easily be explained the reason for which, the famous *Huygens Principle* **appears** to be in rule. As numerous CoVPMPs are passing simultaneously through a point P, these (photons), due to some cause, are more or less randomly spreading in the space around; and the *geometrical locus* on which the vibration-phase of these photons is (momentarily) constant, is (for an isotropic medium) a sphere with its center at the point P and its surface propagating with the velocity of light. We see that what is "dissolved" in space, is not an individual photon, but the photon-bunches. Of course around the point P the spreading photon-bunch creates a 'pseudo-wave'; and this makes the classical wave-optics calculations very safe and successful to describe the wave behavior of the photons.
Here we explain and the reason for which Fresnel's zones plates (FZP) work. After the spreading of the photons behind the plate, they follow such trajectories so that to be rearranged (by mutual-partial re-overlapping), so to obtain rays of coherently vibrating photons behind the FZPs, making them to act as positive-negative multi-focal systems.

Visibility of fringes

Here we explain the reason for which the observation of the interference fringes in a Michelson interferometer, appears first a '*visibility*' V = 1 in the case of zero path difference, but the fringes show second a 'visibility' V =0.5, in the case of path difference equal to the one half of the coh*erence length* (linear dependence of visibility from path-difference)
The *visibility* of the fringes is defined (after Michelson) by the equation:

$$V = \frac{I_{\max} - I_{\min}}{I_{\max} + I_{\min}}$$

In the second case by assuming that each one of the two coherent halves has 2N photons, we have 2N photons spreading uniformly in the field (coming from the two non-overlapping parts of the initial coherent light bunch) Fig. 5:



in Fig. 5 $\left(I_{\max} = I_{\min} = N\right)_{diffu\,\sin\,g}$

(each area –of max- or –of min- light receives N photons)
but the two remainder overlapping parts of the initial light-bunch are interfering creating i.e.

$\left(I_{\max} = 2N\right)_{\text{int}\,erf.}$ and $\left(I_{\min} = 0\right)_{\text{int}\,erf.}$

and the above Michelson equation gives for the second case:

$$V = \frac{3N - N}{3N + N} = 0.5$$

These calculations are applied equally well, in divided bunches (of initially coherent photons), no matter if the coherence length is 1m or more in lasers, or 10 λ (as the ordinary filtered red light).

Mizobuchi-Ohtake Experiment

It easily be explained the reason for which the Mizobuchi-Ohtake' experiment [10] works. The M-O is critical to decide about the validity of our theory.
The M-O experiment shows both and the wave-nature of light, (which is verified by propagating -'tunneling' of our micro-wave-photons through the prisms gap) and the photon nature of light, (which also is verified by the anti-correlation around the prisms gap as it be used as a beam splitter).

"Single"-Photon Interference Experiments

The *stimulated emission* mechanism offers first a great number of arriving photons before the slits; and this explains why we observe the two-slit "interference" of photons.. This situation does not changes very much when we try to attenuate the intensity of the arriving light, at a 'single photon level intensity' (SPLI), (by the use of neutral filters or polarizers, small holes, etc). According to the

present theory, and in spite of the mean-value calculations, (speaking about the "*single photon sequences*" or "*single photon beams*"), we have to speak now, about (attenuated) but "single-groups of coherent photons"; of course these 'single-groups of coherent photons' now will be separated by a multiple distance than the, previously calculated, mean-distance-separation of the "single-photons". Thus our mean- value calculations remain unaltered but in reality we now have NOT "*single photon interferences*" but 'multi-photon ones'. Thus has been cancelled the proper difficulty to comprehend the so-called "*single" photon interference* experiments ("S" PIEs).

Taylor's Experiment

Regarding to the most famous (historically) "S" PI-experiment, performed by G. I. Taylor (-later honorably re-named Sir Geoffrey -) [1], we have to note his carelessness: First, he had not, in his epoch, neutral filters (NF) to attenuate the light from his own source (a gas flame), and so he used fumed glasses, which of course restrict the passing spectrum only in the red; and since we know the small efficiency or inactivity of the red light to react with the films of the epoch, we can understand why he had needed such a long time (about three months) to take a good photographic effect (although relatively a large number of red photons had to pass at a moment). Second, in order to estimate the rate of the passing photons, he compared the experimentally obtained photographic effect with the effect on a similar film lighted for 10 sec, by a prototype candle without any filter; this made his measurement quite erroneous, because the candle had its own entire spectrum and thus it was more effective in its reaction to the film. These two reasons together were responsible for the serious under-estimation of the flux of the (red) light in his experiment.

Some "Single" – Photon – Interference - Demonstrations

Among the most impressive modern SPIE-demonstrations-, we can mention [11, 12], where their performers had used the commonly known: 1 mW – of continuous work (c.w.)- He-Ne laser (λ = 632.8 nm). They had make their own (ordinary) mean-value estimates, according to which, the strongly attenuated laser beam had offered to them a "sequence of single photons" separated by sufficient mean distance (equal about to 2 km in [12]). But this ideal mean-value calculation is far away from the reality of the physics of photons! Although we have to do, with the nominally c.w. lasers, yet their function is unpredictable in small fractions of the second. There happen "momentary" flashes in the intensity of these lasers [13], and these strong fluctuations are the 'source', which offers to the arrangement of the 'two-(or-more)-slits' the highly coherent bunches of photons. The said strong and coherent flashes of the laser beam are the cause for the 'surviving', in their passing through the strong attenuators, in the form of a sufficient number of coherently vibrating photons each time; these photons are arriving simultaneously in front of the slits and then be interfering (see above). Of course for the same reason any strongly fluctuating-flashing laser, (at least) like the nominally c.w. He-Ne laser (!) can make a Michelson or a Mach-Zehnder interferometer to behave, at the 'flashing moments', as it behaves containing the classical coherent-light-waves (although the calculated mean-values of the attenuated laser **mean**-intensity, speaks about a SPI situation); this also explains the demonstrations [14] and [15], which also erroneously are regarded as SPIEs.

Discussion

This dynamical theory about the photons, unveils the unique nature of light, explaining easily the phenomena of the so-called wave-behavior of photons. It is notable that when a coherently vibrating bunch of photons is spreading behind a slit (or slits) the enormous number of the photons, create a state very similar to a 'pseudo – wave'; it is not then curious why we can safely use the classical wave-optics calculations to describe the statistical behavior of photons regarding their distribution in space. The classical phenomena of the diffraction and interference of the coherently vibrating photon-bunches are the dynamical effects of the forces acting between the photons. According to Maxwell's theory the flux of photons from diffraction and interference phenomena is expressed physically by the relation: $I = \left(\sum \vec{E}_o\right)^2 + \left(\sum \vec{B}_o\right)^2$ (where $\vec{E}_o$ and $\vec{B}_o$ are the elementary-vibrating-fields, carried by the photons). The initially coherently vibrating photons before the slit(s) are re-distributed automatically behind the slit(s), obeying to their own formed macroscopic resultant Maxwellian-E/M-force, which does really measures the strength by which the photons are mutually attracted; that is why the final resultant appears as to determine their presence to that or that direction of space. When thus a such CoVPMP-bunch comes to slit (s), we can argue that as the economy of the Nature dictates the photons start to interact mutually (when they meet at small angles) avoiding the directions for which it is

$$\Sigma\vec{E}_o = 0 \text{ or } \Sigma\vec{B}_o = 0$$

(i.e. due of the opposition of the vibration-phases the photons avoid the creation of any *e/m-friction*); Even the boson-behavior of photons is owed in the fact that as more and more CoVPMPs are in the state, the more greater becomes the resultant of their fields and this makes this resultant to become more and more effective to "its task" i.e. to catch more and more coherently vibrating photons..

Like the Newtonian 'corpuscles of light' the photons have their own concrete classical trajectories but finally the photons follow the trajectories along which they vibrate more coherently i.e. where their resultant strength is greater, apparently governed by Maxwell's resultant-fields created by them in non-quantized ether.

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De Broglie - waves are 'agitation' - waves in ether and as 'tail-waves' follow from back the moving particles.

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This paper offers a more natural interpretation or explanation about the De-Broglie's waves. These waves have to not be considered yet as propagated, in front of the particle at the -commonly believed- superluminal "*phase velocities*" (c^2/υ), but rather to follow as 'ether agitation tails' the moving particle since these be propagated at a speed $\upsilon/2$ i.e. half of the velocity of the non-relativistic particle. These **'**following from back**'** "Slow De-Broglie waves" (SDBW) seem to have their origin in the agitation or vibration of the ether medium after the passing of the moving (energetic) particle. Thus, the back space of the moving particle is filled with the SDBWs. This "agitating - vibrating ether tail" extending in the back space of the moving particle and under the rule or validity in ether of "Zero Relative Phase Difference Principle" (ZRPDP), this "wave tail" should interacts finally with the following (from back) particles (-of the particle beam-) so to keep or make the beam spatially coherent. The last sentence may be rewritten as follows: "The mechanically agitating ether –by the motion of the beam particles in it- creates necessarily a spatial coherence between the moving particles in order their individual SDBWs to vibrate coherently". Accurately this spatial coherence of incoming particles should explain the so called "wave-behavior" of the moving particles in classical terms of trajectories and with the real particles not conceivable as "dissolved" in waves.

