Part 4b- Quantum level

7- Heisenberg's relationships

7(1)-General aspect

The interpretation of Heisenberg relationships according to H particle-paths hypothesis viewpoint differs from classical notion of point-like particles. In other words, the H particle-paths population density at a location replaces the concept of probabilistic existence of a particle in the latter case, at that location. Otherwise, there is no way to picture particles as objective elements of reality that occupy definite regions of space at all time.

I) According to uncertainty relationships, *Remark 7(1)1*, the extension of matter wave counterpart of H system *A* (e.g. electron as wave), nominating *case W*, in a length Δx in the x - axis is accompanied by an uncertainty of Δk in finding exact value of wave number k_0, as follows:

$$\Delta k.\Delta x \approx 2\pi \qquad 7(1)$$

$$\Delta x = P, \qquad \textit{Comment 7(1)1, and Sec. 7(3)} \qquad 7(2)$$

Where:

1) P, The spatial path as in *Sec. 3(1)1, Figs 3(2), 3(3).*

2) N, the number of single direction H particle-paths unit through path P.

3) a, the media coefficient, *Sec. 7(4)3*, of time inverse dimension, *Note 1(2)1.*

4) $|a|$, the dimensionless magnitude of media coefficient a, i.e. $|a| = \frac{a}{a_s}$, *Note 1(2)1.*

5) K_P, a proportionality factor, *Note 3(1)1c*.

Thus, according to *Eqs. 7(1), 7(2).*

$$\Delta k \approx \frac{2\pi}{P} \qquad 7(3)$$

Assuming an H system is traveling along x -axis, and considering *Eq. 2 (77)*:

$$\Delta k = \Delta\left(\frac{2\pi}{\lambda}\right) = \Delta\left(\frac{2\pi\, p_x}{h}\right) = \frac{2\pi}{h}\Delta p_x \qquad 7(4)$$

Substituting this result into *Eq*s. *7(1), 7(3):*

$$\Delta p_x.\Delta x \cong h, \textit{ Remark 7(1)2} \qquad 7(5)$$

Please refer also to *Sec. 9(4), Remark 9(4)1a.*

This relationship, *Eq. 7(5),* somehow can be related to paths constancy, *Sec. 2(1)2*, and linear momentum of an H particle-path (or a group of that); please refer to *Sec. 3(2), Eqs. 3(24) - 3(39).*

II) Similarly to part *I*, considering the H system *A* main-body as particle nominating *case P*. According to *Eq. 1(1),* the N H particle-paths (or N groups of that) that constitute a moving particle main-body e.g., photon, electron, etc, are extended in a limited length or path in space of path-limit Γ, *Eq. 1(3),* related to an H hall package, *Note 7(1)1.* In other words, by analogy to *Eq. 7(5)*, Δx, *Eq. 7(5),* is equal to Γ in this case. Moreover, considering $a = a_1.\Delta N$, *Note 1(2)1,* we have:

$$\Delta p_x = \frac{h}{\Delta x} = \frac{h}{\Gamma} = \frac{ah}{c} = \Delta N\frac{a_1 h}{c} \qquad 7(5)1$$

According to *Sec. 1(2), Eq. 1(1),* and *Note 1(2)1*, we have:

$$\Delta p_x = \Delta p_p = \Delta N\frac{a_1 h}{c} = \Delta N\frac{H}{c} = \frac{\Delta E_p}{c}, \textit{ Note 7(1)2} \qquad 7(6)$$

Where:

- a, the media coefficient, (e.g. a_d, in case of vacuum medium).
- Γ, the path-limit in a medium, (e.g. Γ_d in case of vacuum medium).
- ΔN, H particle-paths variation number in the H system *A* main -body.

Therefore, in case of $\Delta N = 1$, according to *Sec. 1(2),* ΔE_p has its least amount, i.e. $\Delta E_1 = H$, *Consequence 7(1)1*. Please refer also to *Sec. 3(2), Eq. 3(39).*

In other words:

$$E_p = N.H = N.\Delta E_1, \text{ please refer to } \textit{Sec. 7(4)} \qquad 7(7)$$

According to *Eq. 2(117),* in case *P*, e.g. electron, $K_m \approx 1$, *Remark 5(16)c, A4*. As a result obtained based on deBroglie postulate:

$$E_p.\Delta T_p = h \qquad 7(8)$$

Where:

E_p, total energy of the particle

ΔT_p, The time interval of particle's main-body internal motion of its H particle-paths

On the other hand, according to uncertainty relationships, we have:

$\Delta E.\Delta T = h$, 7(10)
Please refer also to *Example 5(16)3g, A1*.
Thus, based on *Eq. 7(10),* we will have::
$\Delta E_1.\Delta T_1 = h$ 7(10)1
Where
Therefore, the *Eq. 7(8)* can be written as following:
$$\frac{E_p}{N}.N\Delta T_p = \Delta E_1.\Delta T_1, \quad \Delta T_1 = N.\Delta T_p \qquad 7(10)2$$
Therefore, ΔT_1 is the highest time interval possible in an H hall package of path-length limits Γ in a medium, *Sec. 7(4)3*, nominating hereafter ΔT_Γ . In other words, according to *Eq. 7(10)1*:
$\Delta E_1.\Delta T_1 = H.\Delta T_\Gamma = h$, or:
$$\Delta T_\Gamma = \frac{h}{H} = a_1^{-1}, \textit{ Note 1(2)1} \qquad 7(11)$$
ΔT_Γ can be regarded as a unit of time, *Sec. 7(4)1*.
According to *Eq. 7(7)*, ΔE_1 , is the least amount that an energy that stated above H system, i.e. electron, *Note 7(1)3*, can select in path-limit Γ . In other words, the energy changes in this H system as a multiple of ΔE_1 and, time interval $\Delta T_1 = \Delta T_\Gamma$ *, Sec. 5(16)3a* in the framework of unit (or cell) of path-length value h, *Sec. 5(16)3g*, i.e.:
$$\Delta E_1 = \frac{E_p}{N} \qquad 7(11)1$$
Similarly according to *Eq. 7(2):*
$$\Delta x = \frac{P}{N} \qquad 7(11)2$$
Similarly to *Eq. 7(7)*:
$$\Delta P_p = \frac{N a_1 h}{c} = \frac{NH}{c} = N\Delta P_1 \qquad 7(11)3$$
Where:
-*H, Sec. 1(2), Eq. 1(1),* the least amount of energy from view point of H particle-paths hypothesis.
- c, the light speed.
- ΔP_1, equal to H/c , the least momentum from viewpoint of *HPPH* in normal vacuum medium, *Sec. 7(4)3, pat A*; please refer to *Consequence 7(1)1* in this regards.
Alternatively, ΔT , *Eq. 7(10),* is the time interval that an H particle-path [or a group of that or an H system, *Sec. 1(6),* consisting of N_t , *Eq. 2(33)*] can stay in a position of path-limit $\Gamma = c/a$ (nominating stay time interval*, Sec. 7(4)2f, part A*) and during that must be transferred to a next position in space, *Comment 7(1)2.* Please refer also to *Sec. 9(4)5*. In other words, any mass-body transferred to a new state of ΔT from view point of H particle-paths moving at c speed accompanied by infinitesimal quantized successive transferred states, *Secs. 7(4)2d, e*; please refer also to *Sec. 5(16)3a.*
A pseudo-particle, *Sec. 2(7),* cannot be transferred to a new next state; thus, decayed. At this stage according to *Sec. 7(2),* and *Sec. 5(16)3a, Eq. 5(70)3*, the overlapped H hall quantized packages of the pseudo-particle split (or expands) to two (or more) H hall quantized packages each relate to a particle produced during the decay process along time's arrow generation. Here photon is regarded as a particle, *Remark 7(1)3*.
From viewpoint of H particle-paths hypothesis, the uncertainty principle have a hard link with time's arrow/time's arrow reversal, *Sec. 5(16)7a*, during a space expansion/contraction process, *Sec. 5(16)9*.

Consequence 7(1)1- The particle energy E_p of an isolated particle in gravitational field free vacuum is uncertain equal, or, more than ΔE_1 , and its momentum equal or more than H/c . Depending on the other media, *Sec. 7(4)3*, the uncertainty of energy, and momentum is increasing more than its least values, i.e. ΔE_1 , ΔP_1 . In fact, the momentum $\Delta P_1 = H/c$ is the least momentum or momentum uncertainty in normal vacuum medium, *Sec. 7(4)3, part A*. In other words, an isolated particle at rest in non-gravitating vacuum medium has an equivalent length Γ_d and momentum uncertainty such that:
$$\Gamma_d.\Delta P_1 \approx h \qquad 7(11)3a$$
Noteworthy, in slit gap medium, *Sec. 7(4)3, part c*, depending on its H particle-paths population densities an spatial geometry at its different locations, the Γ_d in front of the gap is diminished to $\Delta x = \Gamma_{gap}$. Thus, the ΔP_1 is increased to ΔP_{gap} in Eq. *7(11)3a*, i.e. a newly formed H hall package. Similar argument is also valid for $\Delta T, \Delta E$, e.g. $\Delta E_1.\Delta T_\Gamma \approx h$ as in *Eq. 7(11).*

Note 7(1)1 – A particle is confined in an H hall package, *Sec. 5(16)3a*, of path-length value h as a single entity. Therefore, "there is an inverse imprecision when you try to measure both (position and momentum) at the same time as in case of a moving particle like the electron" [370] *Uncertainty principle*. This is a direct result of Heisenberg uncertainty principle when we are looking at a particle as point-like, but according to H particle-paths hypothesis the particle (e.g., electron, *Sec. 4(3)1B*) could no longer be considered as point-like H system, *Sec. 5(16)3b, part D2*. However, it is extended inside an H hall package. "Even in relativity *QM* space and time do not play completely symmetric role, a time-energy uncertainty relation do not play a fundamental role" [410] *section 3B*, contrary to position-momentum uncertainty.

Note 7(1)2- The media coefficient a, and path-limit Γ in free gravitational vacuum medium just during a measurement has constant values a_d, Γ_d, *Sec. 7(4)3, part A,* respectively, please refer also to *Sec. 8(9).*

Comment 7(1)1 - The introducing of path-limit Γ, *Sec. 5(16)3b, part D2,* in the *Eq. 7(5)* is an assumption, according to which, an isolated free moving particle through its motion in vacuum texture medium, *Sec. 5(16)3b, part A,* tends toward length Γ, *Sec. 3(1)1*. Please refer also to *Sec. 7(4)3*. Noteworthy, during an interaction, *Sec. 7(4), Example 7(4)1,* $\Delta x, \Delta p_x$ has the values as discussed through this *section 7*. In other words, after interaction, and through transfer of particle to vacuum medium, $\Delta x \to \Gamma$, and $\Delta p_x \to \Delta p_x'$ in such a way that $\Delta x.\Delta p_x = \Gamma.\Delta p_x' \approx h$ in the vacuum state, *Consequence 7(1)1*, as a free moving H system , i.e. the measured (or interacted) H system is transformed to its new configuration related to its motion through vacuum medium. Therefore, in case of particle of non-zero mass m_0 according to *Sec. 2(1)3, Eq. 2(30),* we have:

$$\Delta p_x' = m_0 c \Delta\alpha = \frac{a_1 h}{\Gamma}, \text{ or } \qquad \Delta\alpha = \frac{a_1 h}{m_0 c \Gamma} = Cons.$$

$\Delta\alpha$ depends on inverse mass, m_0^{-1}, of the particle. Please refer also to *Sec. 3(2), Eqs. 3(38), 3(39).*
Where:
- α, *Sec. 2(1)1a, Eq. 2(7),* is the ratio of single direction (or returned) H particle-paths respect to reversible one "deviation degree from reversibility".

Therefore, in case of macro-bodies (or macro-world), $\Delta\alpha \to 0$. Similarly, in case of $\Delta E.\Delta T \approx h$; please refer to *Sec. 7(4).* Moreover, a wave packet of the length Δx includes a range of wave number, Δk, of the order $\Delta k \approx \Delta x^{-1}$. It is obtained as a superposition of multiple of stored, *Sec. 7(4)1, item3*, H hall packages of appropriate wavelength, *Sec. 5(16)3a*, through the path-limit Γ.
Alternately, an interaction (or measurement, *Sec. 8(7)2*), e.g. collision, of a particle of path-limit Γ through vacuum with a mass-body (or detector), is performed in an infinitesimal time interval Δt, *Eq. 7(20),* related to particle length Δx, *Eq. 7(2),* in the new media regardless of the magnitude of Γ_d of the particle through vacuum. In other words, the interaction is performed according to media coefficient $a_{\det}$ in the new medium (or detector media) through time interval $\Delta t = a_{\det}^{-1}$, and particle length $\Delta x = \Gamma_{\det}$. Therefore, based on relationships *Eq. 7(2)* and *Eq. 5(67)8b* of *Comment 5(16)1c, A1*, we have:

$$|a_d|.\Gamma_d = |a_{\det}|.\Gamma_{\det} = n.\Delta x = C$$

As a result, there are n folds superposition of the particle paths *P* in vacuum after its measurement, *Sec. 8(7)2,* by a mass-body (or detector).
Where:
$|a_d|, |a_{\det}|$, are the dimensionless magnitude of media coefficient $a_d, a_{\det}$, respectively.
C, capital, the path that a light signal travels in one second through vacuum gravitational field free medium.
Similarly, according to above discussion, and referring to *Sec. 7(4)3, part c*, in slit experiment, there is a contraction of particle, e.g., photon, from its $\Delta x = \Gamma_{gap}$, through time interval $\Delta t = a_{gap}^{-1}$, and a reverse process due to exit of photon from slit gap medium to vacuum medium.

Comment 7(1)2 - ΔT in case of isolated particles moving in vacuum medium, can be a fraction of ΔT_Γ, *Sec. 7(4)1.* Moreover, ΔT depends on the H particle-paths population densities η in other media such as gravitational field, excited states in an atom; please refer to *Sec. 7(4)3*.

Remark 7(1)1– From view point of H particle-paths hypothesis, the Heisenberg uncertainty relationships as in *Eqs. 7(1), 7(5), 7(10),* are the result of path-length constancy, *Sec. 2(1)2*, in microcosm; please refer also to *Sec. 2(10)* in case of macrocosm.

Remark 7(1)2- "This result is motivated by the Heisenberg microscope which shows that simultaneous determination of position and momentum for a single particle is limited because of Einstein's relation $E = h\upsilon = \hbar\omega$ for the light as probe". "Heisenberg's uncertainty principle is often confused with Robertson's uncertainty principle. Define $\hat{\Lambda}^2 = \langle \hat{\Lambda}^2 \rangle - \langle \hat{\Lambda} \rangle^2$ to be variance over an ensemble of measurement outcomes for the observable *A*. Then we can prove the generalized uncertainty in equality $\Delta \hat{A} \Delta \hat{B} \geq 1/2 \left| \left\langle \left[\hat{A}, \hat{B} \right] \right\rangle \right|$, in which the uncertainty is non-zero if the two observables do not commute. In case of position and momentum, this means we get $\Delta \hat{x} \Delta \hat{p} \geq h/2$ (Kennard inequality). This result is mathematically rigorous, unlike Heisenberg's result, and conceptually the two are quite distinct" [365], *Uncertainty principle*; please refer also to *Sec. 2(10); Sec. 3(1)1; Sec. 7(2).* Factually, the Heisenberg's empirical relations, *Eqs. 7(5), 7(10)*, are based on experimental results; whereas, Robertson inequality is based on mathematical formalism; please refer to [369], *part 2.5.*

Remark 7(1)3– According to *Eq. 7(10)*, each group (or cell) of H particle-paths has a path-length unit of h value, *Sec. 5(16)3g*. Therefore, to a system that is constituted of n groups, one can attributed merely a path-length of h value regardless of its stored path-length of nh value, *Sec. 7(4).* Note that the total energy, E_t, of the system according to above statement is n times the minimum energy ΔE, i.e.:

$E = n\Delta E_1$, Please refer to *Eq. 7(11)1.* 7(11)4

7(2)-Discussion

7(2)1- General aspect

According to *Eq. 7(7)*, or, *7(9)*, to any isolated H particle-path (e.g. posipa or negapa), or, a group of that, it is attached a path equal to C (or $\frac{c}{a}$). In addition, to both of them together (e.g. neutropa) with *2 H* energy is attached a path or interval equal to C (or $\frac{c}{a}$). Thus, to each of its posipa and negapa individually it is related a path equal to $\frac{C}{2}$ (or $\frac{c}{2a}$) and so on. As the result to an H system of n H particle-paths (or n groups of that) belongs only a C (or $\frac{c}{a}$) path or interval, i.e. an H hall quantized package, *Sec. 5(16)3a*, of path-length value h, *Sec. 5(16)3g*, and store path-length nh, *Comment 7(2)1a*. Thus, a portion of $\frac{C}{n}$ (or $\frac{c}{na}$) is related to an individual H particle-path of it. In fact, the total path of an H system of n H particle-paths (or n groups of that) is the result of coincidence of n individual paths and vice versa. Supposing this H system is split to n particle-paths (or n groups of that) with n non-correlated individual paths at C (or $\frac{c}{a}$) length Γ. According to *Notes 2(1)5, 3(1)1* an H system with an individual path may be the result of, n past events or H systems of n individual paths or intervals Γ. Thus, the total path-length of H systems before interaction is equal to the path-length of the resulting H systems after that; please refer to *Sec. 2(1)2.* Note that each H particle-paths, or a group of that, obeys the *Eq. 7(10).*

The stated above phenomenon is a direct result of space expansion during the conversion of mass (contracted form of the field) to energy or field (expanded form of the mass), *Note 2(1)3b,* and vice versa. In the reverse process, the H hall quantized packages, *Sec. 5(16)3a,* of n H particle-paths (or n groups of that) coincide or overlapped on each other to form a single H hall that is occupied by n H particle-paths (or n groups of that). This phenomenon is accompanied by space contraction and time's arrow reversal, *Sec. 5(16)7a*, or, vice versa. Factually, n H hall packages each of volume V_{HP}, *Sec. 5(16)3a, Eq. 5(70)2*, contracted to a single volume V_{HP}. Moreover, related time interval $n\Delta T_\Gamma$, diminished (or reversed) to single ΔT_Γ, i.e. path-length contraction, *Comment 7(2)1a*, *Sec. 7(4), Note 7(4)1a.* This process is not allowed in spatial medium, *Sec. 7(2)1.*

Factually, an H hall package related to an isolated particle, e.g., photon, electron, moving in vacuum texture, *5(16)3g*, medium has path-length value h, and the particle is extended through path-limit Γ, *Sec. 1(12)*, at an undisturbed manner (equilibrium stage). Noteworthy, during the process of interaction (or measurement, *Sec. 8(7)2*) of the particle with the measuring device, the interacted systems pass through a mixed intermediate states of particle and measuring device of path-length value $2h$, i.e. a pseudo unique H system, *Sec. 7(4)2b, Eq. 7(20).* It ultimately converted to a unique H system of path-length value h, i.e. mass of measuring device, *Sec. 8(7)2a*; please refer to *Sec. 5(16)3b, part c, item a*. However, with the difference that path-limit Γ of the particle wrapped (or curled) in the latter case down to Planck length, l_p, *Sec. 8(7)6, part c, Sec. 7(4)3;* please refer also to *2, Eq. 5(33).* "If a *P* (momentum) measurement disturb *Q* (position), then a simultaneous measurement of *P* and *Q* must yield a different measurement result for *Q* than an undisturbed measurement of *Q* would do". "The interaction of object and measuring instrument being responsible for the disturbance" [364] *Complementarity*. Factually, at the end of measurement, the H hall package of the particle is going to be overlapped (or dissipate) the H hall package of the measuring device. It is due to the huge inertia of the latter as a unique (or common) H hall package, *Sec. 8(7)6, part c* in the *3* spatial dimensions of physical world after measurement process, i.e. post interaction phase. Noteworthy, the particle's H hall package overlapping process is accompanied by appropriate amount of space contraction along with time arrow reversal of the whole system, *Sec. 5(16)7a*, at quantum level, i.e. path-length decrement.

Comment 7(2)1a- This type of path-length contraction can be interpreted as stored path-length, *Sec. 7(4)1, item 3*, of related particle (or H system). Conversely, a particle, e.g. photon of path-length value h can be converted to *N* particles each of path-length value h. Therefore, the initial particle has at least *N* stored path-lengths of total Nh value, evidently, the energy of initial particle decreased accordingly. In other words, the wavelength of the initial particle is increased along with $N.\Delta T_{\Gamma}$ time's arrow, *Sec. 5(16)7*, and $N.V_{HP}$ spatial expansion due to *N* H hall packages generation. "String (in string theory, *Sec. 8(8)2*) can split and combine, which would appear as particles emitting and absorbing other particles, presumably giving rise to the known interactions between particles" [457] Basic properties. The particle axeon, *Sec. 10(8),* in an H hall package *Sec. 5(16)3a* resembles to a string; they can be superimposed on each other. Alternatively, an axeon is split to more axeons; each one is confined in an H hall package. In case of Universe expansion, based on above discussion, a photon is red-shifted, *Sec. 5(16)3b, D2, item VIII*. In the latter case, according to *Sec. 5(16)3b, part B*, the track texture of a photon is converted to the main track texture of red-shifted photon accompanied by sub-track textures, i.e. an expanding track texture. Noteworthy, any two newly born H hall packages are reversed handed of each other based on *Simulation 8(7)2, E5a, item 12* of equal path-length magnitude and opposite signs. Similarly, a newly born H hall package is reversed handed of its parent H hall package of equal path-length magnitude and opposite sign.

7(2)2- Superposition Scenario

7(2)2a- General aspect

The reverse process is not allowed is not allowed in spatial medium that is along with entropy decrement in our expanding matter Universe. Noteworthy, entropy is due to spatial expansion and time's arrow. It is along with equal magnitude of negentropy increment within mass medium, i.e. mass contraction accompanied by time's arrow reversal, *Sec. 5(16)9d*. Please refer also *to Sec. 5(16)11, and Sec. 5(15)2b, diagram 5(1).*

According to above discussion, "In the absence of detector or scatterer, the superposed light beam cross through each other unperturbed"[496] *section 2.2*. Therefore, during the intensity variation of a monochromatic light beam, its frequency remained unchanged". "All waves propagate through each other unperturbed"[496] *section 1.1*. "Our success in restoring causality in optical superposition phenomenon is based on: I) light does not interact with light. *II)* Light amplitude can be divided by diffraction grating and beam splitters an indefinite number of time to arbitrary low amplitude, and *III)* detector do the summation of the superposed fields to display superposition fringes. All classical and quantum mechanical experiment indicate that the first two points above used for light cannot extended to particles. Particles are indivisible quanta. They interact with each other and they normally do not pass through each other in regular scattering experiments"[496] *section 3*. Factually, from viewpoint of H particle-paths hypothesis:

1) The H hall packages of photon in spatial medium cannot recombine in order to generate a single H hall package of a photon with higher frequency. This is due to entropy increment in spatial medium instead of decrement, *Note 7(2)2a1*.
2) The H hall package of photons of equal frequency can be superposed on each other without any recombination. Thus, superimposition does not affect the entropy.
3) The items *1&2* is valid merely for single directions H particle-paths confined in own H hall package of massless particle. In case of particle of rest mass, the items *1 & 2* cannot be applied to their due to reversible character of H particle-paths of these particles at rest state.

According to *Simulation 7(4)3e2, item F*, any coupled particles, e.g. electrons, can be seemed as a single H system with a central reverson that is surrounded by its axeon. Therefore, during stay time, *Sec. 7(4)2f, part A*, intervals ΔT, the axeon changes its handedness successively; thus, emitting type $WR \& WL$ expandons along with $PL \& PR$ contractons respectively towards the related emitting source, i.e. a mass medium, *Sec. 7(4)3, part D*. According to *Sec. 7(4)2f, part E*, the stay time interval ΔT depends on mutual interaction of particle H hall package of particle with that of the spatial medium, *Sec. 7(4)3, parts A, B*, e.g. gravity free vacuum, gravitating vacuum. "The cosmic medium (vacuum) posses various forms of potential stress energies that are capable of giving rise to different kinds of undulatory fields which we experience massless light and particles with inertial mass. Thus, the cosmic medium appears to be an enormous reservoir of various kinds' potential energies". "Can some notions of yet indeterminate dark energy and dark matter be accounted for by the potential stress energies of the cosmic medium that we have hypothesized?"[496] *section 4*. From viewpoint of H particle-paths hypothesis, please refer to *Sec. 5(15)2b* in this regards.

Note 7(2)2a1- The ability of a photon conversion to photons of longer wavelengths is related to fully single direction character of its H particle-paths, contrary to case of particle of rest mass, e.g. leptons. It is depending to H hall package splitting of photon in spatial medium, *Sec. 7(4)3, part A*, i.e. entropy increment.

7(2)2b- Stay time interval and superposition of quantum states scenario

According to *Eq. 7(29)3*, the stay time interval of a particle configuration depends inversely to the frequency equivalent n_{0p} of particle of N_{0p} H particle-paths. Thus, by increment of the N_{0p} (or particle mass), the stay time interval ΔT_{gm} is tending to zero. In other means, the states of the particle (or mass-body) are overlapped (or superimposed) on each other without any distinction. Therefore, in case of, e.g. low energy photon, it can be at two separate states during its stay time interval, e.g. spin up or down. The similar scenario is also valid in case of a particle or mass-body in a denser medium, *Sec. 7(4)3*, than normal vacuum medium. Thus, by increment of H particle-paths densities (or increment of $K_{\Gamma(gm)}$) of the medium, the stay time interval ΔT_{gm} is tending to zero. "Andrew Cleland and his team cooled a tiny metal paddle until it reached its quantum mechanical 'ground state' — the lowest-energy state permitted by quantum mechanics. They then used the weird rules of quantum mechanics to simultaneously set the paddle moving while leaving it standing still."[595] *Largest ever object put into quantum state, Example 7(2)2b1.* Factually, according to *HPPH*, there is no simultaneity, *Note 7(4)2f, c2*. But, in case of a macro-body such as paddle, the stay time interval between two above states is becoming infinitesimal. Therefore, these states seem superimposed. In other words, the sty time interval of paddle is beyond the accuracy of its measuring device. Noteworthy, in case of our every day encountering macro-bodies, this infinitesimal time interval is due to testing conditions and huge masses of macro-bodies respect to that of testing objects. Thus, the infinitesimal time intervals fall bellow the slight preference of right-handedness respect to left-handedness based on bi-Universe hypothesis, *Sec. 5(16)9*. Therefore, a state of the two states dominates preferentially the other one in case of macro-bodies in our every day life. "Dr. Pearle and colleagues in Italy propose to add a term to Schrödinger's equation that, in effect, constantly jiggles the fabric of the universe. Atomic-scale objects only jiggle a little and thus remain a blur, which preserves the predictions of quantum mechanics. Larger objects, like people or the Moon, jiggle more and quickly fall into a definite here and there, which corresponds to everyday experience". "I think most physicists, including myself, would be extremely surprised if quantum mechanics did fail for large objects," Dr. Lukens said. But, he added, Every so often we are surprised"[596]. According to *Sec. 8(7)2, E2*, and the *SUNY* experiment related to superposition of macroscopic quantum states. "A measurement always gives one of the two possible answers, clockwise or counterclockwise, never a zero cancellation"[596]. The above discussion proves during any measurement only a state can be measured, not the both at once. This experiment reveals none zero stay time interval of each of the states. Please refer also to *Sec. 7(4)2h,* in an alternate case."The key point, of course, is that one does not end a quantum computation with an arbitrary superposition, but aims for a very special, 'clever' state—to use Pitowsky term. Quantum computations may not *always* be mimicked with a classical computer because the characterization of the computational subspace of certain quantum states is difficult, and it seems that these special, 'clever', quantum states cannot be classically represented as vectors derivable via a quantum computation in an optimal basis, or at least that one cannot do so in such way that would allow one to calculate the outcome of the final measurement made on these states"[600] What is *Quantum* in Quantum Computing?

Example 7(2)2b1- As an example, consider the paddle at two movie frame *1&2*. A back and forth motion of the two frame during each stay time interval ΔT, the frames *1&2* are interchanging. Here, the resonator (or naked eye) is the measuring device. Therefore, in the range of ability (or accuracy) of the measuring device respect to stay time interval ΔT, the paddle cane detected in stationary state of frame *1*, and moving state *2* (or frame *2*) respect to state *1* at once. In case of hydrogen atom, during absorption of a quanta, the hydrogen atom is excites from its ground state (state 1) to an upper excited state (state *2*). The latter state has a lifetime or sty time interval ΔT, e.g. of the magnitude of $10^{-6}-10^{-8}\,s$, *Note 7(2)2b1*; please refer also to *Sec. 7(4)2b*. Noteworthy, according to *Sec. 8(7)2, part E2*, during a measurement merely state *1* or *2* exists during stay time interval ΔT respect to the measuring device, not the two states at once. In other words, during each stay time interval ΔT, merely a hydrogen atom at ground state plus a free quanta (possibility*1*), or. Hydrogen atom at excited state with no free quanta (possibility *2*). At infinitesimal stay time interval ΔT, e.g. more than $10^{-15}\,s$ related to macro-bodies, there is two possibilities can be seen as superposed at good accuracies.

Note 7(2)2b1- "The average length of time a system remains in a certain state is known as the lifetime τ of the state. The lifetime τ is assumed to be of the same order of magnitude as ¢t (its uncertainty). Consequently, the relationship between the lifetime and energy level width of certain state is $\tau\Delta E \approx \hbar$ "[371] *Lifetimes of energy states.* As an example, "the lifetime of the fourth excited state is $\tau = 2.75\times10^{-9}\,s$ "[371] *Problem supplement.* According to *HPPH*, this lifetime is the same as stay time interval in case of atom's electron shell medium, *Sec. 7(4)3, E3A*.

7(3) - Limiting conditions

In the relativistic domain, the uncertainty principle of Heisenberg must be reconsidered because of the added restriction of special relativity. In particular, introduction of the limiting velocity c imposes a new uncertainty relation on the precision with which momentum p can be measured.

$$\Delta P = \frac{\hbar}{c\Delta t} \qquad 7(12)$$

This relation can be considered to arise from the fact that the position localization Δx (assumed to initially) cannot spread at a rate greater than c. The distance $c\Delta t$ is therefore the maximum possible amount by which the position localization can have been broadened in a time interval Δt to permit a smaller localization the moment; this place a limit on the precision ΔP with which moment *P* can be measured in a time interval Δt [156] *part 3.3*; please refer to *Comment 8(1)3b*.

According to H particle-paths hypothesis in case of $a = a_1, H = a_1 h$, *Eq. 1(1),* the isolated free moving particle, $\Delta T = \Delta T_1 = \Delta T_\Gamma$ time unit, *Eq. 7(11),* can be considered as a consequence of Γ limited length of space unit, *Sec. 1(12).* In other words, their is a space restriction that precludes expansion of Δx more than Γ, i.e. up to ∞*, Remark 7(3)1, part A.* By the way, there is a minimum limited quantity for momentum or energy precision as in, *Eq. 7(7).* On the other hands, there is an analogous limitation on the determination of position x which arises from another characteristics of relativistic quantum field theories. This corresponds to a limiting position uncertainty,

$$\Delta x = \frac{\hbar c}{E} \qquad 7(13)$$

Where *E* is the total mass-energy of the particle; this position uncertainty for a particle of mass m with an initially small momentum is just, *Example 7(3)1.*

$$\Delta x = \frac{\hbar}{mc} \qquad 7(14)$$

The de Broglie wavelengths of the particle [156], *part 3.3,* the problem of particle localization to an infinity small region regarding the above statements interpreted in an alternative method other than such as negative frequency solution, wave traveling with matter. By referring to *Sec. 2(3)1,* of the present article it is interpreted on the basis of H particle-paths hypothesis according to which right- and left-handed wave-like H particle-paths that are conjugate of each other moving at c speed in a forward and backward (counter current, *Sec. 3(1)2*) manner.

Example 7(3)1- "If the electrons were to fall into the nucleus (of an atom), its position would be determined fairly precisely and this would mean that Δx would become very small. The uncertainty principle e.g., *Eq. 7(5),* would then imply that Δp is very large, and this would give the electron a very large amount of kinetic energy resulting the electron flying far away from the proton. and in effect breaking-up the atom"[172], part related to *uncertainty principle*. Therefore, according to H particle-paths hypothesis, Δx, in atoms and particle can never obtained any value from zero up to ∞, *Sec. 7(3);* but Δx may have value Γ (or proportional to it, *Remark 7(3)1, part B*) within the quantum level regarding of course, the charge $-e$ and mass m of the electron. The only fact that we can accept is that the H hall quantized package, *Sec.5(16)3, Remark 5(16)3a1* of a particle, e.g., electron atom irrespective of its total number of H particle-paths and time's arrow, *Sec.7(4),* has a constant and defined path-limit, Γ, *Sec. 1(12),* in the framework of, *Eqs. 7(5), 7(10).* Remarkably, the H hall quantized package of our particle are steadily interchanging with that of other H hall units, (e.g., slits, measuring devices); moreover, all H hall quantized packages have constant path-limit, Γ through normal vacuum.

Remark 7(3)1:

A) In case of $\Gamma \to \infty$, the energy of each cell, ΔE, *Sec. 7(4)*, becoming infinitesimal (or tend to zero). In other words, a particle H system, e.g., electron, photon, is constituted of paradoxical $n = \infty$, number of H particle-paths (or cells) each of $\Delta E \to 0$ energy; please refer also to *Sec. 8(4).*

B) A free moving electron of path-limit Γ in the vacuum, through falling in the atoms its path-limit Γ curl down to the magnitude of atom radius; please also refer to *Sec. 8(7)6*, *part c*.

7(4) - An interpretation of Heisenberg's relationships based on H particle-paths

7(4)1- Preliminary step

An H hall quantized package, *Sec. 5(16)3a*, of an H system in fact is a quantized space-time equivalent, *Sec. 2(3)2b*. Thus, to each H particle-path (or a group of that) in its ultimate extended form, i.e. in an H hall quantized package, we can attributed a time's arrow, *Sec. 5(16)7a*, $\Delta T_\Gamma = a_1^{-1} K_m$, *Sec. 5(16)1c*, *parts A1, A4,* and expanded space of path-limit, $\Delta x = \Gamma$, *Sec. 7(1), Comment 7(1)*, and path-length-value h, *Sec. 5(16)3g.* Please refer to *Sec. 3(1)1,* and *Comment 3(1)1,* and *Secs. 7(1), 7(2).* Now, supposing in a path-limit Γ, of an H hall quantized package [or overlapped H hall quantized package, *Sec. 7(2)*] of an H system, situated a set of N successive H particle-paths groups (or cells), *Remark 7(4)1a*. Moreover, to any of these groups is related an energy unit $H = a_1 h = \frac{\Delta E}{N}$, *Sec. 1(2),* a partial expansion, $\Delta x' = \frac{\Delta x}{N} = \Gamma / N$ and a partial time's arrow $\Delta T = {}^{\Delta T_\Gamma}\!/_N$. In other words, for the whole of the groups, i.e. H system, at the case of a fundamental particle $K_m \approx 1$, *Sec. 5(16)1c, part A*, we have:

$$\Delta T_\Gamma = a_1^{-1} s = \text{invariant constant, } \textit{Eq. 7(11),} \text{ i.e. a quantized time unit, } \textit{Note 7(4)1a} \qquad 7(15)$$

Similarly:

$$\Delta x = N \Delta x' = N.\frac{\Gamma}{N} = \Gamma = \text{constant, i.e. quantized spatial dimension} \qquad 7(16)$$

In fact, ΔT_Γ is time's arrow, *Sec. 5(16)7a,* due to a spatial expansion Γ, i.e. an H hall quantized package generation, *Sec. 7(4)3*. Considering *Eq. 7(15)*:

$$\Delta E.\Delta T = \Delta E.\frac{\Delta T_\Gamma}{N} = h\text{, } \textit{Eq. 7(10),} \quad \textit{Comment 7(4)1b} \qquad 7(17)$$

According to *Eq. 7(17),* in case of an H particle-path moving at c speed, we have:

$$\frac{\Delta E}{c}.\Delta T.c = \Delta p_x.\Delta x = h\text{, } \quad \textit{Eq. 7(5)} \qquad 7(18)$$

Please refer to *Sec. 5(16)1c, Eq. 5(67)8,* and *Sec. 7(4)2h.*

According to *Sec. 7(2)*, through exit of a group of N H particle-paths of $\Delta E'$ energy moving at c speed from a set constituted of n groups (i.e. an H system), the time's arrow, ΔT_Γ along with spatial expansion, Δx or V_{HP} (related to $\Delta E' = NH$, *Remark 7(4)1a*) take places. In other words, during such an interaction a group of H particle-paths of $\Delta E'$ energy of the parent H system gives birth to a new H system, *Sec. 5(16)7a*, *Remark 5(16)7a* of the same energy, $\Delta E'$, of path-limit Γ, and path-length value h. It is accompanied by time's arrow ΔT_Γ generation along with space expansion V_{HP} (or vice versa), *Eqs. 7(17), 7(18);* please refer also to *Secs. 2(9), 2(10)1*, *Sec. 3(1)1, Figs. 3(2), 3(3),* and *7(2),* and *Sec. 7(4)2, Remark 7(4)2a1.*

According to the above statements and *Note 2(10)*, on the basis of H particle-paths hypothesis in the latter example no diminution / increment is taken place at path-limit, Γ, *Sec. 1(12),* of an isolated H system moving in vacuum space. In other words, a contraction/ dilation is occurred merely on the wavelength of the H particle-paths (proportional to time's arrow of the parent H system), e.g., photon, of the parent H system propagating in vacuum space regarding *Doppler Effect*, i.e. λ_F, λ_B, *Sec. 2(10),* through entering /exiting of H particle-paths groups (energy increasing /decreasing). Whereas, the total path-length of the whole system as an isolated H system remains constant, *Sec. 2(1)2,* in each spatial direction; please refer to *Sec. 2(1)1b,* path-constancy for additional information.