Why infinite speed of the de-Broglie waves?

De-Broglie had confronted with the difficult problem of physics of his epoch, "*the double wave-quantum character of light*", - regarded by Einstein as the "*greatest problem of physics"* [1]-.

De-Broglie reasoned very curiously generalizing the wave behavior in physics: "If light, having a well-recognized wave character, exposes and a quantum or particle behavior, then why the well-recognized particles, should not expose and a wave character" too?

That is why de-Broglie was the first who thought to use the relation $E = h\nu$ and for the particles:

$$h\cdot\nu = \frac{m_0 C^2}{\sqrt{1-\frac{\upsilon^2}{C^2}}} \qquad (1)$$

He thus determined, by relation (1), the frequency of the "material wave [2]". He also considered [2] the velocity υ of the particle as the *group velocity* of the "material wave" thus he wrote down the known relation from the mechanics (composition) of the waves:

$$u_{group} \equiv \frac{d\nu}{d\left(\frac{1}{\lambda}\right)} = \frac{d\nu}{d\upsilon}\cdot\frac{d\upsilon}{d\left(\frac{1}{\lambda}\right)} \equiv \upsilon \qquad (2)$$

From (1) he received by differentiation the relation:

$$\frac{d\nu}{d\upsilon} = \frac{m_0}{h}\frac{\upsilon}{\left(1-\frac{\upsilon^2}{C^2}\right)^{\frac{3}{2}}} \qquad (3)$$

Thus from (2) and (3) he found the relation

$$d\left(\frac{1}{\lambda}\right) = \frac{m_0}{h}\frac{d\upsilon}{\left(1-\frac{\upsilon^2}{C^2}\right)^{\frac{3}{2}}} \qquad (4)$$

He integrated relation (4) between the limits: υ=0 to $\upsilon = \upsilon$, of course he reasoned [2] that for υ=0 it should be $\frac{1}{\lambda_0} = 0$.

Thus,De-Broglie [2] managed to present his own wavelength of the "material waves":

$$\frac{1}{\lambda} = \frac{m_0\upsilon}{h\sqrt{1-\frac{\upsilon^2}{C^2}}} = \frac{p}{h} \qquad (5)$$

Relation (5) is a well-established law of Physics. But above De-Broglie had done a hidden but very serious mistake: For $\upsilon = 0$ he assumed essentially $\frac{1}{\lambda_0} = 0$ i.e. $\lambda_0 = \infty$; but this means that he introduced tacitly in Physics an infinite speed $(u = \infty)$ of propagation for the "material waves". Really for $\upsilon \to 0$, relation (1) gives a basic concrete frequency of magnitude: $\nu_0 = \frac{m_0 C^2}{h}$ to be generated by the stationary particle and as $\lambda_0 = \infty$ we get $u(\upsilon \to 0) = \nu_0 \cdot \lambda_0 \to \infty$.

The speed of De-Broglie waves currently is calculated [2, 3] propagating at superluminal speeds:

$$u = \lambda\cdot\nu = C^2/\upsilon \qquad (6)$$

[the above mentioned infinite velocity $u(\upsilon \to 0) = \infty$ is consequence of (6)].

If in contrary for $\upsilon \to 0$ it could not be $u \neq \infty$ then due of $\nu_0 = \frac{m_0 C^2}{h}$ then it should be $\frac{1}{\lambda_0} \neq 0$ and relation (5) should contain the difference $(1/\lambda) - (1/\lambda_0)$ in its 1st member i.e.

De-Broglie wavelength: $\left(\frac{1}{\lambda}-\frac{1}{\lambda_0}\right)=\frac{p}{h}$ (not valid)

De-Broglie was an "etherist" (real waves need a real, –not mathematical-, medium to vibrate). Does the "ether" (or any ether or whatever it is in free space) really expose such an extremely great range of speeds for de-Broglie waves, extended from $u \to C$ (when $\upsilon \to C$) until infinite speeds $u \to \infty$ (when $\upsilon \to 0$)! Relation (6) was immediately recognized as flatly opposed to the relativistic conclusions about the speed of light C (as the upper speed in physics). That is why theorists argue that "*phase waves don't carry at all any energy with them!!*" Of course here the theoreticians are entirely wrong, for the following reasons: 1) the product ($h \cdot \nu$) –containing this very *phase frequency* – still has energy-dimensions; this means that the *phase wave* has energy by itself, 2) a phase wave carry and energy otherwise the superposition of two phase-waves, -to *wave-group* formation, should transfer not any energy and the formed group of waves should also be empty of energy!

Which should be the need for such superluminal speeds? Why Nature should be "hurry" to interact, - after de-Broglie calculations-, so rapidly or "instantly" $(u \to \infty)$ when it simply has to govern such slowly developed $(\upsilon \to 0)$ movements in space? Our calculation about De-Broglie wave have to corrected.

De Broglie - waves are mechanically produced agitation-waves in ether and like 'tails' follow -from back- the moving particles.

The motion of a particle in the ether can be parallelized with the motion of a bullet thought the air. The air seems, (in infrared photographs), to create a wave frond of compressed air which "initially expands around and back of the bullet" and which "later acquires its initial state after the passing of the bullet". Instead thus to consider the particles as coming into being by the suitable composition of waves, it is reasonable to think, that the particles as they move in ether can create behind waves.

We accept the De-Broglie wavelength of relation (5), but in order to avoid the superluminal speeds of propagation, we must introduce the frequency of the particle through the equation:

$$\nu \equiv \frac{K_{kinetic.energy}}{h}=\frac{m_0 \cdot c^2}{h}\left(\frac{1}{\sqrt{1-\frac{\upsilon^2}{c^2}}}-1\right) \qquad (7)$$

The de-Broglie waves should be generated when there should be a cause for that i.e. when the particle should move in "ether" and not when it is at rest." This mean: $\nu = 0$ when $\upsilon = 0$.

Relation (7) determines the frequency ν of the "tail–waves" following from back the moving particle. The speed of these "agitation-of-ether-waves" (following as "tails" behind the moving particles), is given by the equation:

$$u = \lambda \cdot \nu = \frac{c^2}{\upsilon}\left(1-\sqrt{1-\frac{\upsilon^2}{c^2}}\right) \approx \frac{\upsilon}{2} \qquad (8)$$

Ether agitation waves

According to my own opinion the De-Broglie waves seem to have their origin in the agitation of the ether medium after the passing of the moving particle. Thus the back space of the moving particle is occupied by the Slow De-Broglie waves (SDBWs). Let's calculate now the extension which acquires the SDBW behind the moving particle: For a De-Broglie period: $T=1/\nu=(2h)/(m\upsilon\upsilon)$ the moving particle has a velocity excess (relative to the velocity of the following SDBW), equal to $\upsilon/2$; thus during the time interval T (= De-Broglie period) is created behind the particle the De-Broglie wavelength: $\lambda = h/m\upsilon$. It seems very logical then the back agitated ether to permit to the group of free moving particles (but of the same mass and velocity) to be arranged the one after the other at distances equal to one De-Broglie wavelength.

The co-existence of any group of free moving particles (of the same mass and definite velocity $\vec{\upsilon}$) and of De-Broglie waves generated by agitation of the ether, forces each one of the particles to be micro-accommodated (or be micro-arranged) at distances λ the one after the other so that to form the **spatially coherent beams** of De-Broglie waves (where the particles acquire necessarily not random positions between them). This coherent beam of particles and their waves can produce the "*Bragg reflections*" in crystals (experiments [5, 6]), or to give ordinary Optical Interference -by the grating on the crystal surface – [7], or to produce interference fringes falling on a suitable "electric biprisma" [8].

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‘Slow De-Broglie waves’ in Bohr atom and *Bremsstahlung*

(How ether radiates in Bohr atom and *bremsstrahlung*)

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Abstract: Although, the higher than the basic ($n=1$) orbits of Bohr atom, are usually considered in Physics Texts as unstable ones (to say of a *life-time* $10^{-8}\,s$), yet we adopt here Bohr’s own assumption about the *stability* of his own homocentric electron orbits of his own model. The prediction of the total spectrum of hydrogen atom was really a very great success in Physics; but a physicist looking for a better, or more accurate *Causality* in the mechanics of Bohr atom, can points an apparent weakness:
1) Any photon emitted by Bohr atom cannot rise back (when it absorbed) the electron from one circular stable orbit to the next higher one (this can be obtained only by collisions with other atoms or electrons!).
2) As now Bohr circular orbits are considered stable and is need for one collision by another electron to detach the orbiting electron, this has to follow generally an elliptical trajectory (obeying Sommerfeld’s quantum rules). Let the orbiting electron was initially to say in 2nd orbit, and by an external collision it arrives at the vicinity of 4th stable circular orbit; but in order to be captured (or be introduced) this transposed electron to the 4th circular orbit, there should take place a “help” from a new suitable collision so its velocity to become tangent to the new 4th circular orbit (of course its velocity have to become suitable for that); whole the above procedure was to become “excited” the Bohr atom (from 2nd to 4th orbit) and now we should need two more collisions to make the said electron to be detached from 4th circular orbit and another suitable one to be set in the initial 2th circular orbit, then visual line H_β should be emitted; with whole the above mechanism of two necessary and probable collisions (detaching electron from 2nd and 4th orbits) and two other “helping” collisions (to introduce softly the detached electron respectively at 4th and 2nd orbits), the excitation and emission of any line from Bohr atom should become a scarce or impossible event. How nature realizes the “excitation-emission” of H-atom? This is the task of this paper.