Noteworthy during a measurement (or interaction), *Sec. 8(7)2,* the H hall package, *Sec. 5(16)3a*, of the particle (or H system) under investigation is linked to that of measuring device in the form of a pseudo unique H system, *Sec. 7(4)2b,* of total path-length value of the latter is equal to $2h$. Please refer to *Sec. 8(9)3, Remark 8(9)3a*, in this regards.

As the result:

1) Any isolated system (e.g. photon, electron, many particles, *Sec. 8(7)6*) before measurement can be regarded as a unique H system, *Sec. 8(5),* of path-length value h regardless of the number of its particles.

2) During an interaction of, e.g., two particles, a cell [or groups of H particle-paths, *Sec. 7(4)*] of energy $\Delta E'$, and path-length value h interchanged between them, which obeys the relationship, *Eq. 7(10),* as quanta (or baby H system). Moreover, in this intermediate stage the interacting H systems constitute a pseudo unique H system, *Sec. 8(7)2*. Noteworthy, this baby H system can be regarded as H hall package of interacting medium, e.g., H hall package of vacuum medium at the region of interaction, or, in other words, within the space-time region, *Sec. 2(3)2b*.

3) Any H system can be considered as a set of cells each of stored path-length value h, *Sec. 7(2), Comment 7(2)1a.* Therefore, an H system constituting of n cells has hidden (or stored) path-length of nh, that each of them can be revealed during an interaction, *Sec. 7(2),* in the form of a newly H system that can be existed individually or to be linked (or overlapped) with one of the interacting H systems. Nevertheless, at the final stage each individual H system has path-length value h regardless of its stored path-length, *Consequence 7(4)1a*. Please refer also to *Sec. 1(16),* and *Example 5(16)3g, A1.*

4) During fission or beta decay an H system of initial path-length value h is disintegrated to *N* individual correlated, *Sec. 8(7),* H systems (or particles) each of their gaining a path-length value h just after a measurement (or interaction), *Sec. 8(7)2,* and *Sec. 8(7)6, part D*. Therefore, at the final stages the path-length of the whole system increased from $1h$ to Nh; please refer *to Sec. 5(16)6, Comment 5(16)6a,* and *Sec. 5(16)8*. Factually, before interaction, the whole H system (i.e. an isolated many particle H system, *Sec. 8(7)6*, is regarded as a unique H system of path-length value h, *Sec. 5(16)3g*.)

5) Any particle of path-length value h obeys the relationship $E.\Delta T = h$, *Eq. 7(8),* where *E* is its total energy and ΔT the internal time interval, *Sec. 2(10),* related to H particle-paths motion, *Sec. 7(4)4,* of the particle. The energy *E*, partial time ΔT varies merely through a measurement (or interaction) in the framework of the latter equation.

6) Based on *Sec. 2(10)1, Eq. 2(119),* and *Remark 2(10)1b*, the true quantized time unit ΔT_Γ is the algebraic sum of forwarding time arrow ΔT_F and backwarding time arrow ΔT_B, *Sec. 2(9).*

Consequence 7(4)1a– The path-length of a particle is an intrinsic characteristic of its H hall package, thus it is independent of its total energy content. The H hall package of an H system depending on external media (or conditions) has its own energy ΔE, time ΔT, (e.g. at the order of vacuum quantized texture energy density) or, momentum Δp_x, length Δx, such that $\Delta E.\Delta T = \Delta p_x.\Delta x \approx h$, i.e. its path-length value remains unchanged, *Comment 7(4)1a*. Therefore, an H system of path-length value h split to two H systems, *Sec. 7(2),* each of path-length value h, or vice versa. The path-length unit of h value is the unit in spatial medium quantization, e.g., vacuum medium, and gravitational field media, potential well medium. An H hall packages exchange, its elements, e.g., ΔE, ΔT, Δp_x, Δp_x, etc, with the related H system and spatial medium as in *Sec. 7(4)2b, Eq. 20*. The path-length texture of a media is based on set (or contribution) of H hall packages of h value, *Sec. 8(2)2*.

Note 7(4)1a- $\Delta T_\Gamma = a_1^{-1} K_m$, *Eq. 7(17),* is proportional to gravitational time unit, $d\tau$, *Sec. 5(16)1a, Eq. 5(51).* Therefore, it can be regarded as a Universal quantized time unit, *Note 2(3)2b1*. "Is time infinitely divisible? Yes, because general relativity and quantum mechanics require time to be a continuum. However, the answer is no if these theories are eventually replaced by a relativistic quantum mechanics that quantizes time. Although there have been suggestion that space-time may have a discrete structure." [434] *part 4c infinite time.* Supposing a source composed of N_S H particle-paths emits a photon of N_P H particle-paths. During the photon motion in spatial medium, *Sec. 7(4)3, part A*, it transfer from an vacuum H hall package of e.g. type R to other one of type L configuration of path-length $N_P.\Delta T_P = \Delta T_\Gamma$, *Sec. 7(1)*. It is along with the source transfer from an H hall package of type L to other one of type R (or vice versa) at opposite direction respect to observer A of $CMPRF$ of the whole system, *Sec. 8(9)2*, of path-length $N_S.\Delta T_S = \Delta T_\Gamma$ of opposite sign of the former, *Sec. 5(16)11*, i.e. the total path-length of source-photon system is remained unchanged:

$N_P.\Delta T_P = N_S.\Delta T_S = \Delta T_\Gamma = 0$ 7(19)

Thus, any time arrow in spatial medium is accompanied with time arrow reversal in mass medium depending on the number of their H particle-paths that is based on Mirror Image Effect, *Sec. 6(2)3*.

Note 7(4)1b – The transition from an excited state to other excited states or, ground state is governed by this lifetime-energy level width relationship in the former excited states.

Comment 7(4)1a- "Note that $\Delta x, \Delta p_x, \Delta E, \Delta T$, are not standard deviations but unspecified measures of the size of a wave packet"[369] *Bohr's view on the uncertainty relations.* According to *HPPH*, the H hall package of path-limit Γ , *Sec. 5(16)3b, part D2*i, s regarded as an equivalent to wave packet. Based on *Simulation 7(4)2e1*, the photon main-body can be regarded as a particle of specified energy that is confined in path-limit Γ of defined length in a medium, e.g. normal vacuum,. In other words, photons of different frequencies irrespective of their energies have equal path-limits, *Sec. 3(3),* in a medium, e.g. normal vacuum. Therefore, the H hall package of photon main-body from viewpoint of *HPPH* has no arbitrary spatial extension.
"Note that Δ*x*, Δσ, etc., are not standard deviations but unspecified measures of the size of a wave packet [369] *Bohr's view on the uncertainty relations..*

Comment 7(4)1b– According to *Sec. 7(4)3, part H*, the partial time's arrow ΔT varies from its minimum, i.e. Planck time ΔT_P, in mass media, *Sec. 7(4)3, part D*, up to its maximum value ΔT_d in gravitational field free vacuum medium, *Sec. 7(4)3, part A*. Therefore, the energy of an H hall package varies from its maximum value to its minimum one accordingly. Please refer to *Sec. 5(8)2, Sec. 5(8)1, Eq. 5(33)1.*

Remark 7(4)1a – Factually, a moving H system, e.g., moving free electron or photon, is supposed as a set of neutropa cells, *Sec. 4(3)1, part B*. Therefore, during an interacting a set of these neutropa cell can be regarded as a unique cell (or group of H particle-paths) that can be appeared as a new (or transferring) H system of path-length value h, that obeys the *Eq. 7(10).* This can be viewed as an interpretation of uncertainty principle from viewpoint of H particle-paths hypothesis. "The uncertainty principle in quantum mechanic" is sometimes erroneously explained by claiming that the measurement of position necessarily disturb a particle's momentum". "The more modern uncertainty relations deal with independent measurements being done on an ensemble of systems. This raises interesting questions about the nature of matter which are as yet not well understood" [368] *Wave-particle duality*.

Remark 7(4)1b- According to *Sec. 1(16),* the exit and entrance of H particle-paths are performed through its H hall package. In other words, the exit of H particle-paths is accompanied by H hall package generation each of path-length value h , *Sec. 5(16)3g,* from its initial H hall package of the related H system (or, vice versa in case of entrance of H particle-paths in an H system), *Sec. 7(2)*. Therefore, according to above discussion, H hall package generation is along with time's arrow, ΔT_Γ , *Eq. 7(17),* and path-limit Γ related to spatial expansion V_{HP} , *Sec. 5(16)3a*. Note that, any newly born H hall package is correlated with its main H hall package generator (or source), *Secs. 8(7), 8(9)1.* According to *Sec. 5(16)1a, Eq. 5(54),* the whole system has a total stored, *Comment 7(2)1a*, path-length, $L_t = n\Gamma$, where, n is the number of correlated H hall packages, and Γ is the path-limit, *Sec. 1(12).* Moreover, H hall package absorption is accompanied by time's arrow reversal, and space contraction, and handedness reversal, *Sec. 5(16)9b*, increment of related H system. Photon (or quanta) of the light beam can be considered as an example in this regards.

7(4)2- Discussion

7(4)2a – General aspect

A) Before the interaction of e.g., photon & electron at rest state, *Sec. 3(1)1*, each of these H systems have initial path-length value h. However, these particles individually have its own stored path-length.

B) During interaction, a cell (or groups of H particle-paths) of path-length value h as a new H system that obey the relationship *Eq. 7(17),* is transferred from photon to electron in order to reach to an equilibrium (intermediate state) along with a discontinuous change of both electron and photon momentum. "At the instant of time when the position is determined, that is, at the instant when the photon is scattered by the electron, the electron undergoes a discontinuous change in momentum" [369] *part 2.2*. Please refer also to *Sec. 7(4)2b, Eq. 7(20).*

C) After interaction, the stored path-length, *Sec. 7(2), Comment 7(2)1a,* of photon is diminished by unit of path-length h, *Sec. 7(2), Comment 7(2)1a;* whereas, the stored path-length of the electron increased accordingly. Nevertheless, the path-length value of photon and electron individually after interacting has unit of path-length, i.e. h. Therefore, the total algebraic sum path-length of interacting H systems remains constant, *Sec. 5(16)11,* at stages *A, B,* i.e. $2h$. "A measurement does not only serve to give meaning to a quantity, it creates a particular value for this principle" [369] *part 2.2.*

Please refer also to *Sec. 7(4)2c*.

Factually, in case of striking photon with a mirror (detector) in macro-world, the intermediate case *B* is replaced with its Mirror Image Effect, *Sec. 6(2)3*, conjugate due to the huge inertia, *Sec. 2(1)4*, of the mirror. According to *Sec. 3(1)1, Figs 3(2), 3(3),* lower number of H particle-paths, N , each of energy $\Delta E'$ in an H hall package of an H system is accompanied by more time interval ΔT, in the total path-limit Γ, through its motion in vacuum medium (or vice versa) in such away that $(N.\Delta E')\Delta T = h =$ *Constant*. It is an intrinsic characteristic of a particle in micro-world.

7(4)2b – Bounded electron in atom

In case of an electron in hydrogen atom, the electron is in ground state of principal quantum number $n=1$; thus, it has an angular momentum $\hbar$ of path-length value h.

I) Now, an electron that absorbs a photon of appropriate energy of path-length value h, *Sec. 5(16)3g*, gains a quanta of energy. So it jumps to an orbit of principal state $n=2$ that is farther from the nucleus, the atom-photon system has angular momentum $2\hbar$, and total path-length value $2h$; please refer to *Sec. 9(4), Remark 9(4)1a*. Therefore, it is consistent with path-length constancy, *Sec. 2(1)2*. This additional path-length unit of h value of entered photon is revealed as path-length due to the lifetime-energy level width relationship; *Note 7(4)1b*. Whereas, in the ground state the minimum possible path-length is h. "The lifetime-energy level width relationship states that $\Delta E.\tau \cong \hbar \rightarrow \Delta E \cong \frac{\hbar}{\tau}$. The uncertainty in energy only applies to excited state, because the ground state has an infinite life-time"[371], *ps-problem 4*. Please refer to Sec. *9(4)6*.

II) Now, considering the electron at ground state gains an appropriate quanta of energy, e.g. photon of path-length value h, it jumps to an orbit related to $n=3$ of angular momentum $3\hbar$. Whereas, the path-length of the system increases one unit of h, i.e. $2h$. In this case, the hydrogen atom makes two form of transition from the third excited state to lower state as following:

a) The electron makes a transition from the third excited state to ground state through emission of a photon of path-length value h. The total path-length of the atom-photon system remains unchanged as stated above (case *I*) in the second excited state related to Lyman series.

b) The electron makes a transition from the third excited state to second one related to Balmer series. Therefore, the total path-length of the atom is diminished one h unit due to exit of the photon. Now, the electron is in the second excited state, $n=2$ state and a path-limit of h value revealed due to the lifetime-energy level as in case *I*. The electron of excited atom at principal state $n=2$ exit a photon of path-length value h, and so jump to the ground state ($n=1$) related to Lyman series. In this case, the initial (or absorbed) photon is split to two emitted photons each of path-length value h; please refer to *Sec. 7(2)*. In other words, an initial H hall package of path-length value h is converted to two resulting H hall packages each of h value, i.e. path-length increment, that is accompanied by spatial expansion V_{HP}, along with time arrow, ΔT_{Γ}, generation, *Sec. 7(4)*. Please refer also to *Secs. 5(16)3a, 5(16)7a*.

In the above examples, the absorbed photon by electron of hydrogen atom delivers most of its energy (or H particle-paths) from its H hall package to the electron's H hall package. In other words, a nearly empty H hall package of low H particle-paths population (i.e. low energy ΔE) remains. Thus, during photon emission by excited electron, the reverse process is performed, i.e. H hall package of absorbed photon takes again its delivered H particle-paths (or part of it according to *case IIb* of Ballmer series), and appeared as a emitting photon.

As a result, the H hall package in this example can not be reached to full emptiness of H particle-paths; but, it must contains at least one , or, a few number of H particle-paths (or energy). Therefore, in all of the cases, the path-length unit of H hall package is equal to h value regardless of its energy content (or number of H particle-paths), i.e. $\Delta E \downarrow .\Delta T \uparrow \approx h$; please refer to *Sec. 3(1)1, Figs. 3(2), 3(3).* According to the above statements, the following model can be visualized:

$$\underset{\text{Photon H hall (1)}}{[*********]} + \underset{\text{Electron H hall (2)}}{[*********]} \Rightarrow (\underset{\text{Baby H hall (3)}}{[***]} + \underset{\text{Exited electron H hall (4)}}{[****************]}) \quad \textit{Remark 7(4)2b1} \qquad 7(20)$$

Please refer also to *Note 7(2)2b1.*

In other words, between parent H system [*No.1*, *2* of model *Eq. 7(20)*] in left side, and its baby counterpart [*No.3*], *Note 7(4)2b1,* and excited electron in right side of *Eq. 7(20),* there is an equilibrium. According to this modeling, as an example, *10* H particle-paths of photon strike with *10* H particle-paths of electron. Therefore, the result of this interaction is *19* to *17* H particle-paths of exited electron (photon + electron H particle-paths) that is in a correlation with *1* to *3* H particle-paths remained from photon transfer to electron, i.e. a hybrid stage. Please refer also to *Sec. 9(4)7.*

The right hand side of *Eq. 7(20)* as in intermediate mixed states of photon absorption, *Sec. 7(4)2a, paragraph B*, can be regarded as an unstable pseudo-unique H system, *Sec. 8(5)*, of path-length value of $2h$ that is leading to photon emission by hydrogen atom. According to *Sec. 9(3)1b*, in case of hydrogen atom, the exited electron (*No. 4*) in its H hall can be regarded as a quasi-particle (or virtual particle) of lifetime *Note 5(16)3b, part D2*, or, better to say stay time ΔT_p, *Sec. 7(4)2f, part A*, that is obtained from uncertainty relationship. Therefore, it has an excess partial charge $-\delta e$ within its lifetime.

According to *Sec. 2(10), Eq. 2(117)*, the following relation is valid in case of particle, i.e. $K_m \approx 1$. Thus:

$$N_3.H.\Delta T_3 = N_4.H.\Delta T_4 \approx h, \quad \text{or} \quad \frac{N_3}{N_4} = \frac{\Delta T_4}{\Delta T_3} \qquad 7(21)$$

Where:

- N_3, N_4, are the number of H particle-paths in H hall packages *No. 3, No.4* respectively.
- $\Delta T_3, \Delta T_4$, are the time interval between two neighboring H particle-paths in H hall packages *No. 3, No.4* respectively.