1. The data from Bohr atom

1.1). Bohr had stated that angular momentum of the orbiting electron around the (heavy) nucleus is given by the relation:

$$(m\upsilon)\cdot r=\hbar\cdot n \qquad (9)$$

While the (circular) orbit is governed by the relation:

$$\frac{m\upsilon^2}{r}=\frac{e^2}{r^2} \qquad (10)$$

From (9) and (10) he got

$$\upsilon=\frac{e^2}{\hbar}\cdot\frac{1}{n} \qquad (11)$$

and

$$r_n=\frac{\hbar^2}{me^2}\cdot n^2=\alpha_1\cdot n^2 \qquad (12)$$

for *n*=1 he got the ‘first (basic) Bohr radius’

$$\alpha_1=\frac{\hbar^2}{me^2} \qquad (13)$$

The total energy of the *n*-th circular orbit is:

$$E_{(n)}=\frac{1}{2}m\upsilon_n{}^2-\frac{e^2}{r_n}=-\frac{1}{2}\frac{me^4}{\hbar^2}\cdot\frac{1}{n^2}=-\frac{1}{2}\cdot\frac{e^2}{r_n}=-\frac{1}{2}\cdot\left(\frac{e^2}{a_1}\right)\cdot\frac{1}{n^2} \qquad (14)$$

The energy of the electron at $(n+z)^{th}$ state is:

$$E_{(n+k)}=-\frac{1}{2}\frac{me^4}{\hbar^2}\cdot\frac{1}{(n+z)^2}=-\frac{1}{2}\cdot\frac{e^2}{a_1\cdot(n+z)^2} \qquad (15)$$

According to Bohr emission mechanism “the emitted photon was carrying out the difference of the total energies of the electron in its circular orbits”:

$$h\cdot\nu\equiv E_{(n+z)}-E_{(n)}=\frac{1}{2}\cdot\frac{e^2}{a_1}\left[\frac{1}{n^2}-\frac{1}{(n+z)^2}\right] \qquad (16)$$

1.2 A first weakness of Bohr atom

According to the Bohr emission mechanism "the emitted photon, why could not have to carry out, and an angular momentum $\left(\frac{h\cdot\nu}{c}\right)\cdot D$,- measured relative the stationary nucleus-, and equal to the difference of the angular momenta of the electron in the said orbits (n+z) and (n)"? i.e.

$$\left(\frac{h\cdot\nu}{c}\right)\cdot D = z\cdot\hbar \qquad (17)$$

D is the 'arm' or -normal- distance from stationary nucleus to the linear momentum vector $(h\cdot\nu/c)$ of the emitted photon. From (17), (16), and (13) we get

$$\frac{D}{\alpha_1} = 2\frac{\hbar\cdot c}{e^2}\left[z\cdot\frac{n^2\cdot(n+z)^2}{(n+z)^2-n^2}\right] \qquad (18)$$

The emitted photon from Bohr atom, cannot fulfill Bohr's own rule for "angular momentum changes of the transiting electron";
In order, "Bohr angular momentum rule", be fulfilled the emitted photon must be created at inconsistently large distances from the center of the atom: at least some hundreds or thousand times the 'Bohr first radius'. Thus, the absorbed photon is unable to raise the electron to a Bohr's higher homocentric orbit; we must search for some improving details in Bohr's emission mechanism.

1.3) A second difficult problem of Bohr atom

Bohr had assumed the "preferred" or "stable" homocentric circular orbits of the electron around nucleus. In this original Bohr model, the orbiting electron should not escape from its "stable" circular orbits without any "help", (i.e. collisions with other electrons or atoms -that is why we put it in a Geissler tube to receive the spectrum of the atom). By looking at Bohr atom (with its homocentric stable orbits) one untrained physicist should count "four" collisions, (from which at least "two" of them are suitable "helpings" -but very improbable-), in order to become able the atom to radiate a photon**:** First, one collision (this is probable) to extract electron from "n^{th} –stable circular orbit"-; second, another suitable helping collision (very improbable) to park this ejected, electron in "$(n+k)^{th}$-stable circular-orbit"; third, we need a new collision (this is probable) to eject the orbiting electron from its intermediate $(n+k)^{th}$-stable circular-orbit to the initial "n^{th}-orbit" and fourth, another suitable helping collision (very improbable) to park back the electron in its initial "n^{th}–stable- circular-orbit"; by that manner the photon is emitted due of the transition:{(n+k) → n}. Such two "successive – suitable - collisions or helps" to the "absorption-emission process" should make the phenomenon of absorption and emission **extremely scarce or impossible** of course one should think that and the calculation of energy emission should become quite unpredictable.
Our purpose is to understand the 'excitation-emission' mechanism of nature.

TABLE I

First lines of Hydrogen atom spectrum series (z =1)		"Arm" D of the angular momentum of the emitted photon from nucleus	
		D/α_1	$D/[\alpha_1(n+1)^2]$
Lyman	n =1	365	91
Balmer	n =2	1973	219
Paschen	n =3	5676	355
Brackett	n =4	12178	487

1.4) The Bohr - Sommerfeld atom

Sommerfeld had generalized, Bohr's own quantum rule about the momentum of the electron, and extended it to express and the elliptical electron orbits of H-atom. The elliptical electron orbits of H-atom, given by Sommerfeld, are "prefered" among the infinite variety of possible elliptical orbits.
Sommerfeld's ellipses partially solve the above apparently difficult problem of Bohr atom

Due of the Coulomb central force of the proton (taken for simplicity at absolute rest):
1) The electron describes an elliptical orbit with proton placed at its one, of the two foci:

$$r = \frac{P}{1 + \varepsilon \cdot \cos\theta} \qquad (19)$$

P is the parameter and ε the eccentricity of the ellipse.
2) The angular momentum of the electron around the (resting) proton is constant

$$M = m \cdot r^2 \dot{\theta} \qquad (20)$$

3) The total energy of the electron is also constant:

$$E = \frac{1}{2} m(\dot{r}^2 + r^2 \dot{\theta}^2) - \frac{e^2}{r} \qquad (21)$$

From (19) we get by differentiation with θ:

$$\frac{dr}{d\theta} = \frac{P \cdot \varepsilon \cdot \sin\theta}{(1 + \varepsilon \cdot \cos\theta)^2} \qquad (22)$$

After (22), (19) and (20) we get:

$$\dot{r} = \frac{dr}{d\theta} \cdot \dot{\theta} = \frac{\varepsilon \cdot M}{m \cdot P} \cdot \sin\theta \qquad (23)$$

After (23), (20) and (19) the equation (21) for the Energy of the electron becomes:

$$E = -\frac{e^2}{P} + \frac{1}{2}\frac{M^2}{mP^2}(1 + \varepsilon^2) + \left(\frac{M^2 \varepsilon}{mP^2} - \frac{e^2 \varepsilon}{P}\right)\cos\theta \qquad (24)$$

Since E is an integral i.e. constant at any position of the electron orbit the parenthesis factor of $\cos\theta$ above must be zero and thus we deduce:

$$P = \frac{M^2}{m \cdot e^2} \qquad (25)$$

the above equation for the Energy becomes:

$$E = -\frac{1}{2} \cdot \frac{me^4}{M^2} \cdot (1 - \varepsilon^2) \qquad (26)$$

The kinetic energy of the electron (responsible for SDBW) is:

$$T = \frac{1}{2} \cdot \frac{me^4}{M^2}(1 + 2\varepsilon \cdot \cos\theta + \varepsilon^2) \qquad (27)$$

Let us now consider Sommerfeld's quantum condition:

$$\oint \vec{p} \circ \vec{ds} = n \cdot h \qquad (28)$$

(h is Planck's constant, and n is proper quantum number)
Since it is

$$\vec{p} = m\dot{r} \cdot \vec{r}_o + m(r\dot{\theta}) \cdot \vec{\theta}_o$$

and

$$\vec{ds} = dr \cdot \vec{r}_o + rd\theta \cdot \vec{\theta}_o$$

$\vec{r}_o$ and $\vec{\theta}_o$ are respectively the unit vectors along the distance $\vec{r}$ and the normal to it (turned 90° CCWS)
Due of the last two equations the condition (28) becomes:

$$\oint \vec{P} \cdot \vec{ds} = \oint (m\dot{r})dr + \oint (mr\dot{\theta})rd\theta = \\ = k \cdot h + \ell \cdot h \qquad (29)$$

i.e. we have a relation of integers:

$$k + \ell = n \qquad (30)$$

By taking in mind (20) we get

$$\oint (mr\dot{\theta})rd\theta = \oint \mathrm{M}d\theta = 2\pi \cdot \mathrm{M} \equiv \ell \cdot h \qquad (31)$$

while by taking in mind (23), (22), (20) and (19) we get

$$\oint(m\dot{r})dr = M\varepsilon^2\oint\frac{\sin^2\theta}{(1+\varepsilon\cos\theta)^2}d\theta \qquad (32)$$

But since it is

$$\oint\frac{\sin^2\theta}{(1+\varepsilon\cos\theta)^2}d\theta = \frac{2\pi}{1-\varepsilon^2+\sqrt{1-\varepsilon^2}}$$

relation (32) becomes

$$\oint(m\dot{r})dr = \frac{2\pi\cdot M\varepsilon^2}{1-\varepsilon^2+\sqrt{1-\varepsilon^2}} \equiv k\cdot h \qquad (33)$$

From (31) we get

$$M = \frac{h}{2\pi}\cdot\ell \equiv \hbar\cdot\ell \qquad (34)$$

while substituting (34) into (33) we get

$$\frac{\varepsilon^2}{1-\varepsilon^2+\sqrt{1-\varepsilon^2}} = \frac{k}{\ell} \qquad (35)$$

In Relation (35) we put $k = n-\ell$ and thus the eccentricities ε of the elliptical orbits are found:

$$\varepsilon \equiv \sqrt{1-\frac{\ell^2}{n^2}} \qquad (36)$$

Substituting in (26) relation (34) and (36) we get
The Energy of the electron in n^{th} quantum state is:

$$E_n = -\frac{1}{2}\cdot\frac{me^4}{\hbar^2}\cdot\frac{1}{n^2} \qquad (37)$$

For $k=0$ i.e. when ($n=\ell$) it is $\varepsilon = 0$, and we get Bohr's homocentric "stable circular electron orbits":

$$P = a_1\cdot\ell^2 \qquad (\text{where } \ell = n) \qquad (38)$$

here $a_1 = \frac{\hbar^2}{me^2}$ is the radius of basic Bohr orbit

Sommerfeld's elliptical orbits have the following equations.

$$r = \frac{\ell^2\cdot a_1}{1+\varepsilon\cdot\cos\theta} = \frac{\ell^2\cdot a_1}{1+\sqrt{1-\frac{\ell^2}{n^2}}\cdot\cos\theta} \qquad (39)$$

1.5) Sommerfeld's ellipses and their families: of Lyman ($\ell=1$), of Balmer ($\ell=2$), of Phaschen ($\ell=3$)…

In Bohr atom its basic angular momentum is $\ell = 1,$ (and $k=0$) it is $n\equiv(\ell+k)=1,$ it corresponds to the "first (basic) circular stable orbit of the electron"; Bohr basic orbit and the other ellipses of the family $\ell = 1,$ with increased eccentricities and energies E_n i.e. with $k = 1,2,3,..$ and $n\equiv\ell+k = 2,3,4$, will regarded here to belong all to the "Lyman family of orbits".

"Lyman family of orbits" can radiate only the Lyman series. Bohr basic circular orbit ($\ell = 1,\ k = 0,$ and $n\equiv\ell+k=1,$) contains the proton in its center. This basic circular orbit cuts by its diameter all the ellipses of "Lyman family". We will see that all the Lyman ellipses with $\ell = 1,$ and $k = 1,2,3,..$ (and $n = \ell+k \geq 2,$) start and finish at the ends of diameter of Bohr basic orbit:

$$R_{BOHR...1..ORBIT} \equiv a_1 \qquad r_{LYMAN...FAMILY} = \frac{1^2\cdot a_1}{1+\sqrt{1-\frac{1^2}{(1+k)^2}}\cdot\cos\theta} \qquad (40)$$

by these ellipses only and Bohr 1-orbit it becomes possible the process of "excitation and emission" of Lyman serie

$$\frac{1}{\lambda_{Ly}} = R_{ydberg}\cdot\left(\frac{1}{1^2}-\frac{1}{(1+k)^2}\right)$$

"Balmer family of orbits" can radiate only the Balmer series. For the "second" Bohr circular orbit we have: $\ell = 2$,($k=0$) and $n\equiv(\ell+k)=2,$ this "second" circular orbit cuts by its diameter all the ellipses of "Balmer family" $\ell = 2$,($k = 1,2,3,..$). We see that all

the Balmer ellipses of successively increasing energies –and eccentricities- with $\ell = 2$ and $k = 1,2,3,...$ (and $n \equiv \ell + k \geq 3,$), start and finish at the ends of diameter of the "second" Bohr orbit:

$$R_{BOHR...2..ORBIT} \equiv 2^2 \cdot a_1 \qquad r_{BALMER...FAMILY} = \frac{2^2 \cdot a_1}{1 + \sqrt{1 - \frac{2^2}{(2+k)^2}} \cdot \cos\theta} \qquad (41)$$

by these ellipses only and Bohr 2-orbit it becomes possible the process of "excitation and emission" of Balmer series

$$\frac{1}{\lambda_{Ba}} = R_{ydberg} \cdot \left(\frac{1}{2^2} - \frac{1}{(2+k)^2} \right)$$

"Paschen family of orbits" can radiate only the Paschen series. For the "third" Bohr circular orbit we have $\ell = 3$,($k = 0$) and $n \equiv (\ell + k) = 3,$; this "third" circular orbit cuts by its diameter all the ellipses of "Paschen family". We see that all the Paschen ellipses of successively increasing energies –and eccentricities- with $\ell = 3$ and $k = 1,2,3,...$ (and $n \equiv \ell + k \geq 4,$), start and finish at the ends of diameter of the "third" circular Bohr orbit:

$$r_{BOHR...3..ORBIT} \equiv 3^2 \cdot a_1 \qquad r_{PASCHEN...FAMILY} = \frac{3^2 \cdot a_1}{1 + \sqrt{1 - \frac{3^2}{(3+k)^2}} \cdot \cos\theta} \qquad (42)$$

by these ellipses only and Bohr 3-orbid it becomes possible the process of "excitation and emission" of Paschen serie

$$\frac{1}{\lambda_{Pa}} = R_{ydberg} \cdot \left(\frac{1}{3^2} - \frac{1}{(3+k)^2} \right)$$

Similarly we work with the other families of Brakett, Pfund, Humphrey, etc.

2.1) The De-Broglie wave superposition over Bohr circular orbits.

Since our college epoch the Atomic Physics Text drawings for Bohr atom, we have been familiarized with the strong influence of De-Broglie waves on electron orbit; the Bohr atom is presented as a circular stable electron orbit (around nucleus) and on this orbit are superimposed the 'De-Broglie propagating waves', containing an *integer number* of wavelengths; this is written in mathematical form:

$$\frac{2\pi \cdot r}{\lambda_{D-B}} = \frac{2\pi \cdot r}{h/(m \cdot \upsilon)} = \frac{(m\upsilon) \cdot r}{\hbar} = n \qquad (43)$$

In the (43) condition there have been incorporated both: the De-Broglie wave coherence over the "stable circular orbits of the electron" and also it has been produced Bohr's condition for his own "stable circular orbits of the electron". Now we can ask our own question**: How does the De-Broglie wave could encircle the atom?**

2.2) Answering the question: "How does the De-Broglie wave could encircle atom?"

If the De-Broglie waves were propagating straight way at superluminal speeds how they could be curved around the atom? We know that only the electron was attracted by nucleus and now we are forced to admit that and the mysterious De-Broglie waves are also being attracted (at larger and larger forces, -as we go outside the atom-, because of their greater and greater superluminal speeds of De-Broglie waves emerging from the slower and slower moving orbiting electrons -as we go outside the atom-)!

The answer is only one: "the De-Broglie waves encircle and are superimposed of the 'circular stable orbit of the electron' because these waves are released passively as 'tail - waves' behind the electron following it at half the velocity of the particle ($\upsilon / 2$) – here electron-".

2.3) The De-Broglie's strong frequency is tuned over Bohr circular orbit.