- *H*, energy related to an H particle-path, *Sec. 1(2), Eq. 1(1).*
Noteworthy, $\tau = N_3.\Delta T_3 = N_4.\Delta T_4$, the lifetime of the related excited state, *Remark 7(4)2b2*. Moreover, according to *Sec. 7(4)1* $\tau = \Delta T_\Gamma$.

Note 7(4)2b1- The baby H hall package, *Eq. 7(20),* is an example of empty H hall package of the particle, e.g. photon, track texture in a medium, *Sec. 7(4)3, E2, item E*, e.g. within mass medium related to electron in an atom. Factually, photon leaves its H hall package, and transferred to the H hall package of electron in a new medium of photon-electron system. The exited electron (or photon-electron) system constitutes a new combined H hall package track texture, *Sec. 7(4)3, E2, item c,* at higher energy level please refer also to *Sec. 7(4)3, E1 part A*. Electron during its stay time ΔT_p is transferred to its lower energy level H hall package of its track texture, i.e. ground state, and photon occupying its H hall package track texture again, and leaves the medium. Factually, according to *Sec. 7(5)1*, the empty baby H hall package as in *Eq. 7(20)* is related to reverson. In other words, the reverson at an exited state is the energy that is needed to transfer the electron to vacuum medium, i.e. ionization energy.

Remark 7(4)2b1 - The paradoxical mixed states (*No. 3, 4*)in the right hand side of *Eq. 7(20)* from pure state of electron H hall can be interpreted according to *Sec. 5(7)5*, due to the presence of another universe, e.g., type *L* (antimatter), as conjugate of our type *R* Universe (matter one), *Sec. 5(16)9a*. In other words, baby H hall package in the transition time interval τ , *Remark 7(4)2b2*, is transferred to the latter one and stay in it through this lifetime. It is because of the correlations between the states of both universes as mixed quantum states.

Remark 7(4)2b2 – The baby H hall formation is due to H particle-paths transfer of the H hall package, *Sec. 5(16)3a*, of absorbed photon to one of the n^2 H hall packages of electron in order to reach to that of vacuum texture in the baby H hall. In other words, there is a competition between the H hall package of vacuum texture and H hall package of quantized state of electron each of path-length value h through an equilibrium as in *Eq. 7(20)* within a time interval τ . In fact, τ corresponds to discrete (or quantized) time interval of local vacuum texture density (or energy density, *Sec. 5(16)3c*), i.e. lab. Therefore, by vacuum energy density variation due to the effect of an external field τ will be altered accordingly. Alternately, by analogy to *Sec. 7(4)2e*, the baby H hall is related to wave counterpart of photon as particle of *SM* configuration and reversible character. Factually, the transition time interval τ by comparing to stay time's arrow ΔT , *Sec. 7(4)2f, part A*, of irreversible expanding one can be regarded as a reversible stay time due to *T*-symmetry, *Sec. 2(4)4*, after photon emission. Therefore, the baby H hall package is related to H hall package of a reversible expandon-like (pseudo-expandon) particle of non-expanding character (*SM* configuration) generation that is reversed back (or disappeared) along with photon emission by the excited electron. Please refer also to *Sec. 7(4)2f, part B,* and *Note 7(2)2b1*.

7(4)2c – A proposed Mechanism

According to *Sec. 5(16)9*, there is a competition between matter and antimatter Universes with the preference of the former (bi-Universes Hypothesis). Therefore, in case of a free moving particle in vacuum medium, *Sec. 5(16)3b*, according to *Sec. 7(1), Eq. 7(5),* $\Delta x, \Delta p_x$ have equilibrated absolute value (or magnitude) in this relationship. In other words, $\Delta x, \Delta p_x$ as two inseparable entities have equal probabilities to be simultaneously either positive, or, negative in the matter and antimatter Universes respectively, i.e. h with positive sign in *Eq. 7(5).* Similarly, when a parent particle H system give birth to a baby H system, its stored energy, and its stored time is diminished accordingly, i.e. ΔE , and ΔT are both negative. In other words, its stored path-length diminished by h unit (or vice versa). Therefore, there is an equal probability both of ΔE , ΔT be negative or positive analogous to $\Delta x, \Delta p_x$. In other means, one can refer to absolute value of their in *Eqs. 7(5), 7(10).* "Heisenberg is concerned with unpredictability: the point is not that the momentum of a particle changes due to a position measurement, but rather that it changes by an unpredictable amount" [369], *part 2-2*. By the way, in case of particle regarded as isolated in vacuum texture medium, *Sec. 5(16)3, part A*, there is an equilibrium in the magnitude of $\Delta x, \Delta p_x$. However during a measurement, according to the kind of accurate measurement of position (or momentum) of the particle by a measuring device, there will be $\Delta x \downarrow, \Delta p_x \uparrow$ (or $\Delta x \uparrow, \Delta p_x \downarrow$) during born of a baby H system of path-length unit of h value, *Sec. 5(16)3,* from the parent one. As an example photon (as in the case *B* of *Sec. 7(4)2a*) through an interaction with electron can be considered. As the result, the momentum and position, (or, energy and time) of a particle undergoes two kinds of uncertainty based on relation *7(5) [or 7(10)]*:

1) During its motion before interaction (or measurement, *Sec. 8(7)2*), i.e. case *A*, and after measurement, i.e. case *c, Sec. 7(4)2a*. According to *Sec. 2(10)1, Eq. 2(117)*, the ΔT is infinitesimal and non measurable in case *A*.
2) During measurement the above *item1*, is broken in the framework of case *B*, i.e. the birth of an H system as individual (or as transferring intermediate H system) of path-length value h, that make the *item I* negligible. In other words, the low energy quanta of baby H hall exchange with low energy of vacuum texture; therefore, it's ΔT is high. "In every phenomenon the interaction between the object and the apparatus comprises at least one quantum" [369], *part 3,1*, i.e. a unit of action h, *Sec. 2(4).*

As the result, the Heisenberg uncertainty relationship of position and momentum (or time and energy) in all the time is an inherent characteristic of a particle during an interaction (or measurement). In macro-world it is become negligible in case of massif mass-body due to huge inertia of the latter, *Sec. 8(7)6, Example 8(7)6a*. Noteworthy, during the motion of a free moving particle in gravitational field, the vacuum quantized texture changes accordingly, *Sec. 7(4)3, part B*. Note that, the $\Delta x, \Delta p_x$, or, $\Delta E, \Delta T$ of the particle reaches to a local equilibrium during its motion based on steady exchange of its baby H system with that of vacuum texture. Therefore, $\Delta x, \Delta p_x$ has both negative value during the birth of baby H system and positive value during its return from vacuum texture to the parent particle's H system during equilibrium. Therefore, it is better to say, there is a steady H particle-paths mutual exchange in the framework of quanta between particle, and vacuum quantized texture. Moreover, the exchange of quantas in the latter case is infinitesimally low energy, i.e. $\Delta E \to 0$, because of low energy density of vacuum texture, *Secs. 5(16)3d*. However, this equilibrium changes (or breaks) according to the texture density of vacuum medium, e.g., in gravitational field, *Sec. 7(4)3, part B*; please refer also to *Sec. 5(16)1b, part A*. Moreover, accurate measurement of position (or momentum) is equivalent to the restriction of particles by the measuring device in a position (or to specific momentum) as a unique H system, *Sec. 8(5).* It is constituted of particle and measuring device after passing through a mixed intermediate state (i.e. a pseudo unique H system) e.g. slit gap medium, *Sec. 7(4)3, part C.* Please refer to *Sec. 8(7)2, part D,* and *Consequence 7(4)2c1.*

Consequence 7(4)2c1- Noteworthy, an entangled pair of particle is also regarded as a unique H system with its own path-limit Γ. During the measurement, the measured one obtains the equal magnitude of path-limit Γ at opposite sign from measuring device due to Mirror Image, *Sec. 6(2)3,* based on bi-Universe hypothesis, *Sec. 5(16)9*. Therefore, the correlation of non-interacted particle is interrupted from measured one along with a handedness reversal, *Sec. 5(16)9b*. In other words, the non-interacted particle is taken form within initial unique H hall package with its path-limit Γ remained from the initial entangled pair H system before measurement.

7(4)2d- Entangled pair of particle measurement

Referring to *Sec. 5(16)1b, part A, Fig. 5(8), paragraph 21*, any two superimposed expandons of types *R & L*, (or W_R, W_L, *P*-expandons, *Simulation 7(4)2e1*) are reversed handedness of each other along with slight preference of the former one in a matter Universe. Now supposing, the vacuum quantized texture is analogous to that of gravitational field in *Fig. 5(8).* Therefore, any photon transfer to a new adjacent position (or texture cells) in vacuum texture is equivalent randomly, *Sec. 8(7)2, part E4,* to its reverse handedness in the last position from viewpoint of spin orientation, and electric *(E)*, magnetic *(B)* field's vectors, *Sec. 4(3)1,* of related neutropa cells confining in an H hall package. Therefore, the photon during its propagation at c speed in vacuum space successively changes its electric, and magnetic fields respect to an observer at rest in an inertial reference frame, *Sec. 7(4)2e*. It is based on bi-Universe hypothesis, *Sec. 5(16)9*, according to that there is a competition between type *R*, and type *L* positions within time interval ΔT along with slight preference of the former in our matter Universe; please refer also to *Sec. 5(16)11*. Noteworthy, the time interval ΔT has positive, and negative values in type *R*, and type *L* positions respectively, i.e. uncertain time's arrow interval, and its reversal. As a result, considering a photon as particle (or main-body, *Sec. 7(4)2e*) is constructed of successive counter-current neutropa cells of *SM* configuration within an H hall package, *Sec. 3(1)2, Fig. 3(4)c*. Thus, photon during its propagation through vacuum quantized (or gravitational field, *Fig. 5(8)*) texture changes its handedness successively, *Sec. 7(4)2e*, by the texture cells up to an interaction (or measurement, *Sec. 8(7)2*) by a measuring device. Therefore, the detected photon handedness at this moment is accepted as its stabilized handedness due to huge inertia of measuring device. In case of entangled pair of particle, *Sec. 8(7),* if we analyze the counter-current motion of type *R*, and type *L* H particle-paths (i.e. negapa, and posipa) of the photon in three perpendicular x, y, z- axes, the detection in the direction of spin orientation, e.g. z-axis, terminates the counter-currency in that direction. The effect is transferred through the common (or main) H hall package, *Sec. 7(2),* of entangled pair instantaneously, *Sec. 7(4)2f, part c,* to the non-detected counterpart, *Note 7(4)2d1*. Thus, stabilizes the spin orientation in the *Z*-axis of the latter. In other words, the non-detected photon that lost its entanglement with the detected one conserves it entanglement with the initial source. Whereas, the non-detected photon in x-, and y- plane components conserves the counter-current motion of its H particle-paths up to a new detection (or measurement). As a result, the detected photon individually robs its H hall package of path-length value h from the initial common H hall package that is considered as overlapped H hall packages, *Sec. 7(2),* of the pair in the z-axis. The remained main H hall package that is confined in x-, y- plane can be regarded as individual H hall package of non-detected particle up to a measurement. Noteworthy, during any successive measurement (or detection) for the reason of equilibrium, *Note 7(4)2d2*, an H hall package in the direction of particle spin is robbed by detected particle via the common H hall package, *Sec. 5(9)3d, part c*, as its own H hall package in order to reach a new equilibrium in the new modified main H hall package in the related medium, *Remark 7(4)2d1*. Moreover, the huge inertia of the source respect to the photon stabilized this kind of equilibrium respect to an observer at the origin of *CMPRF* of particle-source system that is locate for the reason of source's inertia on the latter, *Sec. 8(9).* According to *Note 8(3)2a*, the detected photon transfers an expanding type R_e (or L_e), *Remark 7(4)2d2,* path-length of $+h$ value to the detector through vacuum texture at finite speed. At the instant of detection, the detector sends a contracting type L_c (or R_c) path-length of $-h$ value through common (or main) H hall package to the source instantaneously, nominating contracton of type *P* (or *P*-contracton), *Comment 5(2)1c1*. Note that, type R_e (or L_e) path-length is reversed handedness of type L_c (or R_c) one in the stated above process just during detection; please refer also to *Sec. 7(4)2e*. Moreover, type L_c (or R_c) path-length that is transferred from the detector of detected particle to the source shrinks the main H hall package down to the source; while, the other part (i.e. from source to non-detected particle) remained unchanged.

Note 7(4)2d1- Similar scenario as in case of interacting mass-bodies m_1, m_2 also is valid; please refer to *Sec. 5(9)3d, part c, Eq. 5(38)8* in this regards.

Note 7(4)2d2- According to *Sec. 1(1)*, the H particle-paths of an H system at rest state respect to its observer in an inertial reference frame undergoes an equilibrium in three spatial directions at c speed. In case of entangled pair of particle moving at two opposite directions respect to the related source (regarded as observer *S*), there is also an equilibrium in three spatial directions along with common motion of H particle-paths, *Sec. 1(3)*, at an spatial axis (i.e. motion axis), and at two opposite direction. Now, by removing one of these common motions through a measurement in one of the direction of motion axis, the equilibrium is broken in other direction as reversed handedness of measured one. Factually, there is a correlation of non-detected particle with the source (i.e. mass). According to *Sec. 5(16)11*, the non-detected particle (e.g. photon) has an expanding type R_e (or L_e) path-length. Whereas, in the source medium (i.e. mass), there is a contracting type L_c (or R_c) path-length counterpart of reversed handedness (up to a measurement) that control the non-detected particle arrangement through its motion in normal vacuum space; please refer also to *Sec. 8(3)*.

Remark 7(4)2d1- the path-limit Γ of common H hall package is elongated up to a measuring device (detector). Just during interaction (or measurement, *Sec. 8(7)2*) by detector, the detected particle acquiring the path-limit Γ of the medium, *Sec. 7(4)3, part G*.

Remark 7(4)2d2- According to *Sec. 8(9)1*, there is a superimposition of entangled photon of type *R&L* (indistinguishability, *Sec. 7(4)2f, part B*) in the framework of *SM* configuration, *Sec. 3(1)2,* at co- and counter-direction of photon propagation, *Fig. 8(1).* In other words, the type R_e and L_e path-lengths in spatial medium have equal probabilities. Moreover, type L_c and R_c path-lengths in the photon main-body have equal probabilities for a measurement.

7(4)2e- A mechanism of particle-wave duality

A) General aspect

According to *Comment 7(1)2*, and *Sec. 2(10)1, Eq. 2(117),* the partial time interval ΔT depends on total energy of an isolated free moving particle, e.g. photon, electron, The more energy, the lower ΔT , or, vice versa. The time interval defines the stay time of particle in an H hall package (or state). As an example, in our matter Universe, photon as a particle in its *SM* configuration depending on its energy (or its total H particle-paths population) has an stay time ΔT , *Sec. 7(4)2d*, in both of its indistinguishable SN_r , and SP_l configurations, *Sec. 8(9)1*. It is along with slight preference of the former successively in a path-limit Γ (of an H hall package of path-length value h, *Sec. 5(16)3g*), in case of photon of SN_r configuration, and vice versa in case of photon of SP_l one. During any transition, e.g. SN_r to SP_l configuration, an H particle-path (or a group of that) is separated from the main photon of reversed handedness as its track texture (or pilot wave), *Sec. 5(16)3b, part B*. In other words, a photon main-body at its contracting SN_r (or SP_l) configuration [related to type R_c (or L_c) path-lengths] is accompanied by an expanding type SP_l (or SN_r) track texture configuration [related to type L_e (or R_e) path-lengths], *Remark 7(4)2e1,* in such a manner that its initial *SM* configuration is conserved. Therefore, the photon travel as an isolated particle is along with a track texture (or deBroglie- Bohm pilot wave), *Remark 7(4)2e1*.

Resuming, a free moving photon depending on its energy has a stay time ΔT , *Sec. 7(4)2f*, in a position on an H hall package of normal vacuum medium. In other words, a more energetic photon along with its pilot wave has a lower ΔT stay time, which defines the wavelength of photon as a wave at its constant speed, i.e. light speed c. Moreover, the successive cells of photon wave counterpart of SN_r and SP_l configurations define its electric and magnetic field vectors, *Sec. 4(4), Fig. 4(8)*; please refer also to *Comment 7(4)2e1*.

According to above discussion, there are two main results as following:

I) The population density of H particle-paths in an H hall package is leading to probability of generation of deBroglie matter-wave, *Sec. 5(6)*, from main photon package. Therefore, the matter wave depends to population density, and inversely to the partial time interval ΔT . The former leading to matter wave frequency υ , and the latter is related to internal motion of H particle-paths of frequency equivalent n of photon main-body. Please refer to *Note 2(3)1*, *Eq. 2(56).*

II) The decrement of H particle-paths population density due to H particle-paths generation of deBroglie wave in case *I* is leading to ΔT increment (or deBroglie wave wavelength increment), i.e. photon red-shifting, *Sec. 7(4)2e, part B,*, during long period of time elapse.

Please refer also to *Example 7(4)2e1*, and *Simulation 7(4)2e1*. Noteworthy, according to *Sec. 8(9)1, Fig. 8(1),* the emitted photon is correlated through source-photon common H hall package with the source. In other words, this correlation is performed by extension of its axeon, *Sec. 10(8)*, or, track texture, *Sec. 5(16)3b, part B*, before detection (or measurement, *Sec. 8(7)2*).

According to above discussion, the gravitational expanding spheres, *Sec. 5(16)1b, part A*, of a particle, e.g. kaon, *Sec. 5(16)8*, have the following features:

A) SN_r configuration of type *R* path-length related to type *R* Universe, *Sec. 5(16)9a*.

B) SP_l configuration of type L path-length related to type L Universe.

C) The exit of gravitational spheres of expanding SN_r configuration (type R_e path-length) is accompanied by kaon main-body at its contracting SP_l configuration (matter). Moreover, the exit of gravitational spheres of expanding SP_l configuration (type L_e path-length) is accompanied by anti-kaon main-body at its contracting SN_r configuration (antimatter)*, Comment 7(4)2e1*. It is based on Mirror Image Effect, *Sec. 6(2)3*. Please refer also to *Eqs. 5(67)5, 6* of *Sec. 5(16)1c, part A1.*

D) Analogous to case c, the exit of gravitational spheres of expanding SP_l configuration (type L_e path-length) is along with anti-kaon at its contracting type SN_r configuration (type R_c path-length) related to antimatters.