From equation (7) we get, -by definition-, the De-Broglie frequency of the orbiting electron on Bohr circular orbit:

$$v_{De-Broglie} \equiv \frac{1}{2} \cdot \frac{m}{h} \cdot \upsilon_\ell^{\,2} = \frac{1}{2} \cdot \frac{m}{h} \cdot \frac{e^4}{\hbar^2 \cdot \ell^2} \equiv \frac{1}{T_{De-Broglie}} \qquad (44)$$

Thus we get for the period of De-Broglie wave:

$$T_{De-Broglie} \equiv \frac{2 \cdot h}{m \cdot \upsilon_\ell^{\,2}} = \frac{2 \cdot h}{m} \cdot \frac{\hbar^2 \cdot \ell^2}{e^4} \qquad (45)$$

this period is the 'time interval' which needs a De-Broglie wave to travel a distance $\lambda_{De-Broglie}$ at its velocity $\upsilon / 2$:

$$t = \frac{\lambda_{De-Broglie}}{\upsilon / 2} = \frac{h/(m\upsilon_\ell)}{\upsilon_\ell / 2} = \frac{2 \cdot h}{m \cdot \upsilon_\ell^{\,2}} = T_{De-Broglie} \qquad (46)$$

As now the Bohr circularly - orbiting electron has a velocity excess exactly equal to $\upsilon/2$, relative to the velocity of its tail-wave, it means that the "head-electron" needs the same time to pass through a traveling De-Broglie wavelength $\lambda_{De-Broglie}$

$$t_{electron.to.travel.over.a.propagating.wavelength} = \frac{\lambda_{De-Broglie}}{\upsilon/2} = \frac{h/(m\upsilon_\ell)}{\upsilon_\ell/2} = \frac{2\cdot h}{m\cdot \upsilon_\ell^{\,2}} = T_{De-Broglie} \qquad (47)$$

The equality of the three time-periods given by the relations (45), (46) and (47) reveal both: 1) The strength of the de-Broglie frequency which is superimposed over the Bohr circular orbits, and 2) The related very strong stability of Bohr circular orbits. This stability is obtained due of the condition (43) and the discussed properties of the de-Broglie waves.

These De-Broglie propagating waves tuned over the Bohr circular orbit(s) become very strong and these are continuing to vibrate and circulate along the Bohr circular orbit even during a **"short absence of the electron"** (due of its elevation in the related family of elliptic orbits) and these long circulating De-Broglie waves are able to do both: (1) to radiate out instantly (as photon the difference of the frequencies of SDBWs of the excited electron minus the frequency of the tuned Bohr orbit) and (2) to catch back, -to the Bohr circular orbit- the just (previously) excited electron; the emission of a visual photon –of the "weak" momentum $\{(h\nu)/c\}$- cannot push back the electron to its own initial circular orbit; this is obtained only by the action of the strongly tuned SDBWs along the basic circular orbit.

2. 5) How the emission mechanism may works in Bohr H-atom

The "De-Broglie standing waves" over Bohr orbit are sufficiently strong and these are vibrating even in a "absence of the electron. The tuned De-Broglie frequency (over Bohr circular orbit) is responsible to both: (1) To radiate out instantly (as photon the difference of the frequencies of SDBWs of the excited electron minus the frequency of the tuned Bohr orbit) and (2) To catch back, to the initial Bohr circular orbit the just (previously) excited electron; conclusively the SDBWs being into the circular orbits offer the mechanism by which the energetically "excited - elevated" electron can "remember" its previous frequency (and its previous energy), and thus to be emitted each time the correct difference of frequencies as photons.

Additionally the just-previously excited electron can be catch back in circular Bohr orbit.

Applying initially 500-800 Volts outside the Hydrogen Geissler tube until to pass through it an electric current. There takes place first the dissociation of H_2 molecule in H atoms. There also occurs excitation of the electron from Bohr basic circular orbit; necessarily this electron have to go statistically to the elliptical orbits of the Lyman family; half of these electrons following the short path of ellipses may emit the first photons; while statistically the other half of electrons will follow the long paths during of which the electrons may collide, (with other external electrons), and then the corresponding (2^{nd} , 3^{rd} , 4^{th} …) Bohr circular –stable- orbits may be established. At this point we will refer to the Fig. 1.

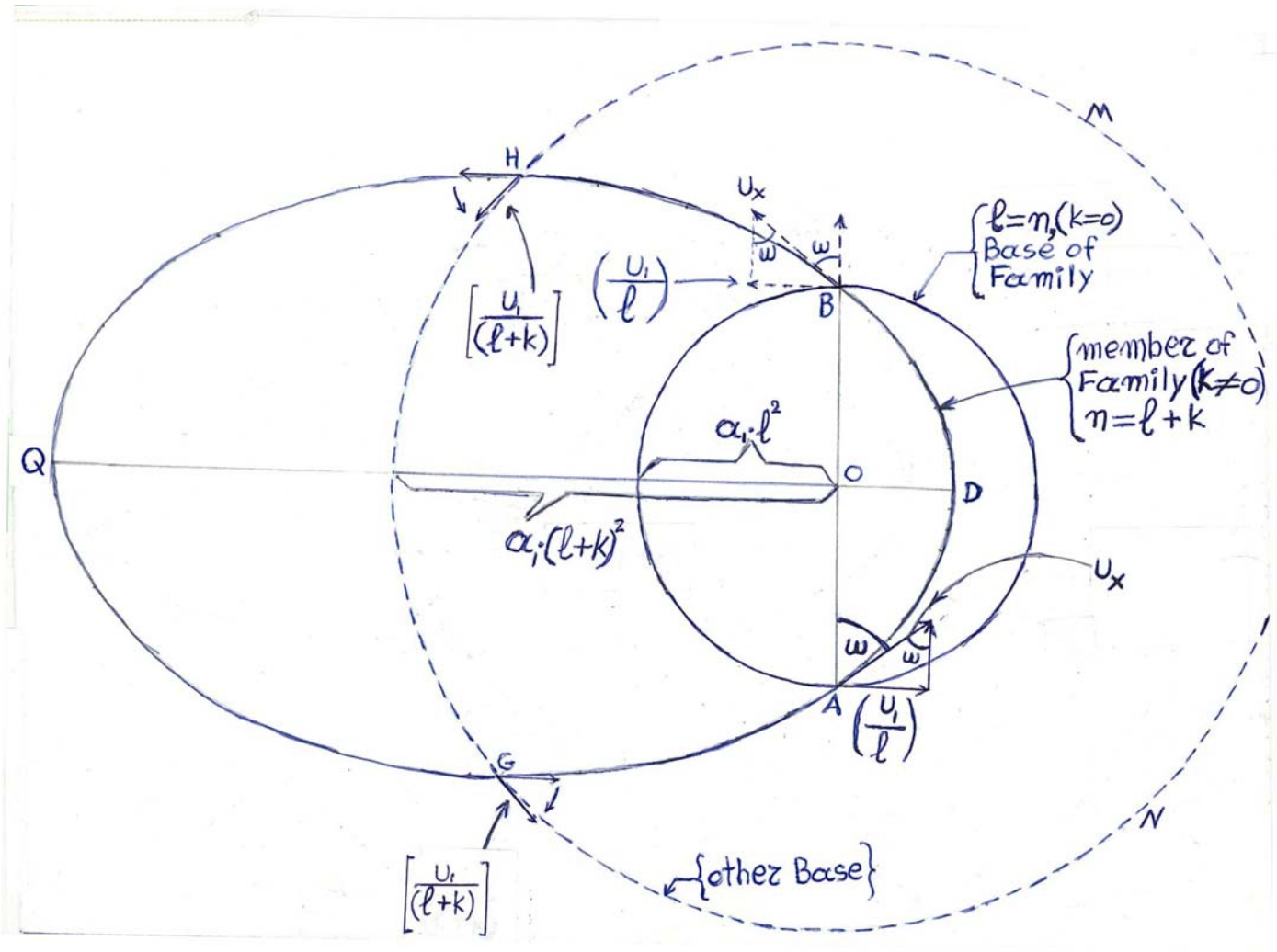

Figure 1

Fig.1 is showing the ℓ th circular Bohr orbit or radius $a_1\cdot\ell^2$, (ℓ is the quantum number of its angular momentum), and where the rotating electron moves CCW at a velocity υ_1/ℓ (vectors $\frac{1}{\ell}\cdot\vec{\upsilon}_1$ are shown tangential at the points A and B of the orbit). Now let us consider external perpendicular pushes (-made by electrons-) to the vectors $\frac{1}{\ell}\vec{\upsilon}_1$ making the rotating electrons to acquire the "excited" velocity vectors $\vec{\upsilon}_x$ (at point A or B) it will be

$$\vec{\upsilon}_x=\left(\frac{\vec{\upsilon}_1/\ell}{\sin\omega}\right). \qquad (48)$$

The pointed angle ω is between the diameter AB and vectors $\vec{\upsilon}_x$ (tangent to the ellipse of - ℓ -family- with proper quantum number $n=\ell+k$) we have from analytic geometry:

$$\frac{1}{\left(\sin^2\omega\right)_{\theta=\pi/2}}\equiv\frac{(rd\theta)^2+(dr)^2}{(rd\theta)^2}=1+\left(\frac{dr}{r\cdot d\theta}\right)^2=1+\left(\frac{\varepsilon^2\cdot\sin^2\theta}{(1+\varepsilon\cdot\cos\theta)^2}\right)_{\theta=\pi/2}=1+\varepsilon^2$$

$$\frac{1}{\left(\sin^2\omega\right)_{\theta=\pi/2}}=1+\varepsilon^2=2-\frac{\ell^2}{(\ell+k)^2} \qquad (49)$$

By squaring relation (48), and with the help of (49) we get:

$$\vec{\upsilon}_x^2=\frac{\upsilon_1^2/\ell^2}{\sin^2\omega}=\frac{\upsilon_1^2}{\ell^2}\cdot\left(2-\frac{\ell^2}{(\ell+k)^2}\right)$$

$$\vec{\upsilon}_x^2 - \frac{\upsilon_1^2}{\ell^2} = \frac{\upsilon_1^2}{\ell^2}\cdot\left(1-\frac{\ell^2}{(\ell+k)^2}\right) = \upsilon_1^2\cdot\left(\frac{1}{\ell^2}-\frac{1}{(\ell+k)^2}\right)$$

and

$$\frac{1}{2}\cdot m\vec{\upsilon}_x^2 - \frac{1}{2}\cdot m\left(\frac{\upsilon_1}{\ell}\right)^2 = \frac{1}{2}\cdot m\left(\frac{\upsilon_1}{\ell}\right)^2\left(1-\frac{\ell^2}{(\ell+k)^2}\right) = \frac{1}{2}m\upsilon_1^2\cdot\left(\frac{1}{\ell^2}-\frac{1}{(\ell+k)^2}\right) = h\cdot\nu \quad (50)$$

The last equation expresses the difference of the kinetic energies -at the point A (and B)- after and before the external collision. At point A the electron was "excited" and after the short travel ADB the electron emits the difference of kinetic energies at point B. The same excitation of the circularly rotating electron can happen at point B and after the traveling along BZA the excited electron can emit the difference of kinetic energies at point A; meanwhile along the long path BZA there is some probability to be turned, at the distance $a_1\cdot(\ell+k)^2$ from nucleus -by suitable collision-, the direction (only) of the velocity $\frac{1}{(\ell+k)}\cdot\vec{\upsilon}_1$ thus the circular orbit –of radius $a_1\cdot(\ell+k)^2$ and of – orbital velocity $\frac{1}{(\ell+k)}\cdot\vec{\upsilon}_1$ of the electron to be formed. Thus from the basic Bohr circular orbit $\ell=1,$ the next ones can be obtained and the families (Lyman, Balmer, etc) can radiate.

Important notes.

1). In Lyman series the "pushes" of the external electrons along the diameter of the basic circular orbit $(\ell=1)$ have to have the following energy transfer to the "excited" kinetic energy of the electron as the table

Energy transfer for formation of Lyman family of ellipses

From the basic circular orbit ($\ell=1,$) of kinetic energy: $\frac{1}{2}\cdot m\vec{\upsilon}_1^2 = 13.60$ (eV)			
To excited energy at A $\frac{1}{2}\cdot m\vec{\upsilon}_{(\ell=1,k=1)}^2$	To excited energy at A $\frac{1}{2}\cdot m\vec{\upsilon}_{(\ell=1,k=2)}^2$	To excited energy at A $\frac{1}{2}\cdot m\vec{\upsilon}_{(\ell=1,k=3)}^2$	To excited energy at A $\frac{1}{2}\cdot m\vec{\upsilon}_{(\ell=1,k=4)}^2$
Energy transfer 10.20 (eV)	Energy transfer 12.09 (eV)	Energy transfer 12.75 (eV)	Energy transfer 13.056 (eV)

In Balmer series the "pushes" of the external electrons along the diameter of the second circular orbit $(\ell=2)$ have to have the following energy transfers to the "excited" kinetic energy of the electron as the table

Energy transfer for formation of Balmer family of the ellipses

From the basic circular orbit ($\ell=2,$) of kinetic energy: $\frac{1}{2}\cdot m\vec{\upsilon}_1^2/4 = 3.4$ (eV)			
To excited energy at A $\frac{1}{2}\cdot m\vec{\upsilon}_{(\ell=2,k=1)}^2$	To excited energy at A $\frac{1}{2}\cdot m\vec{\upsilon}_{(\ell=2,k=2)}^2$	To excited energy at A $\frac{1}{2}\cdot m\vec{\upsilon}_{(\ell=2,k=3)}^2$	To excited energy at A $\frac{1}{2}\cdot m\vec{\upsilon}_{(\ell=2,k=4)}^2$
Energy transfer 1.89 (eV)	Energy transfer 2.55 (eV)	Energy transfer 2.856 (eV)	Energy transfer 3.022 (eV)

This second table reveals that if we are interested to have a good function of the Geissler to produce the Balmer series then it is need to reduce up to 5 times the original voltage of the Geissler. Thus from the statistically greater electron energies the 1st Lyman ellipse can be formed, from which the 2nd circular orbit can formed (as fig. 1 shows). After the formation of the 2nd circular orbit the lower electron acceleration can form the Balmer family of ellipses to receive the Balmer series.

2). The fact that the 2nd, 3rd ,… etc circular orbits are constant i.e. "long lived", (-in absence of external collisions-), due of the property of the de-Broglie tail waves; this do expressed experimentally by the fact that hydrogen Geissler is turned on and off automatically in time intervals of 30 seconds in order to saved the life of the Geissler tube. The fact that after 30 s the Balmer works well it means the long living of 2nd circular orbit, etc. **3).** In the modern Texts of Atomic Physics there are referred to the "Rydberg atom" with $(\ell=10^4-10^5)$ i.e. of magnitude of a bacterium; The existence of such large hydrogen atoms is due to the properties of SDBW. **4).**On the other hand microwave radiations come from hydrogen atom with $(\ell=200-500)$ etc . The existence of such large hydrogen atoms is due to the properties of SDBW.

***Bremsstrahlung* (an effect of De-Broglie tail waves in ether)**

In *bremsstrahlung* the emission of photon is created at the "end" of the abrupt deceleration process of the electron; if the final kinetic energy of the electron is T_{final} then its "final De-Broglie local frequency" in ether is T_{final}/h and thus the incoming wave tail -at greater speed-, of the "initial De-Broglie local frequency" of electron should interfere with the present "final frequency" and the difference of these frequencies (of these De-Broglie states) is emitted as photon. "Ether needs a coherence in its vibrations and this be satisfied by the presence in the same point of identical frequencies of De- Broglie waves but when meet two rays of De-Broglie waves having different frequencies (and energy) then ether have to radiate-out and away any difference of the crossing frequencies - i.e. ether radiates the frequency-:

$$\nu = (T_{initial} - T_{final})/h \qquad (51)$$

and if the final kinetic energy becomes very small ($T_{final} \approx 0$), the emitted photon has frequency

$$\nu = (T_{initial} - T_{final})/h \approx \frac{1}{2}\cdot\frac{m\cdot\upsilon^2_{initial}}{h} \qquad (52)$$

The in-coming from back de-Broglie-waves explain how the electron "memorizes" its own initial kinetic energy and how the "difference between the initial-final kinetic energies" is emitted as a photon but from ether.

As the emission of photon is realized in Bohr atom by the emission of the superfluous kinetic energy of the electron the same can very well be applied and in the understanding of *Bremsstrahlung* emission mechanism.

***Bremsstrahlung*.** Since the emission of the homonymous photons occurs when the kinetic energy of the fast moving electrons be reduced or be zeroed the following question arises: How does the electron "remember" its *previous* or its own *original* kinetic energies so to emit the photon (what is more in absence of quantum numbers):

$$\frac{1}{2}\cdot m\cdot(\upsilon^2_{initial} - \upsilon^2_{final}) = h\cdot(\nu_{initial} - \nu_{final}) = h\cdot\nu$$

this "memory" (is realized in nature by means of the "initial SDBWs" "coming from back" or "-following from back" the electron- and which "initial SDBWs" fall on the "final -(but more slowed)-SDBWs"; The difference of the frequencies between the "initial" and the "final" SDBWs forces the vibrating ether to the emission of the suitable photon in ***Bremsstrahlung.***

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The SDBWs of basic Bohr orbit of He-atom, radiate out the difference of the frequencies (of SDBWs), of the excited electron.

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SDBWs = Slow De-Broglie Waves (following from back the moving particles) (see above)
In this paper, we try to determine the basic Bohr orbit of the He atom as well and the position of the second electron, by making use of the two ionizing potentials of He atom. We then study only one "of the persistent lines" (selected in visual range λ = 5875.615 Angstroms); and prove that there are four ways (two, for each one of the two electrons of He atom,) to be excited and radiate out this wavelength but of course only when the excited electron is "plunged" back into Bohr basic orbit (tuned by SDBWs).

Introduction

We will start with a classical **determination of Planck constant** $\hbar$ by means of the ionization energy of the He^+ atom and the presumably known magnitudes of the electron charge and mass. The electric charge is taken $e = 4.8031 \cdot 10^{-10}$ esu and the electron resting mass equal to and $m_o = 9.10914 \cdot 10^{-28}$ gr. The least ionization energy for the neutral He atom is 24.587387936 eV (i.e. this energy is the least one which if be offered to the "external electron" it comes out from atom –with nearly zero kinetic energy-); while the ionization energy of He^+ atom is 54.41776311 eV (this is the least energy required to detach and the second electron from its inner orbit so to eject it outside the He^+ atom, –also with nearly zero kinetic energy-,).

We can use safely the accepted equivalence coefficient:

$$1\,eV = 1.60214170564 \cdot 10^{-12} \text{ ergs},$$

Thus we get the values of the two above ionization energies in ergs:

The first ionization energy of the neutral He atom is $E^+ = 39.392479645 \cdot 10^{-12}$ ergs, while the second ionization energy for is $E^{++} = 87.1849678061 \cdot 10^{-12}$ ergs.