E) The time interval ΔT , *Sec. 7(4)2f,* between two successive exit of gravitational spheres depends inversely on mass magnitude (or total energy) of the related particle, e.g. kaon, according to *Sec. 2(10)1, Eq. 2(117),* at microcosm. In case of macrocosm, please refer to *Sec. 5(16)1a, Eq. 5(51).*

F) In our matter Universe, there is a slight preference of kaon main-body at its SP_l configuration over SN_r one, *Sec. 5(16)8*, i.e. total path-length of type L_c in mass medium, *Sec. 7(4)3, part D*, of kaon main-body. Similarly, there is a slight preference of gravitational sphere of SN_r configuration respect to SP_l one, i.e. total path-length of type R_e in spatial medium, *Sec. 7(4)3, part A*. According to *Sec. 5(16)11*, the magnitude of path-length of type L_c in mass medium is equal to type R_e one in spatial medium, *Note 7(4)2e3*. In case of anti-kaon, the reversal of stated above process can be considered.

G) Analogous to photon, kaon as a particle of rest mass is correlated with the source through their common H hall package; please refer also to *Sec. 5(9)3c, Fig. 5(5)1*, in case of two mass-bodies.

H) Before measurement process, the same scenario as in case of entangled photon, *Secs. 7(4)2d, 8(7),* hold for kaon due to indistinguishability behavior, *Remark 7(4)2e1*.

Noteworthy, the surface of H hall package axeon, *Sec. 10(8)*, of the photon particle main-body can be regarded as surface of singularity (or zone area), *Sec. 7(5)3b*. It is equivalent to the Schwarzschild surface of a mass-body that is constituting of n_s , *Sec. 5(1)1*, Planck areas. By analogy, in case of photon n_s is equal to unity (n_s =*1*). Therefore, referring to *Sec. 5(16)1b, part A, paragraph 7*, its gravitational surface is consisting merely of an expanding neutropa cell. Contrary to case of mass-body, this cell is taken form from two co-direction posipa and negapa as in *Sec. 4(4), Fig. 4(8)*. The successive generation of cells of reversed handedness of photon main-body is leading to its reversal spatial configurations that forming the matter-wave counterpart of photon as in *Fig. 4(8), part* c. In other words, we encounter with an open-end chain of reversed handedness, along with spatial geometrical shape of expanding cells as photon matter-wave that are moving at the same speed of photon particle's main-body, i.e. light speed c. Please refer also to *Sec. 5(16)3b, Part B*.

Moreover, According to *Sec. 7(1),* and *Sec. 5(16)1b, part G1*, the *Eq. 5(67)4b*, and *Eq. 5(67)4c*, in vacuum media (e.g. gravitational, and gravity free) are linked to each other. In other words, the light speed c and Planck constant h in both media are depended on each other's. Moreover, in *Eq. 5(67)4b*, the stay time interval ΔT , *Sec. 7(4)2f, part A*, in both media are depended to the related path-length limit Γ . It is due to the propagation of generated expandon at light speed c in the related media. Thus, analogous to a photon as particle, the related emitted expandon propagates at the same speed c in both media, *Simulation 7(4)2e1*. By this analogy, any main- or sub-cell in *Fig. 5(8),* can be regarded as a particle that emits expandons. Any emitted expandon as latter can be considered as particle that emits expandon and so on based on Huygens Principle, *Note 5(2)1e1,* during stay time interval ΔT . Factually, the particle behavior (or characteristic) of a photon or expandon can be related to contracton that is released during expandon generation; while, the emitted expandon is related to wave behavior of the particle.

Example 7(4)2e1- Supposing, N_p the total number of single direction H particle-paths of photon as particle (i.e. main-body), and ΔT_p the related time interval. Therefore, Λ_p *Note 2(3)1a*, *Eq. 2(57),* is the wavelength of internal motion of H particle-paths of photon's main-body. In other hand, considering N_w the total number of H particle-paths of wave counterpart of photon related to photon as wave, and ΔT_w the related time interval. Thus, λ_w is the related wavelength of photon's wave counterpart. According to path-constancy, *Sec. 2(1)2*, and referring to *Consequence 2(10)1c, Eq. 2(116)2*, we have:

$$N_p.\Delta T_p = N_w.\Delta T_w = K_m / a_1 \qquad 7(22)$$

Noteworthy, in case of particle, e.g. photon, electron, $K_m \approx 1$, through gravitational field free vacuum medium, *Consequence 2(10)1b*; thus, according to *Sec. 7(4)1*, $K_m / a_1 = \Delta T_\Gamma$.

Considering, c (the light speed), the velocity of H particle-paths in both spatial and mass medium, we have:

$$N_p.c\Delta T_p = N_w.c\Delta T_w \qquad 7(23)$$

$c\Delta T_p, c\Delta T_w$, are the wavelengths Λ_p, λ_w, in free vacuum and mass media respectively. Thus:

$$N_p.\Lambda_p = N_w.\lambda_w \text{, or} \qquad 7(24)$$

In other words:

$$N_p.\frac{c}{n_p} = N_w.\frac{c}{\upsilon_w} \text{ , or}$$

$$K_\Gamma = \frac{\upsilon_w}{n_p} = \frac{N_w}{N_p} \qquad 7(25)$$

Where:

- K_Γ, the dimensionless proportionality factor of photon wave counterpart (or photon as wave) of SN_r configuration through spatial medium respect to frequency equivalent of photon as particle of SP_l configuration through mass medium; please refer also to *Note 2(3)1a, Eq. 2(56)*.
- a_1 , constant of media coefficient, *Note 1(2)1*.

- υ_w, the wave counterpart frequency of photon
- n_p, The frequency equivalent of photon main-body

Simulation 7*(4)2e1*- Considering the photon main-body in its position 1 at SP_l configuration, i.e. the element PL_1. Within partial time interval ΔT, it generates a matter-wave cell at SP_l configuration, i.e. the element WL_1. Thus, converting to SN_r configuration, i.e. PR_2, along a $\lambda/2$ position, *Note 4(4)1*, transfer at c speed, *Example 7(4)2e1,* at position 2. In other words, according to *Sec. 5(16)2a*, photon main-body PL_1 after WL_1 generation is contracting towards singularity of zone area of photon H hall package, and reversed back based on Mirror Image Effect, *Sec. 6(2)3*, right-handedly at expanding mode to PR_2 up to WR_2 cell of matter wave counterpart generation, i.e. de Broglie wave, *Sec. 5(6)*. At this stage, the former is reversed back at contracting mode towards H hall package of photon main-body zone area (i.e. beat, *Sec. 7(5)3d, part D* or pulse), and so on. As a result, the photon main-body is oscillating at partial time intervals ΔT, and $\lambda/2$ spatial transfers, along with its matter wave counterpart generation. Moreover, the $PR \to WR$ matter-wave generation is along with spatially expanding type R_e path-length; while, $PR \to PL$ conversion is accompanied contracting type L_c one related to matter Universe, *Sec. 5(16)9*, at equal magnitude, and opposite signs. Similarly, the $PL \to WL$ matter-wave generation is along with spatially expanding type L_e path-length; while, $PL \to PR$ conversion, *Comment 7(4)2e2,* is accompanied contracting type R_c one related to antimatter Universe at equal magnitude, and opposite signs, *Sec. 5(16)11.* Noteworthy, PL, PR are reverse handedness of each other. Similarly, WL, WR are also reverse handedness of each other along with their type L_e, R_e path-lengths respectively. In other words, $PR \to WR$ occupy type *R* H hall package; while, $PL \to WL$ one, during time interval ΔT cannot stay in type *R* H hall packages. Thus, transferring to type *L* H hall packages, *Consequence 7(4)2ea,* and vice versa. Noteworthy, any *PL* photon main-body during its transition emits *PL* contracton. Similarly, any *PR* photon main-body emits *PR* contracton towards the source i.e. mass medium, *Sec. 7(4)3, part D*, spontaneously, *Sec. 7(4)2f, part c*, and so on. Moreover, the expandon propagates in spatial medium at speed less or equal to the light speed c. Any *PL*, (or *PR*) H hall package unit, *Sec. 5(16)3b*, nominating type *L* (or *R*) unit respectively each related to half of a wavelength of photon $\lambda/2$. Thus, each type *R* (or *L*) unit constitutes the expanding type *R* (or *L*) part of a particle beat, i.e. the antinode, *Simulation 3(1)2a*. Therefore, the intersection of type *R* and *L* units of a beat nominating node, i.e. the type *R* or *L* contracting part of the beat. The contracton is releasing at the node mode configuration. The two type *R & L* of entities are based on bi-Universe hypothesis, *Sec. 5(16)9a*.

$$\begin{array}{ccccccc} WL_1 & & WR_2 & & WL_3 & & \\ \uparrow & & \uparrow & & \uparrow & & \\ PL_1 & \xrightarrow{\Delta T,\lambda/2} & PR_2 & \xrightarrow{\Delta T,\lambda/2} & PL_3 & \xrightarrow{\Delta T,\lambda/2} & \cdots\cdots \end{array}$$ *Note 7(4)2e1*

Fig. 7(4)1- Schema of photon-matter wave simulation

Photon motion in gravity free spatial medium, *Fig. 7(4)1*, is analogous to the motion of single direction an H particle-path or a group of H particle-paths in a medium; please refer to *Remark 1(1)4*. Moreover, according to *Fig. 4(8),* and *Remark 1(1)4*, the *WR* or *WL* expandon propagates in plane that are normal to their individual spin configuration.

The elements $WL_1, WR_2, WL_3, \ldots..$, are considered as *P*-expandons, *Note 7(4)2e2,* in case of a free motion of a particle, e.g. photon, electron. Please refer also to *Sec. 7(4)2f, part E2*. By analogy to expandons generated in gravitational field of mass-bodies (or particles) at rest state, the *P*-expandons are involving in gravitational interaction of related particles. Moreover, similarly, to case of gravitational interaction, *Sec. 5(9)3d, Fig. 5(5)2*, the *P*-expandons have contracton conjugates nominating *P*-contractons, *Comment 5(2)1c1*, that transfer successively to the particle's source through the related common H hall packages, *Sec. 8(9)1, Fig. 8(1)*, spontaneously up to a measurement, *Sec. 7(4)2f, part c*. Therefore, photon despite of zero rest mass imparts its own gravitational field. Moreover, similarly to gravitational field, any *P*-expandon is splitting to sub-expandons, *Sec. 5(16)1a, part B*. Thus, leading to an expanding track textures, *Sec. 5(16)3b, part B*, through the spatial medium that defines the trajectory of photon during its motion between two points A, B, *Remark 2(4)1a*. Note that, the assembly of $WL_1, WR_2, WL_3, \ldots..$, etc. *P*-expandons impart an H hall package of h value along with time's arrow ΔT_Γ, *Sec. 7(4)1, Eq. 7(17),* and spatial expansion volume V_{HP}, *Remark 7(4)1*, just during an interaction (or measurement, *Sec. 8(7)2*). Moreover, According to *Sec. 7(1), Eq. 8*, photon in its H hall package has an energy E_P, and time interval ΔT_P. Similarly, each of its *P*-expandon (in photon matterwave counterpart) has energy E_W, and time interval ΔT_W in its related H hall package obtained as following:

$$E_P.\Delta T_p = h,\; E_W.\Delta T_W = h \qquad 7(25)1$$

Therefore, according to *Note 2(3)1a, Eq. 2(56)*, we have:

$$E_W = K_\Gamma E_P = h K_\Gamma \Delta T_P^{-1} \qquad 7(25)2$$

Thus, according to *Eq. 7(25)1*, we have:

$$\Delta T_W = K_\Gamma^{-1} \Delta T_P \qquad 7(25)3$$

Please refer also to *Sec. 7(4)2e, part A,* in case of particle-wave duality of photon

Consequence 7(4)2ea- Based on *Sec. 4(4), Fig. 4(8),* and *Simulation 7(4)2e1, Schema 7(4)1*, any $WL_1 \to WR_2$ of H hall package unit, e.g. type *R*, related to type *R* beat, and $WR_2 \to WL_3$ of H hall package unit type *L* to beat of type *L*. Moreover, both are related to half a matter-wavelength $\lambda/2$ of $+E\uparrow \& -E\downarrow$ electric field unit vectors respectively, *Fig. 4(8)*. Thus, according to *Sec. 5(16)3c*, each $\lambda/2$ part contributes to a cycle of the successive beats (e.g. type *R* or *L* beat), *Sec. 7(5)3d, part D,* of frequency υ and equal magnitude of energy $\frac{1}{2}h\upsilon$. Factually in our matter Universe type *R* beat frequency has a slight preference over type *L* one.

Note 7(4)2e1- In case of antimatter, e.g. positron, according to *Comment 5(16)9b3,* the *WR* (or *WL*) expandon is generated from spatially left-handed spirally expanding gravitational spheres (group *L*) that are shown with $\overline{WR}$ (or $\overline{WL}$) bar symbols Similarly, its related contractons are shown with $\overline{PL}$ (or $\overline{PR}$) respectively. Referring to *Remark 5(16)1b, A1*, there is a superimposition of matter and antimatter universes with slight preference of the former based on bi-Universe hypothesis, *Sec. 5(16)9*. Therefore, the *WR* (or *WL*) expandons has a $\overline{WR}$ (or $\overline{WL}$) conjugate in antimatter Universe. Moreover, the *PL* (or *PR*) has $\overline{PL}$ (or $\overline{PR}$) conjugates respectively. In other words, there is a superimposition of *WR* (or *WL*), and *PL* (or *PR*) with related antimatter conjugates in Fig. *7(4)1* that are not shown for reason of simplicity at an indistinguishable manner, *Sec. 7(4)2f, part B*. In addition, any expandon, contracton and related antimatter conjugate can exist merely in one state during infinitesimal stay time interval ΔT, *Sec. 8(7)2, part E2,* not all of states at the same time. As if, all of expandons and contractons and related conjugates are coexisted at long (or averaged) time interval in an indistinguishable manner.

Note 7(4)2e2- Based on path-constancy, and referring to *Note 3(1)2a, Eq. 3(25),* there is a relationship between height r of an expandon *WR* or *WL* and its matterwave wavelength λ. Thus:

$$\lambda = 2\pi r \qquad 7(25)3a$$

Therefore, supposing the height of an expandon r, its weight is $\lambda/2$ or πr, i.e. a spindle-like shape.

Note 7(4)2e3- The action variation (or path-length unit) in spatial medium δS_g, and in mass medium δS_m have, two type $R \& L$ path-lengths. In other words, δS_g in vacuum medium have successively expanding types R_e and L_e path-lengths through vacuum medium. It is accompanied by contracting types L_c and R_c path-length of δS_m through mass medium respectively at equal magnitude and opposite sign. Therefore, at each stage, the *Eq. 2(103)2 of Sec. 2(4)2* is holding along with slight preference of type R_e path-length over type L_e one of δS_g through vacuum medium, or, slight preference of type L_c path-length over R_c one of δS_m in the mass medium. It leading to right-handed spatial expansion and left-handed mass contraction at equal magnitude related to entropy and negentropy, *Sec. 5(16)9d*, respectively. Please refer also to *Sec. 5(16)3g*, and *Sec. 8(7)2, part E5*.

Comment 7(4)2e1- In case of particle of rest mass, the SN_r (or SP_l) configuration in both gravitational field and mass-body means the slight preference of SN_r over SP_l (or SP_l over SN_r) as two counter-current H particle-paths of SN_r and SP_l configurations, *Sec. 3(1)2, Eq. 3(5).* While, in case of photon due to translational motion of photon's main-body, we encounter with purely SN_r and SP_l configurations as singlet, *Note 4(1)1*, individually in any of two adjacent cells. Thus, leading to electric and magnetic fields through spatial medium contrary to particles (or mass-bodies) of rest mass at rest state, *Sec. 5(16)1b, part A, paragraph 15*. Therefore, in the latter case, the slight preference phenomenon is leading to ultra-weak phenomenon of gravitomagnetism, *Sec. 5(2)1c*. Moreover, the path-length of SN_r configuration is of equal magnitude to that of the SP_l configuration, but at opposite sign in both spatial and mass media, *Sec. 7(4)3, parts A, D*. "The main novelty resides in the attribution to the de Broglie's wave an electromagnetic character"[494] *discussion*. According to *Sec. 5(6)2*, the de Broglie wave has also gravitational character. Therefore, there is a correlation between gravity and electromagnetism from the stated above viewpoints. Please refer also to *Sec.5 (16)1d*.

Comment 7(4)2e2- A free moving particle, e.g. photon, electron, during any type *WR* (or *WL*) expandon emission has a stay time interval $\Delta T_{P(Spatial)}$, or, $\Delta T_{P(d)}$, in spatial medium, *Sec. 7(4)3, part A*, (anti-node) at expanding mode. It is along with type *PL* (or *PR*) contracton release within the reverax, *Sec. 7(5)3b*, *item II*, related to mass medium, *Sec. 7(4)3, part D*, during infinitesimal time interval $\Delta T_{P(mass)}$, (node), or, $\Delta T_{P(c)}$ at contracting mode. The ratio of $\Delta T_{P(mass)}$ to $\Delta T_{P(Spatial)}$ is $K_\Gamma \approx 1.95\times10^{-34}$, *Sec. 8(7)2, part D*. In other words, the particle stay time in a state is $\Delta T_{P(Spatial)}$, of two types $\Delta T_{(PR)} \& \Delta T_{(PL)}$, *Note 8(7)2, E2a*, along with slight preference of the former one. Thus, the particle transfer from a state to next one is $\Delta T_{P(mass)}$, i.e. $PL \to PR$ conversion of two distinct types *R & L*. It is analogous to movie frames in a film, the stay time of a frame is $\Delta T_{P(Spatial)}$; while, the change of a frame to next one is $\Delta T_{P(mass)}$. Please refer also to *Simulation 3(1)2a* in case of node and anti-node. Therefore the time interval taking for a contracton transfer from a particle and to be absorbed by related suppermassif

black hole of the host galaxies & clusters, *Sec. 5(7)8*, is $\Delta T_{P(mass)}$. By analogy to *Sec. 5(16)1b, part F1*, the stay time interval of a particle in an expanded state is related to time symmetry. While, the infinitesimal stay time interval of a particle during its transfer to the next state that is along with contracton releasing is depending on time's arrow.
Resuming in case of a particle, e.g. photon, electron, the path-limit Γ_d of H hall package of vacuum gravity free medium is contracted down to Planck length l_p, *Sec. 5(8)1, Eq. 5(33),* or the least magnitude of Γ_{mass}, *Remark 2(3)1b*, during the transfer of the particle to the next state (or H hall package) during related stay time interval $\Delta T_{P(c)}$. The particle again is expanded up to Γ_d during stay time $\Delta T_{P(e)}$ along with emission of types *R(*or *L*)expandons successively, *Simulation 7(4)2e1*, and so on.

Remark 7(4)2e1- According to *Sec. 7(4)2d*, photon during its propagation is entangled with its pair, or, correlated to its source by a common H hall package up to a detection (or measurement, *Sec. 8(7)2*). Therefore, photon in its common H hall package changes successively its handedness, *Simulation 7(4)2e1.* In other words, the photon wave counterpart $PL \to WL$, and photon main-body $PL \to PR$ transitions occupying the left-, and right-handed cells of vacuum texture (or $PR \to WR$, and $PR \to PL$ transition occupying the right and left-handed cells of vacuum texture), *Note 5(16)3b, A2*, successively up to a detection (or interaction) by a measuring device. By the way, according to *Remark 7(4)2d2*, due to indistinguishability phenomenon, there is a superimposition of type *R&L* photon (or photon *1&2*) at each instant at equal probability at co- and counter-direction of photon motion, *Sec. 8(9)1, paragraph 3, Fig. 8(1),* all over its path (or H hall package). In other words, in position *1*, there is a superimposition of WL_1, WR_1 on each other, and PL_1, PR_1 on each other. Therefore, WL_1, WR_1, and PL_1, PR_1 are indistinguishable before a measurement. Similarly, the same scenario is valid for other positions 2*, 3, 4,...*that is not shown in *Fig. 7(4)1* for reason of simplicity. In other means, items in the *Fig. 7(4)1* must be accessible (or overlapped) with its reversed handedness at co- and counter-direction of pair propagation, i.e. fully equilibrium of H particle-paths of an H system from viewpoint of motion, and handedness, please refer also to *Sec. 8(9)1* in this regards. As a result, through measurement of one of the entangled photon pair, the items as is shown in *Fig. 7(4)1* hold for the non-detected one. According to *Sec. 5(9)3*, the H particle-paths of contracting path-length is reversed back to the mass, and the H particle-paths of expanding path-length to the spatial medium. Similarly, in case of photon the expanding H particle-paths related to expanding items (e.g. expandons) are transferred to spatial medium and its contracting ones (e.g. contractons) related to contracting items reversed back to the photon's main-body, and ultimately to related source at equal magnitude and opposite sign. Please refer also to *Sec. 5(16)3f, part B,* and *Sec. 7(4)2e, part A, last paragraph.*

B) Photon red-shifting

The particle, e.g. photon, red-shifting, *Sec. 5(16)1a, part c*, is along with the type *R* H hall packages generation due to matter-wave formation through spatial medium, i.e. spatial expansion. In other words, the generated H hall packages that are along with arrows of time, *Sec. 5(16)7*, are depending on stored path-lengths, *Sec. 7(4)1, item3*, decrement of the photon main-body as particle. Factually, just during an interaction (or measurement, *Sec. 8(7)2*) that the generated H hall packages taking their existence, *Sec. 5(7)3*. In other words, before interaction the photon particle and its matter-wave counterparts can be regarded as a unique H system, *Sec. 8(5),* of path-length value h, *Sec. 5(16)3g*. Noteworthy, the cosmic microwaves background radiation, *Sec. 5(5),* are the survival of primordial post big Bang photons that are red-shifted during the time. As a result, during photon red-shifting of this kind, the light speed c is remained unchanged as an immutable constant c, i.e. there is no superluminality through normal vacuum medium, *Sec. 5(16)7b, part B,* during the time, *Sec. 7(4)4*. Noteworthy, the energy diminution is perpendicular to the photon motion direction. Therefore, in case of particle of rest mass and at rest state that can be viewed as composed of H particle-paths moving at c speed at all direction, *Sec. 1(3)*, the energy losses in all three dimensional directions at the same rate. Factually, photon lost slightly its energy, *Note 7(4)2f, A2*, during a passage in a spatial medium, (e.g. gravitational field, particle track texture, *Sec. 7(4)3,* dark matter, *Sec. 5(1)2*) that can be neglected in short traveling distance. However, at galactic distances, this energy loss is considerable. "The existence of high redshift $(Z > 5)$ and the cosmic Microwave background radiation at $Z \sim 1000$ "[485]. Please refer also to *Sec. 5(16)7b, part B.* As the results:

1) The photon during its travel loses its energy (red-shifted) depending on decreasing spatial media H particle paths (or expandons, *Sec. 5(16)1a, part B*) densities from big bang up to present *Note 7(4)2e, B1.*
2) At equal distances, the photon red-shifted faster in the past at a decreasing mode until the present time. Thus, Z is a factor of the spatial media H particle-paths population densities at very extreme cosmological distances.
3) According to *Note 7(4)2f, A2*, the stay time ΔT_{gm} of primordial photon is increased as Z increased due to mutual interaction of the primordial photon with the related spatial media according to its H particle-paths population densities . Moreover, the coefficient $K_{\Gamma gm}$ of the spatial media is decreased accordingly.
4) The most probable of above cases, is the mutual interaction of photon H particle-paths with H hall package H particle-paths of *SM* configuration, *Sec. 5(15)2d,* of vacuum medium.

Please refer to *Note 7(4)2e, B1, B2*, in case of H particle-paths population densities.

Note 7(4)2e, B1- "$\Omega_{m0} = \dfrac{8\pi G}{3H_0^2}\rho_{m0}$, where, the subscript 0 represent the quantities measured at present time, and the cosmic scale factor is normalized such that it is equal to one today. The ρ is the density in matter and radiation. The subscript m refers to the contribution of matter. (The contribution of radiation to the density has been dropped since it is of negligible size today (10^{-5}). The inclusion of radiation is important only in the evaluation of the very early Universe"[486]. Factually, the density parameter Ω_{m0} is defined as the ratio of the actual (or observed) density ρ_{m0} to the critical density $\rho_c = \frac{3H_0^2}{8\pi G}$, i.e. $\Omega_{m0} = \frac{\rho_{m0}}{\rho_c}$. Thus, ρ_c the critical density for which the spatial density is flat (or Euclidean), *Comment 7(4)3, H1*. Moreover the H particle-paths energy density ρ_Λ of dark energy formation, *Sec. 5(15)2*, related to parameter vacuum energy density $\Omega_{\Lambda 0} = \frac{\Lambda}{3H_0^2}$ at $\Lambda > 0$ also has interacting effect with the photon in order to increase photon energy loss. However, the dilution of H particle-paths population densities due to spatial expansion (or dark energy) decelerates the photon's energy loss. Please refer also to *Sec. 5(16)3c*. The total density parameter of the Universe at any time from big bang era can be denoted by $\Omega_{total} = \Omega_m + \Omega_\Lambda$. Where, Ω_m the matter (dark plus baryonic) parameter density, Ω_Λ the vacuum parameter (energy) density. Factually, "The ratio between the energy density due to cosmological constant and the critical density of the Universe is denoted by Ω_Λ "[487] *Omega lambda*. According to *Sec. 5(15)2*, at the big bang, the vacuum energy parameter density was negligible through consumption of dark matter to dark energy during the time Ω_m is decreasing; while, Ω_Λ is increasing. Therefore, we encountered to an accelerated expanding Universe, *Sec. 5(15)2b*.

Note 7(4)2e, B2- Factually, according to H particle-paths hypothesis the both matter and energy are constituted of H particle-paths in its different aspects. "Cosmologists estimate that the acceleration began roughly 5 billion years ago. Before that, it is thought that the expansion was decelerating, due to the attractive influence of dark matter and baryons. The density of dark matter in an expanding universe decreases more quickly than dark energy, and eventually the dark energy dominate. Specially, when the value of the Universe doubles the density of dark matter is halved but the density of dark energy is nearly unchanged) it is exactly constant in the case of a cosmological constant)"[489]. "If the supernova data and the *CMB* data are correct, then the vacuum density is about *73%* of the total density now. But t red shift *Z=2* which occurred *10 Gyr* ago for this model if $H_0 = 71$, the vacuum energy density was only 9% of the total density."[515] *The Dicke coincidence argument*.

Comment 7(4)2e, B1- "Looks like Einstein may have been wrong — An international team of scientists at CERN has recorded neutrino particles traveling faster than the speed of light". "measurements over three years showed the neutrinos moving 60 nanoseconds quicker than light over a distance of 730 km between Geneva and Gran Sasso, Italy". "If confirmed, the discovery would overturn a key part of Albert Einstein's 1905 theory of special relativity, which says that nothing in the universe can travel faster than light" [621]. According to *HPPH*, a particle, e.g. photon, moving in spatial medium, *Sec. 7(4)3, part A,* has irreversible path-length, *Sec. 2(4)4*, of expanding characteristic of SN_r configuration and time's arrow; while, a particle moving in mass medium, *Sec. 7(4)3, part D*, has irreversible path-length of contracting mode of SP_l configuration at opposite sign to the former and time arrow reversal. Therefore, neutrino contrary to photon that reflects by the mirror can penetrate in mass medium. Thus, its total time travel just during the measurement is reduced respect to that of photon in this regards; please refer also to *Sec. 5(16)11*, *Sec. 5(15)2b,* and *Simulation 8(7)2, E5a, item 17E*. Factually:
A) Just at the moment of neutrino detection (or striking) by detector, according to *Note 5(16)7, g2,* contractons (as signal) is emitted spontaneously, *Sec. 7(4)2f, part c,* within H hall-package tunnel, *Sec. 5(9)3d, part c*, in backward path of neutrino emission towards the source, *Fig. 5(10),* i.e. completeness of measurement. In other words, the neutrino path is composed of two paths in vacuum and mass media as stated above with two different characteristics path-lengths of opposite sign.
B) The mass medium of neutrino travel is its detector "The *OPERA* neutrino detector at *LNGS* is composed of two identical Super Modules, each consisting of an instrumented target section with a mass of about *625* tons followed by a magnetic muon spectrometer. Each section is succession of walls filled with emulsion film/lead units interleaved with pairs of 6.7×6.7 m^2 planes of *256* horizontal and vertical scintillator strips composing of target Tracker (*TT*). The *TT* allows the location of neutrino interactions in the target."[623] *section 2*.
As a result, the neutrino like other particles may moves equal or than less than light speed in free vacuum. "The findings may need many runs and checks to be confirmed. Once confirmed, it raises many questions, including why such an effect wasn't noticed before. The big question would be this: What happens to Special Relativity, which is an extremely reliable theory?" [622]; please refer also to *Sec. 2(6)2a*.

C)- Doppler effect

1) Considering a satellite is moving towards a star at v speed**.** According to *Sec. 8(7)2, schema E5a*, in case of macro-bodies, by increment of satellite speed v, the spatial *S*-patch texture of satellite is becoming denser towards the motion direction as v increased respect to observer c at origin of *CMPRF* of satellite-star system. It is overlapped with center of mass of the star because of huge inertia of the star respect to satellite. Therefore, according to *Sec. 7(4)2f, part A*, the frequency of expandon emission, i.e. photon matter wave frequency, of emitted photon by star is increased accordingly in spatial patch medium of the satellite (or, vice versa in case of receding satellite).

2) Now supposing the satellite speed is increasing with a constant rate, and installing a sheet of dA area at point A respect to origin S of the satellite. In case of constant distance AS, there is a constant flow of H particle-paths of emitted expandons from the dA surface and normal to AS line in the direction of $\overrightarrow{SA}$ at a constant acceleration of satellite respect to observer c of

CMPRF. Therefore, the apparent (or false) gravitational field of satellite is somehow related to Doppler Effect of the spatial patch texture of the mass-body. Please refer also to *Sec. 5(3)1* in this regards.

7(4)2f – Particle stay time in an H hall package

A) Stay time in gravitational field

Considering an isolated particle of momentum p, and rest mass m_0 moving at v speed accompanied by its matterwave counterpart*, Sec. 5(6)*, of wavelength λ, frequency, υ. According to *Note 2(3)1a, Eqs. 2(72), (73),* we have:

$$\lambda = \frac{h}{p} = \frac{h}{m_{0p}\alpha c} = \frac{c}{\upsilon}$$

Similarly to stated above case, supposing this particle at rest state is surrounded with an stationary matterwave counterpart of intrinsic frequency υ_{0p}, and wavelength λ_{0p}. Thus, according to *Note 2(3)1a, Eq. 2(56),* and Sec. 5(6), we have:

$$\upsilon_{0p} = \frac{c}{\lambda_{0p}} = K_\Gamma n_{0p} \qquad 7(25)4$$

Where:

- n_{0p}, the frequency equivalent number of H particle-paths of particle at rest state
- K_Γ, the proportionality factor of stationary matterwave frequency υ_{0p} with that of n_{0p}, the frequency equivalent of particle through gravity free vacuum medium, *Sec. 7(4)3, part A*. Therefore:

$$\Delta T_0 = \upsilon_{0p}^{-1} = K_\Gamma^{-1}.n_{0p}^{-1}, \text{ Comment 7(4)2f, A1} \qquad 7(26)$$

Please refer also to *Proposal 7(4)3d, A1*.

Thus, by increasing the mass [or frequency equivalent increment, *Sec. 2(1)3, Eq. 2(35)]* of the mass-body $\Delta T_0 \to 0$; please refer also to *Note 7(5)3a2*.

Where, ΔT_0 (or ΔT_{G1}) is the time interval between two successive exit of gravitational spheres on ground sphere, *Sec. 5(16)1a, part B*, though vacuum medium nominating stay time of the particle (or particle's beat, *Simulation 8(7)2, E5a, paragraph 17*) in the related medium.

I) According to *Eq. 7(26),* and *Consequence 2(10)1c, Eq. 2(116)1,* we have:

$$\frac{\Delta T_{G1}}{\Delta T_{0(mass)}} = K_\Gamma^{-1}, \text{ Sec. 7(4)2f, part c} \qquad 7(27)$$

Please refer also to *Remark 2(3)1b* in this regards. According to *Sec. 5(16)1a, Eqs. 5(52), (53),* the product of dM by its related ΔT_{G1} is a constant. In other words, according to *Sec. 5(16)1a, Eq. 5(52)1*, and *Sec. 2(10)1, Eq. 2(117),* we have:

$$\frac{\Delta T_{0(mass)}}{\Delta T_{G1}} = K_\Gamma = \frac{dM}{M} = \frac{K_{m(f)}}{a_1}.H_0 \qquad 7(28)$$

Therefore, according to *Eqs. 5(49), 5(51),* we have:

$$K_\Gamma = \frac{8\pi^2 G}{c^3}\left(\frac{a_s}{b}\right) = 2A\|\hbar\| = 1.95\times10^{-34} \qquad 7(29)$$

Where:

- *A*, Correction factor, *A= 0.9262*; please refer to *Sec. 5(16)1c, part A1*.
- $\|\hbar\|$, is dimensionless numerical magnitudes of *h-bar* of Planck constant *h*, *Remark 5(16)1a3*.

II) According to *Simulation 7(4)2e1*, the particle during its stay time ΔT_{0d} in an H hall package of gravitational field free vacuum of N_{0d} H particle-paths emits a WL or WR cell of its matter-wave counterpart of υ_{0p}, *Eq. 7(25)4*, frequency during a particle beat, *Sec. 7(5)3d, part D*. In one hand, υ_{0p} depends on expandons generation by N_{0d} H particle-paths of a vacuum quantized texture, *Sec. 5(16)3b*. On the other hand, υ_{0p} also depends on N_{0p}, the total number of H particle-paths of the particle of frequency equivalent number n_{0p}, *Note 2(3)1a*, in the related H hall package; please refer also to *Sec. 5(16)3f, part A*. In other words, the stay time of a particle in an H hall package depends on mutual interaction of expandons of the medium with H particle-paths of particle that leading to a matter-wave counterpart cell formation by particle. It is along with particle transfer to adjacent H hall package of the medium and so on, *Sec. 7(4)2f, part E*. According to *Eq. 7(25)4*, we have:

$\upsilon_{0p} = K_d N_{0d}.n_{0p} = K_\Gamma.n_{0p}$ or

$$K_\Gamma = K_d N_{0d} \qquad 7(29)1$$

Please refer also to *Sec. 7(4)2f, parts D, E*, and *Note 5(16)3c1*.

Therefore, K_d similarly to K_Γ be a coefficient that is constant in vacuum gravity free medium. In case of gravitational field, according to *Sec. 5(16)1a, part B*, *Eq. 5(55)11*, an H hall package related to n^{th} gravitational sphere of Γ_{Gn} path-limit, and N_{gn} number of H particle-paths, the related K_Γ can be represented by $K_{\Gamma(gm)}$, *Note 7(4)2f, A1*. Therefore, by analogy to *Eq. 7(29)1*, we have:

$K_{\Gamma(gm)} = K_{gm} . N_{gm}$ 7(29)2

According to *Sec. 5(16)1a, part c, Eq. 5(55)13*, the stay time ΔT_{gm} of a particle in the above case can be obtained by analogy to *Sec. 7(4)2f, Eq. 7(26),* as following:

$$\Delta T_{gm} = \left(K_{\Gamma(gm)}\right)^{-1} . \left(n_{0p(gm)}\right)^{-1} \qquad \textit{Sec. 7(2)2b} \qquad 7(29)3$$

Please refer also to *Sec. 8(7)3.*
Where:
- $n_{0p(gm)}$, the frequency equivalent of particle of N_{0p} H particle-paths in an H hall package of path-limit Γ_{gm}.
Please refer to *Sec. 7(5)3d, part B, item VI*, and *Comment 7(4)2f, A1.*
As a result, because of stay time variation, there is no energy increment or decrement of a photon during its falling or receding in a gravitational field of a mass-body. It is in accordance with a test mass-body falling in an external gravitational field, through which its total energy remained unchanged, *Note 7(4)2f, A2* i.e. there is no mass increases during free falling, *Sec. 5(2)1b.* Noteworthy, according to *Sec. 5(16)1a, part c*, *Eq. 5(55)11a*, the light speed of a photon during its passage through any gravitational sphere of external gravitational field remained unchanged. Thus:

$$a_{Gn} \Gamma_{Gn} = \frac{\Gamma_{Gn}}{\Delta T_{Gn}} = c \qquad \textit{Example 7(4)2f, A1}$$

Where, $\Gamma_{Gn}, \Delta T_{Gn}, a_{Gn}$, are the path-limit, stay time, media coefficient, *Note 1(2)1*, of the particle on n^{th} gravitation sphere of external gravitational field. Noteworthy, the initial wavelength λ_0, [or, l_0 length, *Sec. 2(1)1b, Fig. 2(3)* related to *Delta Effect*] in gravity free vacuum medium is curved during photon falling as in *Fig. 5(7)* of *Sec. 5(10)2* by analogy to constancy of L_G, *Eq. 5(55)12* of *Sec. 5(16)1a, part c*.

Example 7(4)2f, A1- The path-length limit Γ_d in free vacuum is longer than Γ_G in a gravitational field, i.e. Γ_d is contracted in a gravitational field to Γ_G. Similarly, in case of a rectilinear moving of inertial frame *R'* at constant speed respect to an observer at rest in the origin of inertial frame *R*, the path-limit Γ'_d in the direction of motion become shorter than path-limit Γ_d in the rest frame *R*, i.e. $\Gamma_d > \Gamma'_d$ during a length contraction. Therefore, the stay time intervals related to both Γ_G, Γ'_d are shorter than stay time interval of Γ_d. As a result, Γ_d is a measure (or scale), *Sec. 5(16)3b, part D2*, of stay time intervals, i.e. $\Delta T = \frac{\Gamma}{c}$ (or clock rating, *Sec. 7(4)2f, part D3*) in a medium. Noteworthy, similarly to stay time interval ΔT *Sec. 7(4)2f, part A*, the path-limit Γ depends inversely to population density of H particle-paths in a medium, *Sec. 7(4)3*. In case of reference frame transformation, there is an additional path-limit Γ_{ex} related to transformation along with its apparent $\Delta T_{ex} = \frac{\Gamma_{ex}}{c}$ stay time interval related to path-limit of particle or mass-body track texture, *Sec. 5(16)3b, part A*, in spatial medium. As a result, the track texture of an isolated particle or mass-body can be characterized by its path-limit Γ_{ex} and its H hall package stay time interval ΔT_{ex}. Therefore, according to *Sec. 5(6)1, item III,* the motion of a moving object can be analyzed to its external (or common) single direction and internal reversible components.

Note 7(4)2f, A1- The proportionality factor $K_{\Gamma(gm)}$ is the modification of K_Γ in a gravitational field. According to *Sec. 5(16)1c, A1,* in gravity free vacuum medium, K_Γ is equivalent to $2\|\hbar\|$. Thus, the correction factor $A = 0.9262$ is related to gravitational field medium, *Sec. 7(4)3, part B*, on the Earth. In other words, in this case, $K_{\Gamma(gm)} = A K_\Gamma$ due to gravitational field effect of the Earth; please refer also to *Proposal 5(16)1c, A1.*

Note 7(4)2f, A2- Factually, the photon energy is lost slightly during its passage in a gravitational field. In other words, the stay time ΔT_{gm} is decreased through increasing of the gravitational field strength (or density). Thus, the photon beats, *Sec. 7(5)3d, part D*, becomes faster due to the rate of *WR & WL* expandons generation successively in a denser H particle-path densities of gravitational field medium and vice versa. According to *Sec. 5(16)1a, part c*, the stay time ΔT_{gm} decrement related to mutual interaction of photon with the traveled media energy densities, e.g. gravitation field H particle-paths densities. Moreover, according to *Sec. 5(15)2d*, by decrement of H particle-paths densities of *SM* configuration in gravity free vacuum medium, the stay time interval of photon is increasing accordingly due to photon beat decrement.

Comment 7(4)2f, A1- During decrement of clock rating, *Sec. 2(3)2a. Eq. 2(81),* and according to *Sec. 7(4)2f, part A, E q. 7(29)3,* or *Eq. 7(26),* the stay time interval of a particle becomes longer directly. In other words, the rest energy E_0 related to N_0 H particle-paths of the particle decreased to internal energy E_{in} related to N_{in} reversible internal H particle-paths. Therefore, the decay time interval of a non-stable particle at motion ΔT_{in} is becoming longer than that of at rest state, i.e. ΔT_0; please refer to *Sec. 7(5)3d, part B, Eq. 7(49),* in this regards. By analogy to above statement, through decrement of gravitational field, the stay time interval is decreased, or, vice versa. Moreover, the gravitational field depends on rest energy or internal energy of a mass-body, i.e. or its equivalent mass. In case of a moving object in addition to gravitational field, there is a phenomenon nominating gravitomagnetism, *Sec. 5(2)1c,* due to motion part of energy of the object.

B) Indistinguishability Scenario

According to *Part A, paragraph II*, the stay time ΔT (or decoherence, *Sec. 8(7)2, E2*) of an isolated particle in an H hall package depends on its total number H particle-paths, and total number of H particle-paths of H hall package of the related medium, e.g. vacuum medium, gravitating medium, etc., *Sec. 7(4)3*. The H particle-paths of the particle during its entrance in an H hall package interact with that of the latter at a rate, e.g. K_{Γ}, $K_{\Gamma(gm)}$. In other words, during the time interval ΔT of particle an expandon emitted towards the vacuum medium along with contraction towards the mass medium, e.g. black hole, *Sec. 5(7)8*. Noteworthy, a particle, e.g. photon of spin up during stay time interval ΔT, *Sec. 7(4)2f, part A*, emits a *P*-expandon, e.g. WR (or $\overline{WR}$), *Simulation 7(4)2e1*, along with its transfer to a reversed handed H hall package of the previous one; thus, it flips, e.g. to spin down. At this stage, it emits a WL (or $\overline{WL}$) *P*-expandon along with its transfer to a reversed handed H hall package of its previous position, and flips to spin up, and so on; please refer also to *Sec. 4(7),* and *Note 7(4)2e1.* As a result, there is a delay time ΔT at each position (or state). Thus, an isolated particle can not exists spontaneously at any instant at two positions, e.g. up or down, *Sec. 8(7)2, E2,* before the measurement, *Sec. 8(7)2*. In other words, there is a delay time (or stay time) between two positions. While, many particles can exist in different positions at any instant. Therefore, according to *Sec. 8(9),* the indistinguishability of two positions is depending on infinitesimal stay time ΔT, *Note 7(4)2f, B1*, of an entangled pair of particle moving at to opposite directions of each other. Noteworthy, each axeon, *Sec. 10(8),* of a particle of the pair is reverse-handed of other one during stay time interval ΔT. This system is constituted of single direction counter-current H particle-paths before measurement, *Fig. 8(1)*. In other means, the particle position is indistinguishable by taking into account the stay time ΔT within the range $E.\Delta T \cong h$, *Sec. 7(1), Eq. 7(8)*, within an H hall package, *Sec. 5(16)3a.* Where, E is the particle energy of that depending on the population density of H particle-paths in a position (or H hall package). In other words, the indistinguishability is restricted by stay time ΔT in each state of the particle. As a result, the indistinguishability is depended on co-existence of a pair of particle in a common H hall package, and its transfer to a reversed handed one during stay time ΔT (or vice versa), *Comment.7(4)2f, B1*. Noteworthy, any *P*-expandon generation by a particle is along with time's arrow, *Sec. 5(16)7*, and its spatial H hall package (or spatial expandon) formation It is accompanied by related *P*-contracton towards the mass medium (or source). Therefore, an entangled pair of particle is correlated to each other by *P*-contracton conjugates related to its *P*-expandons generation through the emitting source. A system constituted of a source and a particle obeys the same as in case of an entangled pair of particle. In addition, the emission of an absorbed photon by an electron in an atom acts as a system of source (i.e. atom) and single particle (i.e. emitted photon). Therefore, photon has a transition time τ (or stay time) during its emission, *Remark 7(4)2b2*. As a result, the detection of a particle e.g. spin up, that specifies spontaneously the spin down of non detected one, is related to *P*-contracton role of instantaneous*, Sec. 7(4)2f, part c,* transportation of information through the super-massif black hole of host galaxies or cluster, *Sec. 5(7)8*. Therefore, the *P*-contracton have analogous role of *G*-contracton during spontaneous propagation of gravitational interaction (or force), *Sec. 5(2)1d, part A1.* Moreover, the entangled pair of particle are correlate to each other via a common H hall package passing the source through *P*-contracton transmission by analogy to spontaneous mass-bodies mutual gravitational interactions, *Sec. 5(9)3d, part c, Fig. 5(5)2*.

Note 7(4)2f, B1- According to *Note 7(4)2e1*, any expandon, contracton, and related conjugates is existed individually merely during an infinitesimal time interval, *Sec. 8(7)2, part E2*. As if, expandon, contracton and related conjugates or particle, e.g. electron, at its different states are co-existing at longer time interval at indistinguishable probable manner.

C) Spontaneity from viewpoint of H particle-paths hypothesis

Considering, the particles of the entangled pair that emit *P*-expandons, *Simulation, 7(4)2e1*, of two handedness reversal types, *WR & WL* successively moving at finite speed $v \geq c$ through spatial medium, *Sec. 7(4)3, part A,* of normal vacuum texture, *Sec. 5(16)3b, part A*. According to path-constancy, *Sec. 2(1)2,* this path is equal (and at opposite direction) to the path traveled spontaneously by its related *P*-contractons (i.e. conjugates of emitted expandons) within the abstract vacuum, *Sec. 5(16)3h,* of the common H hall package of the pair, *Sec. 7(4)2d*. Therefore, based on *Eq. 7(27),* the spontaneity scenario in case of measurement of an entangled pair of particle and speed of gravity, *Sec. 5(2)1d*, etc. can be related to superluminal speed of interactions (or contractons transfer) at the rate (or speed) of $cK_{\Gamma}^{-1} = 5\times10^{33}c$, *Sec. 5(16)1a, part A, Eq. 5(52),* and *Notes 7(4)2f, c1, c2.* Moreover, the infinitesimal time's arrow reversal, *Sec. 5(16)7c*, in the this case due to transfer of contractons in mass medium of measuring device is 5×10^{33} times smaller than that of traveled time's arrow by the interacting particle through normal vacuum, *Note 7(4)2f, c2.* It is due to two types of WL & WR successive *P*-expandons that are generating up to stated above measurement, *Sec. 8(7)2*. According to *Sec. 5(7)8*, any contracton generated during an interaction, e.g. gravitational, electromagnetical, entangled pair of particle destructive detection, *Sec. 7(4)2d,* etc. is finally transferred through mass medium of related mass-bodies, and their common H hall packages spontaneously up to irreversible absorption by super massif black hole of the host galaxies and cluster of SP_l configuration. This phenomenon is along with time's arrow reversal and related mass-bodies or particle contraction within the mass medium, *Sec. 7(4)3, part D*. Factually, due to non-reversible absorption of contractons, its contracting type L_c path-length through the mass medium is of irreversible kind. While, the path-length in spatial medium related to particle matter wave, i.e. *P*-expandons types WR & WL, generation is becoming also of irreversible kind of expanding type R_e character of SN_r configuration, *Sec. 2(4)4*. It is at equal magnitude and opposite signs of the former one, *Sec. 5(16)11*. Therefore, any sort of information transferred to the black hole, *Sec. 5(7)8*, due to a physical interaction of irreversible kind of path-length is absorbed (or filed) by cone-like cavity, *Sec. 5(2)1d, part D*, of the related super massif black hole of the host galaxies up to Big crunch epoch, *Sec. 5(15)3c*. As a result, the motion of a particle through spatial medium of quantized vacuum texture, *Sec. 5(16)3b, part A,* is not steady and is step-like during stay times ΔT, *part A*, through successive H hall packages of normal vacuum texture of types $R \& L$ configurations that is along with types $WR \& WL$ *P*-expandons generation. Therefore, its speed is confined by vacuum texture geometrical shape, *Sec. 5(16)3b, part D*, up to light speed. While, the speed of interaction depends merely on an H hall package of the mass medium, i.e. particle main-body that elongated up to the source mass medium at one-step nearly spontaneous at $c K_{\Gamma}^{-1}$ speed through H hall package tunnel. Therefore, the entanglement or correlation of particles or mass-bodies is performed through mass medium and related common H hall package perforated through spatial medium without interference with the latter medium.

Resuming, any WR expandon emission by a particle, *Simulation, 7(4)2e1*, of spin L (or down) of the pair in spatial medium is accompanied by a PL type *P*-contracton propagation generation towards the source within an H hall package tunnel. Simultaneously, emission of WL expandon by the second member of the pair of spin *R* (or up) through spatial medium that is accompanied by a PR contracton propagation towards the source up to detection of one of the members of the pair of particle by a measuring device. Thus, the detection of the latter member at spin up (*z*-axis) by measuring device is leading spontaneously to spin down (counter-direction in *z*-axis) configuration, *Note 8(9)1a*, along with related expandons and contracton that is stated above, *Sec. 7(4)2d*. Therefore, contractons generation through H hall package component in z-axis of the non-detected particle is ceased up to a new measurement. In other words, the common H hall package component in z-axis of the pair is collapsed accordingly that confirm the degree of freedom of H particle-paths in any direction of spatial medium along with its related spin (or circular motion), *Sec. 2(1)1d*.

Note 7(4)2f, c1- "A new laboratory experiment at the *NEC* Research Institute in Princeton claims to have achieved propagation speeds of *310c*. This supplements earlier quantum tunneling experiments. Of all these experiments, the binary pulsars, places the strongest lower limit to the speed of gravity $2\times10^{10} c$ " [437] *Experiments measuring the speed of gravity*.

Note 7(4)2f, c2- The spontaneity or instantaneity from view point of H particle-paths hypothesis in this case has an infinitesimal time interval of the order of magnitude $10^{-33} s$ that is out of range of accuracy of detecting device. Therefore, the concept of non-physical zero time interval in the above case has no sense. Noteworthy, in case of entangled pair of particle, the stay time interval ΔT_p, *Sec. 7(4)2f, part H*, of the pair must be included in the time of contracton transfer within H hall package tunnel, i.e. $10^{-33} s$; please refer to Note 8(9)1a in this regards. Factually, the stay time ΔT in both case of entangled pair of particle and expandons is related to successive time intervals between contractons transfer at $5\times10^{33} c$ speed. As a result, there is two separate time as following:

I) Stay time interval ΔT_p related to mutual interaction of H particle-paths of the particle with that of the medium, *Sec. 7(4)2f, part E*. In other words, the handedness of particle is reversed during stay time interval.

II) The time's arrow reversal of contracton transfer within H hall package tunnels, *Sec. 5(9)3d, part c*, in the order of magnitude of $10^{-33} s$

Noteworthy, the spontaneity (or instantaneity), and infinite speed in their abstract concepts, i.e. time interval $\Delta T = 0$, or interaction speed $v = \infty$, and particle located at two different positions at once due to spontaneity, *Sec. 8(7)2, part E2*, has no sense in *HPPH*, *Note 2(1)1a1*.

D) The increment of intrinsic gravitational field of a particle in an external gravitational field

D1) General aspect

According to *Sec. 7(4)2f, part A, Eq. 7(29)1*, in one hand, the frequency υ_{0p} of particle P at rest state depends on H particle-paths population density N_{0d} of the medium. Therefore, in the denser medium, the frequency υ_{0p} is increased linearly with population density N_{0d} for a particle, e.g. electron. In other hand, in an uniform medium, i.e. constant N_{0d}, as in case of gravity free vacuum, the particle stationary matter wave, *Sec. 5(6),* frequency υ_{0p} depends linearly on the rest mass m_{0p} of the particle. Therefore, a particle, or a mass-body in an external gravitational field (or gravitating vacuum) has an induced gravitational field besides its conventional one respect to the same particle in gravity free vacuum. The external field induces a slight additional attraction toward s the Source of external gravitational field as in case of Pioneers *10* and *11* spacecrafts. Thus, the force of gravity deviates from the traditional Newtonian value. Please refer also to *Comment 5(16)1b, A2*. Factually, the rate of gravitational spheres emission of a mass-body in external gravitational field medium is higher than in the non gravitating vacuum, *Sec. 7(4)3*. In other words, respect to an observer on the Earth as lab, the time interval $d\tau$ between two successive gravitational spheres, *Sec. 5(16)1c, part A1, Eq. 5(67)6*, is increased down to reach a continuity of gravitational spheres analogous to case of principal orbits in an atom, *Sec. 5(16)1b, part A, paragraph 2(IIIA).*

"Experiments with a neutron interferometer demonstrating the effects of gravitational fields on the quantum mechanical wave properties of subatomic particle are discussed. The principles of the neutron interferometer, which is usually composed of a single crystal of silicon, are presented, and an experiment carried out to measure the effects of earth's gravity on the phase of the neutron is presented. Results indicating that a weak gravitational field shifts the phase of a neutron wave by the amount predicted by the Schrödinger equation are noted, and the implications of these results for the interpretation of the equivalence principle in quantum mechanics are considered. Other neutron interferometer experiments revealing the effects of earth and particle rotation on the phase and sign of the neutron wave function, respectively, are presented, and the significance of the experimental results to grand unification theories is assessed"[483] *Abstract*. According to *part A*, the above experiment is an example of effect of an external gravitational field, e.g. the Earth, on stay time of a particle, e.g. neutron, in a position that is proportional inversely to its stay time, *Sec. 7(4)2e*, *paragraph E*. In other words, the frequency of particle's *P*-expandons emission by the related particle as its matterwave counterpart is increased by an external field; please refer also to *Sec. 5(10)2*. According to *Sec.5(6)2*, the matterwave counterpart of a particle can be regarded as its gravitational field. Therefore, based on above discussion the external gravitational field affects the gravitational field of the particle. In other means, the mutual gravitational interaction, *part E,* of two masses (e.g. particle, or mass-bodies) affects their gravitational fields. As a result, the particle acceleration in a gravitational field proportionally alters the intrinsic gravitational field of the particle.

D2) Equivalence principle scenario

"Equations of motion in general relativity (*GR*) shows that a body's mass does very slightly (at the order v^2/c^2 [437] *part 5*) affect its own acceleration, violating the equivalence principle. Experimentally, this violation of the equivalence of acceleration and gravitation fields has been observed with neutron interferometer"[483]. According to H particle-paths hypothesis, these kind of discrepancies are removed by contracton generation based on Mirror Image Effect, *Sec. 6(2)3*, please refer to *Sec. 5(2)1e* in this regards.

As a result, according to above discussion, the equivalence principle depends on the medium, e.g. the Earth, the Moon Labs media. In other words, it depends on population densities of H particle-paths of the spatial quantized textures of the media, e.g. vacuum gravitational field free, gravitating vacuum of different field strength, *Sec. 7(4)3, parts A, B*. Moreover, according to discussion held in *Sec. 6(2)2* the equivalence principle is depends on the inertial mass of the testing medium. Therefore, it depends on the mass of investigating medium in the both of its aspects, i.e. gravitational and inertial.

D3) Clock rating

As a result obtained from *part D1*, the clock rating in a gravitational field, *Sec. 5(16)1b, part A, paragraph 2(III),* depends directly on the rate of expanding spheres emission. In other means, the clock rating in an H system is depending on the rate of its mutual interaction of its H particle-paths, *Sec. 7(4)2f, part E*, with that of the related medium, e.g. free vacuum, gravitating vacuum, *Sec, 7(4)3, part A*. The mutual interaction is revealed as handedness reversal at frequency υ_0 of the H system's axeon, *Simulation 7(4)2e1*, that leading to the rate of consumption of dark matter to dark energy via normal matter, *Sec. 5(15)2*. Noteworthy, any increment in clock rating leading to more time's arrow generation, *Sec. 5(16)7*. Please refer also to *Example 7(4)2f, A1,* and *Comment 7(4)2f, A1*.

E) Mutual interaction of particles or mass-bodies with H hall packages of spatial medium
E1) General features

Referring to *Simulation 7(4)3, E2a*, in case of a coupled electron pair in an orbital. Similarly to that, the H hall package of the particle, e.g. of type R, constitutes a coupled H hall package, i.e. a unique H system, *Sec. 8(5),* with that of the medium [e.g. vacuum, gravitational field, track texture] of opposite type, i.e. L, or vice versa. This combined H hall package emits type WR (or WL) expandon along with types PL (or PR) contracton, *Simulation 7(4)2e1*, successively due to mutual interaction of H particle-paths (or its density, *Note 7(4)2f, E1)* of medium H hall packages with that of particle, *Sec. 7(4)2f, part A*, and *Sec. 7(5)3d*. Thus, the handedness of combined H hall package is reversed, e.g. type R to L, (or vice versa) during stay time intervals ΔT_P, *Note 7(4)2f, E2*, and *Comment 7(4)2e2*. In other words, the particle is transferred to a new H hall package of the media of reversed handed of the former one, i.e. type R, (or L) along with type WL (or WR) expandon, PR (or PL) contracton formation in successive manner and so on. Noteworthy, the expandons of SN_r configuration of the media H hall package are interacted with H particle-paths of the particle main-body, and its contractons conjugate of SP_l configuration are released in opposite direction of expandons and reversed handed to their, *Sec. 5(9)3d, part c, Fig. 5(5)2*. Factually, the ΔT_P due to huge inertia of the particle respect to that of the medium is the same as that of the particle in different spatial media. The dark matter of SM configuration conversion to dark energy of SN_r one related to expandon formation, *Sec. 5(15)2b*, *Diagram 5(1)*, is performed according to this type of mutual interaction. "Energy of motion is exchanging back and forth with energy of position."[501] *Principle 1*. "The medium reacts on the particle with a force depending on its position r, say $f(r)$. The Taylor expansion of $f(r)$, for small perturbative displacements η is given by:

$$f(r)=f(r_0)-\left|\frac{\partial f}{\partial r}\right|_{r_0}.\eta+\ldots \qquad 7(29)4$$

To ascertain the stability of the longitudinal motion (of particle), the sign of the second term on the right-hand side of *Eq. 7(29)4* is minus. Thus, for small perturbative displacement η from the longitudinal trajectory the restoring force, to the first approximation is that of a harmonic oscillator"[494] *the physical nature of the de Broglie wave*. "Photons as particles arrange themselves on a wave pattern, with maxima and minima, only because they are constantly under the influence of a low of interaction"[494] *introduction*. According to stochastic electrodynamics (*SED*), "The zero point field (or energy) is a universal field; all physical events should be considered as resulting from the action of this field. For instance, the emission or the absorption of electromagnetic radiation by a hydrogen atom should depend on the zero point field."[494] *SED*. According to *Sec. 7(5)3b, item IV*, the zero point field or energy has an equivalent from viewpoint of H particle-paths hypothesis nominated reverson that is shielded by an axeon. Please refer also to *Sec. 5(16)3c*.

E2) Path-limit of a particle and related field during its motion in spatial medium

The H hall package of path-limit Γ_{mass} of a particle during its motion at v speed in spatial medium, *Sec. 7(4)3, part A*, is combined with the H hall package of path-limit Γ_d. Thus, contracted and converted to the a combined H hall package of path-limit Γ_{mass+d} that because of huge inertia related to H hall package of path-limit Γ_{mass} respect to Γ_d it can be considered as Γ_{mass}. The path-limit Γ_{mass} during particle motion is the same as half of the particle wavelength $\lambda_P/2$. In other words, during a complete cycle of particle beat, *Sec. 7(5)3d, part D*, the path-limit Γ_{mass} is expanded to $\lambda_P/2$. Then it contracted to nil at the node and expands again to $\lambda_P/2$ at the other half of the beat. Thus, per definition the $\lambda_P/2$ can be defined as Γ_{mass} of a particle during its motion. In other mean, the H hall package of path-limit Γ_d of the vacuum gravity free medium is contracting to $\lambda_P/2$, nil and $\lambda_P/2$ respectively during a period of a beat. Moreover, the emitted combined H hall package of path-limit Γ_{mass+d} (as successor of interacted H hall package of vacuum medium) initially at path-limit Γ_{mass} during a beat expands successively in spatial medium analogous to case of a cell in *Sec. 5(16)1b, part A, Fig. 5(8),* up to reach again to path-limit Γ_d. As a result, according to *Sec. 7(1),* and *case E1* during half of a beat of particle, it swallows an H hall package of the vacuum medium of path-limit Γ_d along with changing its position in spatial medium. According to above discussion, the expansion and contraction of an H hall package of a free moving particle, e.g. electron, in spatial medium are compensated with the contraction and expansion of the couple of the particle pair, i.e., analogous to case of particle entanglement, *Sec. 8(7), Sec. 8(9)2*. Thus, leading to a smooth H hall package fluctuation (or prevention of spatial volume gaps between types *L & R* combined H hall packages), i.e. an H hall package at expansion is along with other particle of the pair at contraction and so on. The similar scenario is also valid for an electron pair in an orbital, *Simulation 7(4)3, E2a*, based on Pauli principle. Thus, the combined H hall package of particle of the pair with the spatial H hall package (or micro- spatial *S*-patch, *Sec. 8(7)2, part E5, Schema E5*) beats in spatial medium up to black hole, *Comment 7(4)2f, E2*. As an example, according to *Simulation 7(4)2e1, Fig. 7(4)1,* the photon main-body at *PL1*, (type *L*), configuration, during expansion of its combined H hall package (particle + *S*-patch) emits type *L*, *WL1* expandon. Then, the combined H hall package contracts at node and expands again right-handedly in order to emit type *R*, *WR2* expandon; while, the photon main-body acquires type *R* configuration *PR2* and so on. In other words, the combined H hall package firstly at *L* type and at second stage it converts to type *R* configuration. Moreover, the other photon of the pair firstly has reversed handed combined H hall package of *R* type and secondly its combine H hall package converts to type *L* configuration and so on.

Noteworthy, according to *Comment 5(16)7, g1*, a moving particle H hall package sweeps the H hall packages of the medium, e.g. gravity free vacuum, gravitating vacuum, faster than that of a particle at low speed or at rest. Therefore, ΔT_{gm} in *Eq. 7(29)3* of *Sec. 7(4)2f, part A*, also depends inversely to the speed of particle motion respect to particle's *CMPRF* origin, i.e. the supermassif black hole of the host galaxies & clusters, *Sec. 5(7)8*.

Note 7(4)2f, E1- . "The wave medium - the space around us - is the ONE source of matter and the natural laws. Since the waves of each particle are inter-mingled with the waves of other matter and all contribute to the density of the medium." [501] *Conclusions*. "The density of the wave medium as the sum of the squares of the waves from every particle in the universe, each diminished by the inverse square of the distance". "The matter of the universe combines to tell the space medium what it is and in turn the medium tells all matter how to behave". "Reduced to basics *GTR* calculates the density of space-time at each point in space using the density of matter and energy everywhere in the universe. A varying density is referred to as *curvature of space*. This space density is then used to determine the paths of moving matter and of light which follows the curvature. Archibald Wheeler expressed this: All the matter of the universe tells space what it is and in turn space tells matter how it must move"[501] *How is principle II obtained mathematically?* According to H particle-paths hypothesis, the population (or total path-length) of H particle-paths by all of the matter in a location determine its density at that location that can be evaluated by the media coefficient a, *Note 1(2)1*, of that position. "Eventually, studies of *QFT* in curved space-time show that the particle concept hinges on Poincaré symmetry. This result indicates that the existence of a particle number operator might be a contingent property of the flat Minkowski space-time. In flat space-time Poincaré symmetry is used to pick out a preferred representation of the canonical commutation relations which is equivalent to picking out a preferred vacuum state. This leads to the standard notion of a particle. However, neither the existence of global families of inertial observers nor the Poincaré transformations, which relate between these families, can be generalized to curved space-time. *QFT* in curved space-time can actually teach us something about standard QFT (in flat space-time). Since *QFT* in flat space-time is a special case of *QFT* in curved space-time, *QFT* in curved space-time can help us to see what is contingent in *QFT* in flat space-time"[598] *Further problems for a particle interpretation of QFT*. "On the one side, the adoption of a particle interpretation of QFT would make the importance of particle experiments and the predominance of speaking in terms of particles comprehensible. It could explain why charge only exists in discrete amounts which is a typical feature of particles and not continuously which is characteristic for fields. On the other side, we saw that there are various problems for a particle interpretation. Some results indicate that particle states cannot be localized in any finite region of space-time no matter how large it is. Other results show that the particle number might not be an objective feature. Nevertheless, it turned out that most arguments need to be seen in relative terms. At this stage of research it can only be recorded that there are various potential threats for a particle interpretation" [598] *Results*.

Note 7(4)2f, E2- Please refer to *Sec. 7(5)3d*, and *Sec. 6(2)6* in case of proposed mechanism of this kind of interaction.

Comment 7(4)2f, E2- Any *S*-patch of combined H hall package can be compared with the cone-like cavity, *Sec. 5(2)1d, part D*, supposing the mass-body *M* as related black hole of the host galaxies & clusters.

E3- Particles generation by mass-bodies and supermassif black holes in spatial

According to *Sec. 5(16)1b, part A, Fig. 5(8),* the expandons as particles are generated by mass-body gravity in spatial medium. Noteworthy, based on *Sec. 6(2)6b, part B*, the gauge bosons are generated during collisions and force application. Moreover, according to hawking black hole evaporation, the particles, e.g., electron, are escaped from black hole within spatial medium during pair production as Hawkings' radiation [134].

Note that, from viewpoint of *HPPH*, according to *Sec. 5(15)3d*, *part A*, any particle has imprinted existence related to history of its existence during Universe evolution via related black hole.

According to discussions held in *Sec. 7(4)2f, parts E*, the H system (or H particle-paths) of opposite configurations are engaged in the interactions along with opposite types *R* or *L* expandons and contractons releasing each at successive manner in spatial media and towards related mass media respectively.

7(4)2h- Localization Problems

According to *Sec. 5(16)1b, part A, Fig. 5(8)*, on the Schwarzschild surface of a particle or, mass-body, any two adjacent cells related to Planck areas are *types R & L* conjugates of reversed handed of each others. Thus, cannot be simultaneously existing in expanded form, *Sec. 8(7)2, part G*. By a far analogy, it is similar to two conjugate quantities in Heisenberg relationships, *Sec. 7(4)1*. "If there are, as Heisenberg claims, no experiments that allow a simultaneous precise measurement of two conjugate quantities, then these quantities are also not simultaneously well-defined"[369]*Heisenberg's argument*". Therefore, to some extent, the Heisenberg's conjugate quantities may be related to non-simultaneous type *R & L* configurations of a particle or, mass-body. In other words, by measuring a quantity, e.g. merely a type *R* (or *L*) of configuration of a particle can be defined, *Comment 5(15)3d, B1*. Therefore, the particle at the moment of measuring of its momentum may be in a reversed handed configuration, i.e. type *L* (or *R*). "Bohr pointed out that in the microscope experiment it is not the change of the momentum of the electron that is important, but rather the circumstance that this change cannot be precisely determined in the *same* experiment"[369]*Heisenberg's argument*. Factually, according to *HPPH,* and above discussion, the two measurements, i.e. position and momentum are separated by a time interval ΔT, nominating stay time interval that separates two reversed handed configuration (or states) of the particle, *Sec. 8(7)2, part E2*. This stay time interval is linked to energy uncertainty by a quanta of Planck value h based on Heisenberg time-energy relationship. "In the sequence of measurements we have considered above, the uncertainty in the momentum after the measurement of position has occurred, refers to the idea that the value of the momentum is not fixed just *before* the final momentum measurement takes place". "Clearly, then, Heisenberg is concerned with *unpredictability*: the point is not that the momentum of a particle changes, due to a position measurement, but rather that it changes by an unpredictable amount"[369]*Heisenberg's argument*". According to *Note 2(4)4a1*, any interaction (or expandon, contracton emission) is equivalent at least to a unit of quanta of path-length value h, i.e. S/h. Therefore, during measurement of position (or momentum) at least a unit of path-length of h value is engaged, i.e. a Planck's quantum of action. Moreover, as stated above, any successive type *R* or *L* configurations (or a state) is separated by a unit of path-length value h, i.e. a discontinuity. "In every phenomenon the interaction between the object and the apparatus comprises at least one quantum."[369] *from wave-particle duality to complementarity*. Please refer also to *Note 7(4)3, D1*.

"The localizability condition is the essential ingredient of the particle concept: A particle—in contrast to a field—cannot be found in two disjoint spatial sets at the same time."The locality condition is the main relativistic part of Malament's assumptions; it requires that the statistics for measurements in one space-time region must not depend on whether or not a measurement has been performed in a space-like related second space-time region. Malament's proof has the weight of a no-go theorem provided that we accept his four conditions as natural assumptions for a particle interpretation. A relativistic quantum theory of a fixed number of particles, satisfying in particular the localizability and the locality condition, has to assume a world devoid of particles (or at least a world in which particles can never be detected) in order not to contradict itself. Malament's no-go theorem thus seems to show that there is no middle ground between *QM* and *QFT*, i.e., no theory which deals with a fixed number of particles (like in *QM*) and which is relativistic (like *QFT*) without running into the localizability problem of the no-go theorem. One is forced towards *QFT* which, as Malament is convinced, can only be understood as a field theory. Nevertheless, whether or not a particle interpretation of *QFT* is in fact ruled out by Malament's result is a point of debate. At least prima facie Malament's no-go theorem alone cannot supply a final answer since it assumes a fixed number of particles, an assumption that is not valid in the case of *QFT*"[598] *Localizability Problems*. The results about non-localizability which have been explored above may appear to be not very astonishing in the light of the following facts about ordinary *QM*: Quantum mechanical wave functions (in position representation) are usually smeared out over all $\Re^3$, so that everywhere in space there is a non-vanishing probability for finding a particle. This is even the case arbitrarily close after a sharp position measurement due to the instantaneous spreading of wave packets over all space. Note, however, that ordinary *QM* is non-relativistic. A conflict with *SRT* would thus not be very surprising although it is not yet clear whether the above-mentioned quantum mechanical phenomena can actually be exploited to allow for superluminal signalling. *QFT*, on the other side, has been designed to be in accordance with special relativity theory (*SRT*). The local behaviour of phenomena is one of the leading principles upon which the theory was built. This makes non-localizability within the formalism of *QFT* a much severer problem for a particle interpretation.

Malament's reasoning has come under attack in Fleming & Butterfield 1999 and Busch 1999. Both argue to the effect that there are alternatives to Malament's conclusion. The main line of thought in both criticisms is that Malament's 'mathematical result' might just as well be interpreted as evidence that the assumed concept of a sharp localization operator is flawed and has to be modified either by allowing for unsharp localization (Busch 1999) or for so-called "hyperplane dependent localization" (Fleming & Butterfield 1999). In Saunders 1995 a different conclusion from Malament's (as well as from similar) results is drawn. Rather than granting Malament's four conditions and deriving a problem for a particle interpretation Saunders takes Malament's proof as further evidence that one can not hold on to all four conditions. According to Saunders it is the localizability condition which might not be a natural and necessary requirement on second thought. Stressing that "relativity requires the language of events, not of things" Saunders argues that the localizability condition loses its plausibility when it is applied to events: It makes no sense to postulate that the same event can not occur at two disjoint spatial sets at the same time. One can only require for the same *kind* of event not to occur at both places. For Saunders the particle interpretation as such is not at stake in Malament's argument. The question is rather whether *QFT* speaks about things at all. Saunders considers Malament's result to give a negative answer to this question. A kind of meta paper on Malament's theorem is Clifton & Halvorson 2002. Various objections to the choice of Malament's assumptions and his conclusion are considered and rebutted. Moreover, Clifton and Halvorson establish two further no-go theorems which preserve Malament's theorem by weakening tacit assumptions and showing that the general conclusion still holds. One thing seems to be clear. Since Malament's 'mathematical result' appears to allow for various different conclusions it cannot be taken as conclusive evidence against the tenability of a particle interpretation of *QFT* and the same applies to Redhead's interpretation of the Reeh-Schlieder theorem[598] *Localization Problems*. Please refer also to *Note 7(4)3, D1*. According to *HPPH*, the vacuum medium is linked to mass medium, *Sec. 7(4)3, part D*, via H hall package tunnel, *Sec. 5(9)3d, part c*. Therefore, a particle related to the latter medium must be existed. In other words, the expanding characteristic of vacuum medium of SN_r configuration is along with contracting characteristics of mass medium within a particle of equal path-length magnitude, and opposite signs, *Sec. 5(16)11*. Therefore, a medium of contacting characteristics of SP_l configuration that is equivalent to particle behavior (or mass medium). By far analogy to a sink, it must be existed at all respect to vacuum expanding medium.