Our purpose is to determine and the **fundamental radius** R of the simply ionized helium atom He^+ as well the constant $\hbar$ i.e. the angular momentum of the first captured electron revolving at the above distance R around the nucleus of He^+ atom.

The He nucleus (α-particle) initially caches one electron in its basic orbit –i.e. the closest one to the nucleus- (in which the electron has negative total energy equal to $-E^{++}$) and where there is need the positive energy $E^{++} = 87.1849678061 \cdot 10^{-12}$ to be offered to the electron in order this electron to be liberated i.e. to acquire zero energy.

The equation of the circular motion of the single electron around nucleus is given by equation

$$\frac{2 \cdot e^2}{R^2} = \frac{m_o \cdot \upsilon^2}{R} \qquad (1)$$

and

$$\frac{e^2}{R} = \frac{1}{2} \cdot m_o \cdot \upsilon^2 \qquad (2)$$

Now we can write down the equation of the energy of the first cashed electron (we have to offer the above E^{++} energy to the electron in order it to come far out from the attraction of nucleus -at nearly zero kinetic energy-):

$$\frac{1}{2} \cdot m_o \cdot \upsilon^2 - \frac{2e^2}{R} = -E^{++}$$

or

$$\frac{1}{2} \cdot m_o \cdot \upsilon^2 - \frac{2e^2}{R} + E^{++} = 0 \qquad (3)$$

From relations (2) and (3) we get finally

From (2) we get

$$m_o \cdot \upsilon^2 = \frac{2 \cdot e^2}{R}$$

$$R = \frac{e^2}{E^{++}} = 0.26460719308 \ A^o \ (1A^o = 10^{-8} \text{ cm}) \qquad (4)$$

The magnitude of Planck constant $\hbar$ (after Bohr) is stated

$$\hbar^2 \equiv m_o \cdot m_o \upsilon^2 \cdot R^2 = 2 \cdot m_o \cdot \frac{e^4}{E^{++}} \qquad (5)$$

$$\hbar = e^2 \sqrt{\frac{2 \cdot m_o}{E^{++}}} = 1.05457176136 \text{ cgs} \qquad (6)$$

The value of: $h \equiv 2\pi \cdot \hbar = 6.626069796 \cdot 10^{-27}$ cgs (7)

The period for the revolution of the "circularly orbiting electron" is:

$$T = \frac{1}{\nu} = \frac{2\pi \cdot R}{\upsilon} = \frac{2\pi \cdot R}{e} \cdot \sqrt{\frac{R \cdot m_o}{2}} \qquad (8)$$

and the angular speed of the same electron is:

$$\omega = 2\pi \cdot \nu = \frac{e}{R} \sqrt{\frac{2}{R m_o}} = 1.6534667625 \cdot 10^{17} \text{ rads/s} \qquad (9)$$

Guess about the trajectory of the second orbiting electron.

Due of the strong tuning of SDBWs and the quantization of the circular orbit -of radius R -, we can assume this circular orbit as sufficiently stable (with the radius R and angular speed ω being both of constant magnitude all the time). On the other hand since of the constancy of the He neutral atom, -this constancy becomes more and more certain after repeated bombardments by external electrons-. For above two reasons one can assume the simplest assumption i.e. that both electrons have been caught in the same orbit (avoiding any crossing of orbits and any unpleasant close approximation of the mutually repelled electrons).

Let's now determine the angular distance Θ between the two electrons A and B; –both of them are considered moving CCW where A is going first and B is following-; now we will apply the equation of the energy of the second electron (both rotating in distance R from nucleus and having both the same kinetic energy):

$$\frac{m_o \upsilon^2}{2} - \frac{2e^2}{r} + \frac{e^2}{R\sqrt{2-2\cos\Theta}} - \frac{\mu^2}{R^3\sqrt{(2-2\cos\Theta)^3}} = -E^+ \qquad (10)$$

where the 3rd term is referred to the Coulomb repulsion potential of electrons while the 4th term (containing magnetic moments μ^2) is referred to the spin-spin attraction potential – as both spins are opposite at low energies-. We accept for the magnetic moments the magnitude

$$\mu^2 = \left(\frac{e}{m_o \cdot c}\right)^2 \cdot \left(\frac{\hbar}{2}\right)^2$$

After the substitution of all known constants and data the solution of relation (10) for $\cos\Theta$ gives:

$$\cos\Theta = -0.6638725105$$

$$\Theta = 2.296781484 \text{ rads}$$

Our conclusion is that the two electrons say A and B of the undisturbed He-neutral atom are forming an open pair and are separated by the small angle Θ (AΘB) on fundamental orbit of radius R. We mention again that both electrons A and B be rotating CCW with the same angular speed ω and the same angular momentum $\hbar$ around nucleus.

Now let us select the visual wavelength λ = 5875.615A^o (from the NIST catalog of the "persistent lines" of neutral He-atom-).

Now we can imagine four ways, of (electronic) excitation of either one of the two electrons A or B:

(a) The A-electron is kicked, (by electrons), to the outside of circle R, (b) The B-electron is kicked, (by electrons), to the outside of circle R, (c) The A-electron is kicked, (by electrons), to the inside of circle R, (d) The B-electron is kicked, (by electrons), to the inside of circle R.

If now in the vicinity of each one of the above four excitations is present any traveling photon, of energy equal to the additional kinetic energy offered to the excited electron, then we can assume that this photon is absorbed. (Due of the smallness of the energy of visual photons the "persistent photons" carry least linear momentum $h\nu/c$ which cannot form one "additional angular momentum" so to alter (or be added) to the constant $\hbar$; that is why the persistent radiation needs the electronic excitation of A or B electrons).

The energy of the photon of the said persistent line is added to the "initial energy $-E^+$ " of the "now excited electron" so to increase its own total energy up to the level $\left(-E^+ + h\cdot\frac{c}{\lambda}\right)$;

But due of the constancy of $\hbar$ and of R-orbit we can assume safely that each one of the above excited electrons A (or B) cannot exchange energy or angular momentum with the other electron revolving in R-orbit; and this means that the excited electron keeps also constant its angular momentum at $\hbar$ and its own new energy during the "flying" of the excited electron; the "flying" of the excited electron ends at the crossing of the 'excited trajectory' to R-orbit where the absorbed photon is re-emitted back).

Due of the constancy of the angular momentum ($\hbar$) of the excited electrons A or B and due of the repulsion of other electron (orbiting the R-orbit) the excited electron can be assumed to perform an ellipse that "slides" (i.e. appearing revolution of its axes):

$$r = \frac{P}{1 \pm \varepsilon \cdot \cos\Phi} \qquad (11)$$

The parameter P of the ellipse is the distance *r* from the nucleus when eccentricity ε = 0 or when Φ = π/2 thus we get $P = R$ and thus for an ellipse of rotating axes the Φ is written as

$$\Phi = (\pi/2) + z\cdot\varphi \qquad (12)$$

where *z* is a positive factor (under determination in case) and φ is a real angle in the plane of the R-circle, -measured CCW-.

For the cases of excitation (a) and (b) where the excited electrons travel outside of R-circle we will use the r_{max} of the ellipses (11); thus we will use the formula $r = \frac{R}{1+\varepsilon\cos[(\pi/2)+z\cdot\varphi]}$ (13)

with the real angle φ, (-measured in the level of R-circle-), being measured from the point of excitation (φ=0) to the direction of the general motion (CCW) up to the point r_{max} where is $\varphi = \pi/2\cdot z$

(of course the center of measurement is the nucleus).

But for the cases of excitation (c) and (d) where the excited electrons travel inside of R-circle we will use the r_{min} of the ellipses (11); thus we will use the formula $r = \frac{R}{1-\varepsilon\cos[(\pi/2)+z\cdot\varphi]}$ (14)

with the real angle φ, (-measured in the level of R-circle-), being measured from the point of excitation (φ=0) to the direction of the general motion (CCW) up to the point r_{min} where is $\varphi = \pi/2\cdot z$

(of course the center of measurement is the nucleus).

Now we are ready to apply the energy equation for each one of the mentioned cases (a),(b),(c) and (d) of the excited electrons:

(a) Case: As the excited A-electron goes outside of the R-circle (CCW) it slows down necessarily its own angular speed

(around nucleus) up to the position $r_{\max}$; and thus the electron B moving (CCW -but at greater angular speed-) on R-circle it can arrive in the same direction with the further found A-electron at $r_{\max}$,(synodus of A and B electrons).
Due of the reasons of symmetry with the repulsing B electron it becomes self evident that at the position of $r_{\max}$ it must be $\frac{dr}{d\varphi}=0$; in this case there must take place this synodus of A and B electrons. Thus the equation of the energy is written (15):

$$\frac{\hbar^2}{2m_o r_{\max}^2}-\frac{2e^2}{r_{\max}}+\frac{e^2}{(r_{\max}-R)}-\frac{\mu^2}{(r_{\max}-R)^3}=-E^{+}+\frac{h\cdot c}{\lambda}$$

Solving above equation (15) we find for

$$r_{\max}=0.2665421978A^o$$

and the eccentricity of the ellipse of the excited A-electron is

$$\varepsilon=1-\frac{R}{r_{\max}}=0.00725965621$$

(b) Case: As the B-electron goes outside of the R-circle (CCW) it necessarily slows down its own angular speed (around nucleus) up to the position $r_{\max}$; and thus the electron A moving on R-circle (CCW but at greater angular speed) it can very quickly arrive in opposition to the further found B-electron (opposition of A and B relative the nucleus).
Due of the reasons of symmetry with the repulsing A electron it becomes self evident that at the position of $r_{\max}$ where $\frac{dr}{d\varphi}=0$; in this case there have to take place this opposition of A and B (relative the nucleus). The equation of the energy is written as follows (16):

$$\frac{\hbar^2}{2m_o r_{\max}^2}-\frac{2e^2}{r_{\max}}+\frac{e^2}{(r_{\max}+R)}-\frac{\mu^2}{(r_{\max}+R)^3}=-E^{+}+\frac{h\cdot c}{\lambda}$$

Solving above equation (16) we find for

$$r_{\max}=0.536144318A^o$$

and the eccentricity of the ellipse of the excited B-electron is

$$\varepsilon=1-\frac{R}{r_{\max}}=0.50646274857$$

(c) Case: As the A-electron goes inside of the R-circle (CCW) it increases necessarily its own angular speed (around nucleus) up to the position $r_{\min}$; and thus the electron B moving on R-circle (CCW but rotating at smaller angular speed) it can be found in the opposite direction with the inside ($r_{\min}$) found A-electron (antithesis of A and B electrons relative the nucleus).
Due of the reasons of symmetry with the repulsing B electron it becomes self evident that at the position of $r_{\min}$ it must be $\frac{dr}{d\varphi}=0$; in this case there must take place this antithesis of A and B electrons; the equation of the energy is written (17):

$$\frac{\hbar^2}{2m_o r_{\min}^2}-\frac{2e^2}{r_{\min}}+\frac{e^2}{(r_{\min}+R)}-\frac{\mu^2}{(r_{\min}+R)^3}=-E^{+}+\frac{h\cdot c}{\lambda}$$

Solving above equation (17) we find for

$$r_{\min}=0.2200526244A^o$$

and the eccentricity of the ellipse of the excited A-electron is

$$\varepsilon=\frac{R}{r_{\min}}-1=0.20247233497$$

(d) Case: As the B-electron goes inside of the R-circle (CCW) it increases necessarily its own angular speed (around nucleus) up to the position $r_{\min}$; and thus the electron A moving on R-circle (CCW but at smaller angular speed) it can arrive in the same direction with the closer found B-electron at $r_{\min}$ (synodus of A and B electrons).
Due of the reasons of symmetry with the repulsing A-electron it becomes self evident that at the position of $r_{\min}$ it must be $\frac{dr}{d\varphi}=0$; in this case there must take place this synodus of A and B electrons. The equation of the energy is written (18):

$$\frac{\hbar^2}{2m_o r_{\min}^2}-\frac{2e^2}{r_{\min}}+\frac{e^2}{(R-r_{\min})}-\frac{\mu^2}{(R-r_{\min})^3}=-E^{+}+\frac{h\cdot c}{\lambda}$$

Solving above equation (18) we find for

$$r_{\min}=0.2626721884A^o$$

and the eccentricity of the ellipse of the excited B-electron is

$$\varepsilon=\frac{R}{r_{\min}}-1=0.00736661422$$

In "persisted lines" the excited electrons are assumed to move at $\hbar=1$; thus we can use the equation of conservation of the angular momentum to calculate the times needed the said excited electrons to arrive at the position of their $\frac{dr}{d\varphi}=0$ (i.e. at their $r_{\min}$ or $r_{\max}$)

$$\int_0^t dt=\left(\frac{m_o\cdot R^2}{\hbar}\right)\cdot\int_{\varphi=0}^{\varphi=\pi/2\cdot z}\frac{d\varphi}{\left[1\pm\varepsilon\cos(\pi/2+\varphi\cdot z)\right]^2}\quad(19)$$

From relation (19), by multiplication of both sides with ω , -of relation (9)-, we can find the real angle (in rads) which describes the other non-excited electron on R-circle during the motion of the excited electron, - from its initial position ($\varphi=0$) until the final real angle ($\varphi=\pi/2\cdot z$) where the condition is valid $\frac{dr}{d\varphi}=0$ (i.e. at their $r_{\min}$ or $r_{\max}$)-.

$$\Delta\Psi=\omega\cdot\int_0^t dt=(1rad)\cdot\int_{\varphi=0}^{\varphi=\pi/2\cdot z}\frac{d\varphi}{\left[1\pm\varepsilon\cos(\pi/2+\varphi\cdot z)\right]^2}$$

(20)
The integral (20) is separated in two:

$$(\Delta\Psi)_{OUT}^{EXIT} = (1rad)\cdot\frac{1}{z}\cdot\int_{\varphi=0}^{\varphi=\pi/2\cdot z}\frac{d(\pi/2+\varphi\cdot z)}{[1+\varepsilon\cos(\pi/2+\varphi\cdot z)]^2} \quad (21)$$

which gives the angle $\Delta\Psi$ when the excitation becomes outside the R-circle and

$$(\Delta\Psi)_{IN}^{EXIT} = (1rad)\cdot\frac{1}{z}\cdot\int_{\varphi=0}^{\varphi=\pi/2\cdot z}\frac{d(\pi/2+\varphi\cdot z)}{[1-\varepsilon\cos(\pi/2+\varphi\cdot z)]^2}$$

(22)

which gives the angle $\Delta\Psi$ when the excitation becomes inside the R-circle.

We have thus respectively

$$(\Delta\Psi)_{OUT}^{EXIT} = (1rad)\cdot\frac{1}{z}\cdot\int_{\Phi=\pi/2}^{\Phi=\pi}\frac{d\Phi}{[1+\varepsilon\cos\Phi]^2} \quad (21,a)$$

$$(\Delta\Psi)_{IN}^{EXIT} = (1rad)\cdot\frac{1}{z}\cdot\int_{\Phi=\pi/2}^{\Phi=\pi}\frac{d\Phi}{[1-\varepsilon\cos\Phi]^2} \quad (22,a)$$

The last two integrals (21,a) and (22,a) are calculated and give respectively:

$$\Delta\Psi_{OUT}^{EXIT} = \frac{1}{z}\cdot\left[\frac{\pi}{(1-\varepsilon^2)^{1.5}}+\frac{\varepsilon}{1-\varepsilon^2}-\frac{2}{(1-\varepsilon^2)^{1.5}}\cdot\tan^{-1}\sqrt{\frac{1-\varepsilon}{1+\varepsilon}}\right]$$

$$\Delta\Psi_{IN}^{EXIT} = \frac{1}{z}\cdot\left[\frac{\pi}{(1-\varepsilon^2)^{1.5}}-\frac{\varepsilon}{1-\varepsilon^2}-\frac{2}{(1-\varepsilon^2)^{1.5}}\cdot\tan^{-1}\sqrt{\frac{1+\varepsilon}{1-\varepsilon}}\right]$$

Now we can do our final calculations about the determination of z's for each one of the excitation trajectories:

For **Case (a)** it is $\Delta\Psi_{out}^{exit}$ =1.585440905/z.

Thus we write down the evident relation of the angles at the point of sinodous of the two electrons:

$$\frac{\pi}{2\cdot z}-\Theta=\Delta\Psi_{out}^{exit}$$

from this relation we get the z of case (d) z = 0.00635954349

Conclusion: All the cases of excitation (a,b,c.d) are continuing or pass from their middle point $\frac{dr}{d\varphi}=0$ in a quite symmetric way where the slowly moving electron continues its slow motion while the faster moving one also continues moving faster; the result is that frequently after the coming back to R-circle the excited electron may change its position with other and so the CCW moving electrons can move with B-electron going first and followed by A one.

References : At the Inernet

$$\frac{\pi}{2\cdot z}+\Theta=\Delta\Psi_{out}^{exit}$$

from this relation we find the z of case (a) z = 0.0063761304

For the **Case (b)** it is $\Delta\Psi_{out}^{exit}$ =3.959693526/z

Thus we write down the evident relation of the angles at the point of opposition of two electrons:

$$(\Delta\Psi_{out}^{exit}+\Theta)-\frac{\pi}{2\cdot z}=\pi$$

From this relation we find the z of the case (b) z = 2.82772918439

For the **Case (c)** it is $\Delta\Psi_{in}^{exit}$ =1.244397765/z

Thus we write down the evident relation of the angles at the point of opposition of two electrons:

$$(\frac{\pi}{2\cdot z}+\Theta)-\Delta\Psi_{out}^{exit}=\pi$$

From the last relation we get for the z of case (c) z = 0.38635682568

For the **Case (d)** it is $\Delta\Psi_{in}^{exit}$ =1.556189845/z

Thus we write down the evident relation of the angles at the point of opposition of two electrons: