Part 3e- Discreteness

5(16)3- H hall quantized package

5(16)3a - General aspect

The H hall package of an H system is equivalent to package of energy, e.g., photon, of Einstein's photon theory that is equivalent to any H system from viewpoint of H particle-paths hypothesis.

According *to Sec. 5(16)2a, Eq. 5(67)15a*, we have:

$$\frac{1}{3}dV_{um} = \frac{1}{3}\frac{dV}{V} = \frac{dM}{M_n} = R_n^{-1} = H_o\, d\tau \qquad 5(69)$$

Thus, the mass variation related to mass unit is equal to one third of the related space expansion per unit of volume, i.e. dV_{um}.

$$dV_{um} = 1.55\times10^{-33}\, m^3 \qquad 5(70)1$$

Thus, according to *Eq. 5(5), 5(69):*

$$V_{HP} = \frac{dV_{um}}{N_G} = \frac{3H_o\, d\tau}{N_G} = 0.59\times10^{-49}\, m^3 \quad \textit{Proposal 5(16)3a1} \qquad 5(70)2$$

Where: N_G, is the number of H particle-paths related to mass unit of gravitational field, and V_{HP} is expansion related to an H particle-path in the gravitational field that is 8.5×10^{11} times greater than the minimum volume of an H particle-path in its contracted form, $V_{\min}$, *Eq. 5(37)2*. Moreover, V_{HP} volume nominated as H hall quantized package volume as a measure of quantized space, *Sec. 5(16)3b*, it contain at least one H particle-paths. In fact, according to *Sec. 5(16)4, Eq. 5(70)4; Sec. 9(4), Eq. 9(42)*, H hall quantized package geometry is related to two vacuum constants, i.e. dielectric constant, ε_0 and magnetic permeability, μ_0. In other words, "the speed of light is the square root of the ratio of the dielectric constant, ε_0 and the magnetic permeability, μ_0 of the vacuum"[77]. *Q&A, No.68*. Please refer to *Sec. 5(16)4, Eq. 5(70)7*, in respect of path-length constancy in an H hall vacuum quantized unit.

Generally speaking, according to previous section, field expansion is accompanied by mass (i.e. contracted form of the field), *Note 2(1)3b,* consumption; thus, there is a relationship between their; moreover, according to *Sec. 5(16)7a,* mass can be regarded as a store that generate space and time through gravitational closed surfaces (or spheres) expansion process. As a poor comparison, considering the mass conversion (mass diminution) to energy (energy appearance), *Example 5(16)3a1*, during this process the space expands and vice versa, i.e. the mass has a hard link with the expanding surface, *Sec. 5(4),* or space geometry (H hall shape in this article) as in the general theory of relativity. In the other hand, uncertainty principle, *Sec.7,* define the population and arrangement of H particle-paths, *Eqs. 5(52), 5(53)*, in the stated above H hall quantized package*;* thus, both shape and number of H particle-paths in an H hall quantized package are specified according to the above discussions as illustrated in, *Fig. 5(8)* .

According to *Sec. 7(2),* the space expands accompanied by mass conversion to field in the order of:

Dense mass > medium mass > dense field > medium field > Nil field 5(70)3

i.e. H particle-paths from its contracted form up to its expanded one along with space growing in size over time *Sec. 5(16)7a.*

In other words, to each isolated string-like H particle-path, *Sec. 1(12),* (or groups of their, *Sec. 7(4)*) is related a space unit at volume V_{HP} of the path-limit Γ and path-length physical value h, *Sec. 1(12), Sec. 2(1)2, Note 2(3)2a1,* and *Sec. 7(6),* in the direction of motion, *Comment 5(16)3a1*. The H particle-paths of the H halls can overlap on each other; thus, the extent of overlapness depends on the density of the mass, *Remark 5(16)3a1*. Moreover, H hall quantized package can take the shape of the path of the related H particle-paths (or the field) geometry. According to *Sec. 7(2),* H hall quantized package of n H particle-paths coincide (or overlap) on each other to form a single or common H hall quantized package that is occupied by n H particle-paths ; thus, Δx, *Sec. 7*, *Eq. 7(5),* in uncertainty relationships, is a measure of this overlapness, i.e. H hall quantized package expansion or contraction. As stated above, space is generated (or expand) through mass conversion to the field, *Note 5 (16)3a1*, in the Universe, *Note 5(16)3a2,* from the post Big Bang of "matter dominated Universe [40] era up to now, that is in contradiction with the radiation dominated Universe, i.e. an era before the former one. A replacement proposed era to that of radiation dominated can be considered as contracted state of H particle-paths analogous to the case discussed in, *Sec. 5(16),* moving individually at c speed. Moreover, a particle, e.g., free proton is stable respect to lesser stable one, e.g., free neutron due to lesser contribution of the former to space expansion than the latter one. Because "neutrons beta decay to protons plus electrons plus anti-neutrinos with a half-life of approximately 17 minutes"[40], accompanied by three H hall quantized packages appearance; please refer to *Sec. 5(16)6 to 8.*

According to the above statement regarding, *Notes 5(16)3a1, a2;* mass and its conversion to gravitational field has a main role in space-time, *Sec. 2(3)2b*. In other words, from view point of H particle-paths hypothesis this conversion correlates with simultaneous generation of space and time through H hall quantized packages as a fact of world existence, *Consequence 5(16)3a1*; please refer also to *Remark 5(16)3a2*. In fact H hall quantized packages' population is proportional to the age of the Universe from viewpoint of inseparable space and time quantized units that are linked with left (posipa) and right-handed (negapa) H particle-paths appearance moving at c speed, *Sec. 5(16)7a*. Note that, H hall package can be regarded as closed ended; please refer to *Sec. 9(4), Remark 9(4)1a*, in this regards. Noteworthy, the mutual exchange of H particle-paths between individual H systems is performed through H hall package. Therefore, all over this text the H particle-paths transfer, exit, and entrance are performed through this package.

Resuming according to above discussion, an H hall package of a particle during its appearance is along with a time arrow, Δt_Γ, *Sec. 7(4),* or, vice versa. In other words, a photon during its emission in vacuum medium will be extended in a path-limit

Γ within its H hall package. Moreover, the latter is accompanied by a time arrow of Δt_{Γ}, and a space expansion, V_{HP}, *Eq. 5(70)2*, related to its H hall package of path-length value h and path-limit Γ. According to *Sec. 5(16)3b, part D2*, the shape of path-limit Γ of the H hall package depending on its medium (e.g., normal vacuum medium, gravitational field) varies. In other words, in normal vacuum its shape is straight, in gravitational field it contract, (or wrapped) according to the spatio-temporal geometry of the field, *Secs. 5(9)1, 5(10)*, or dilated during propagation of correlated photon with the source, *Sec. 8(9)1, Fig. 8(1),* before measurement phenomenon*, Sec. 8(7)2*. In all above cases, the magnitude of path-limit is Γ.
Finally, an H hall quantized unit has the total spin of its related H system, e.g., the spin of free moving electron as an individual H system, (or a group of their), i.e. ± 1. Please refer to *Sec. 3(1)1, Note 3(1)1c, Eq. 3(17)1; Sec. 3(1)2, Note 3(1)2a, Eq. 3(27).* Moreover, the H hall quantized packages of the vacuum space, *Sec. 5(16)3b,* has right-handed of SN_r configuration, *Sec. 5(16)9d, part B*, contrary to that of former of left-handed of SP_l configuration. Noteworthy, to any path-length unit of an isolated H system of h value, e.g., particles, *Sec. 5(16)3g*, related an H hall package, *Sec. 5(16)3a*. The H hall package of *SM* configuration is occupied by an H system of bosonic structure. In other words, the latter may be particle (or particles) of bosonic structure, that is formed through a process of combination, *Sec. 9*, (or correlation, *Sec. 8(7)*) of initial fermionic particles, *Example 5(16)3a2*. Therefore, the orbital of an atom is occupied by a pair of fermionic, i.e. electron, at final bosonic structure. As example, please refer to Pauli Exclusion Principle, Cooper pair, etc., *Sec. 9(2), Sec. 9(2)4*. As a result, an H hall package is occupied at final stage by an H system of integer spin of bosonic structure, i.e. $N\hbar$, *Simulation 7(4)3, E2a*. In case of isolated elementary free moving particle, e.g., electron, proton, the coefficient *N* is equal to one, because of path-length constancy, *Sec. 2(1)2*; please refer to *Sec. 3(1)2, Note 3(1)2a, Eq. 3(27).* Moreover, in our matter Universe, the H hall package of SP_l configuration are contracting in mass-bodies constituted of fermionic particles along wit type L_c path-length; whereas, the H hall package of SN_r configuration, *Comment 5(16)3a2*, is expanding through spatial medium accompanied by type R_e path-length, *Note 5(16)3a3*. In case of antimatter one, we encounter with the reverse process. Please refer also to *Sec. 5(15)2b,* and *Sec. 5(16)11*.

Consequence 5(16)3a1- According to this assumption the space expands on the basis of priori specified of its preliminary contracted form since Big Bang, *Secs. 5(5)1, 5(6),* due to initial condition of our Universe. So quantized H hall quantized packages have its own handedness (Lock); thus, accept particles (Key), according to this Lock-Key system; please refer also to *Sec. 5(16)6 & 6(2)5 & Note 10(6)1.*

Example 5(16)3a1 - As a comparative simulating example considering a lake (as Universe) with blocks of ice (as macro-bodies, e.g. galaxies, stars) of different sizes and shapes that are melting [as generating gravitational expanding spheres, *Sec. 5(4)*] the water (as quantized texture) spread uniformly all over the lake. Thus, increasing the area of the lake surface during melting can be referred as expansion. Whereas, the water molecules can be compared with H particle-paths of this vacuum texture with the conception of conversion mass to gravitational field, *Sec. 2(1)3, Note 2(1)3b; Sec. 5(1)* (i.e. gravitational potential). By the difference that, the ratio of expansion to the converted mass is enormously very higher than simply conversion of the ice block to water in this comparative example.

Example 5(16)3a2 – "A superfluid is a liquid that flows without viscosity on inner friction. A liquid of helium-3, an atom whose nucleus is made up of an odd number of particles, is a type of particle known as a fermion. Group of fermions are not allowed to occupy the same quantum state. By cooling the liquid to a low enough temperature, helium-3 atoms can pair up the particles in each nucleus adds up to an even number, making it a type of particle known as a boson. Groups of boson can fall into the same quantum state, and therefore superfluidity can be achieved. Helium-*4*, a boson, does not need to pair up to form a superfluid. Superfluidity, especially the kind that exists in helium-3, is analogous to conventional low-temperature superconductivity, in which electrons flow through certain metals and alloys without resistance. In a superconductor, electrons, which are fermions, pair up in the metal crystal to form Cooper pairs, boson which can then condense into a superconducting state" [362]. Therefore, in the two above cases, i.e. superfluidity or Cooper pair, their unique quantum state coincides with an H hall package of h value from view point of H particle-paths hypothesis.

Example 5(16)3a3 – In an expanding *FLWR* Universe, on the basis of Robertson-Walker metric and referring to [286] "Watch what happens to a light ray moving through space, look at two wave crests in light ray separated in time by Δt time interval. Considering this time interval at the time of emission and observation (at the present time) Δt_e and Δt_o respectively; the relative size, $a(t)$ of spatial curvature radius of emission, $R(t_e)$ respect to observation, $R(t_o)$ is equal to the ratio of related time intervals":

$$\frac{R(t_e)}{R(t_o)} = \frac{\Delta t_e}{\Delta t_0} = \frac{\lambda_o}{\lambda_e} = a(t) = (1+z)^{-1} \qquad 5(70)3a1$$

Please refer also to *Sec. 5(16)2a, part B.*.
Where:
- λ_e, λ_0 are wavelengths of photon at the time of emission and absorption respectively.
- $a(t)$, z, are scale factor and cosmological redshift respectively.

So redshift is related to the expansion factor of the Universe; moreover, expansion has a hard link to time's arrow, *Sec. 5(16)7a*. Please refer also to *Sec. 5(16)3b, D2, item VIII*.

By comparing H particle-paths moving at c speed and simulating its motion with photon (i.e. Single direction H particle-paths), the result obtained from *Eq. 5(70)3a1,* is compatible with Delta Effect, *Sec. 2(1)1b, Fig. 2(3).* This is an example of single direction H particle-paths motion, *Sec. 7(4)4,* on the geodesic of curved space; please refer to *Sec. 5(4)2,* in this regards.

Proposal 5(16)3a1- "The formal analogy between classical and quantum fields as such is not a fully convincing argument for a field interpretation of QFT. If a field interpretation should actually yield the appropriate ontology for QFT than it seems that those objects which are called "quantum fields" are not already the fundamental entities one is looking for, at least not alone. Teller's own proposal is an ontology of QFT in terms of *field quanta*. Teller argues that the "Fock space representation" or "occupation number representation" suggests this conception with objects (quanta) which can be counted or aggregated but which cannot be numbered. The number of objects is given by the degree of excitation of a certain mode of the underlying field. Particle labels like the ones in the Schrödinger many-particle formalism do not occur any more. Teller has been criticized to draw such far-reaching ontological conclusions from one particular representation, in particular since the Fock space representation cannot be appropriate in general because it is only valid for free particles.

The transition from a classical field theory (like electromagnetism) to quantum field theory can be characterized by the transition from the field $\varphi(\mathbf{x},t)$ to the quantum field $\hat{\varphi}(\mathbf{x},t)$, and a corresponding transition for its conjugate field for both of which a certain specification of canonical commutation relations holds. In difference to a classical field $\varphi(\mathbf{x},t)$, the basic fields $\hat{\varphi}(\mathbf{x},t)$ of QFT are *operator-valued fields* since to each point of space and time an operator is attached. There is a formal analogy between classical and quantum fields: field values are attached to space-time points where these values are real-valued in the case of classical fields and operator-valued in the case of quantum fields. In technical terms the analogy reads as one between the mappings $\mathbf{x} \longmapsto \varphi(\mathbf{x},t)$, $\mathbf{x} \quad \Re^3$, and $\mathbf{x} \longmapsto \hat{\varphi}(\mathbf{x},t)$, $\mathbf{x} \quad \Re^3$. This formal analogy between classical and quantum fields is one reason why QFT is taken to be a field theory. However, it has to be examined whether this formal analogy actually justifies this conclusion.

In his paper "What the quantum field is not" (Teller 1990, also chapter five in Teller 1995), Teller criticizes this conclusion. Teller argues that 'quantum fields' lack an essential feature of classical field theories so that the expression 'quantum field' is only justified on a "perverse reading" of the notion of a field. His reason for this conclusion is that in the case of quantum fields—in contrast to classical fields—there are no definite physical values whatsoever assigned to space-time points. Instead, the assigned quantum field operators represent the whole spectrum of possible values so that they rather have the status of observables (Teller: "determinables") or general solutions. Something physical emerges only when the state of the system or when initial and boundary conditions are supplied. Teller's criticism of the standard gloss about operator-valued quantum fields has one justified and one unjustified aspect. The justified aspect is that quantum fields actually differ considerably from classical fields since the field values which are attached to space-time points have no direct physical significance in the case of a quantum field. However, it was not to be expected anyway that one would only encounter definite values for physical quantities in QFT since it is, like QM, an inherently probabilistic theory after all and is equally confronted with the measurement problem"[598] *The field interpretation of QFT.*

Note 5(16)3a1 - According to *Eqs. 5(31), 5(67)5, 5(67)15a, 5(68)1, 5(68)2, 5(38)3,* by differentiating of, *Eq. 5(68)2,* and by a simple manipulation we can obtain:

$$dt = \frac{t_e G}{r c^2 s^3} dM = \frac{t_e}{r s^3} d l_s = \eta^3 \frac{t_e}{r} d l_s \qquad 5(70)3a2$$

Thus, at a constant distance r (fixed point from the center of gravity of mass *M*), the radially time variation, dt in the gravitational field is proportional linearly to dl_s variation of mass *M* due to its mass loss, dM during related time dissipation. In other words, the rate of time consumption is proportional directly to the mass conversion (or loss) to the gravitational field of each point of space.

Note 5(16)3a2- "From viewpoint of *GRT*, what we call space is just another feature of the gravitational field of the Universe, so space and space time can and do not exist apart from the matter and energy that creates the gravitational field" [77], *Q&A, No.8.*

Note 5(16)3a3- The Schwarzschild surface, *Sec. 5(8)1,* is the bordering area (or horizon) of type *R*, and type *L* countercurrent Universes, *Sec. 5(16)9a*. In our matter Universe, the former is expanding (type R_e) from this area, and the latter is contracting (type L_c) towards that, *Sec. 5(16)11*. In case of a particle, its H hall package's area acts as a horizon between these two types of universes. Factually, the singularity at Schwarzschild surface of mass-bodies, *Sec. 5(16)2*, can be viewed as a horizon of this kind.

Comment 5(16)3a1- The open-ended particle, e.g. electron, photon, in an H hall package has path-length value h ; while, the close-ended particle, e.g. expandons, *Sec. 5(16)1c, part A3*, contracton, *Sec. 5(2)1c, part c*, in an H hall package has path-length value $2\hbar$.

Comment 5(16)3a2- According to *Sec. 7(4)2f, part E*, the H hall packages of spatial medium are constituted of type $R \,\&\, L$ along with slight preference of the type R over L one, i.e. SN_r configuration.

Remark 5(16)3a1 (proposal) - Alternately, an H hall quantized package can be viewed in the framework on the basis of energy, space, time correlation, *Sec. 7(6),* as a physical entity of *h* (Planck's constant) quantity units, *Sec. 2(1)2.* In other words, it is the carrier of path-length unit of h (or $\hbar$) value, *Sec. 5(16)3g.* Any H hall quantized package regardless of containing any number of H particle-paths (e.g., a particle such as electron, proton) has a path-limit Γ , *Sec. 7(4)3, part H*, and constant path-length value h , *Sec. 5(16)3g, part A*. Therefore, the energy reveal solely during an interaction or measurement*, Sec. 8(7)2,* during which additional H hall quantized packages appeared, i.e. space expansion accompanied by time's arrow that is equivalent to path-length generation and vice versa, *Example 5(16)3a3*. In other means, Universe is constituted of H hall quantized packages of equal path-length h . Moreover, Universe expands as H hall quantized packages appears; please refer also to *Secs. 7(3), 7(5).* Remarkably, any H particle-path or a group of that (e.g., photon, electromagnetic wave, electron, particle, etc) is confined in a quantized H hall quantized package that is nominated as a quantum state in the language of quantum mechanic, *Sec. 8*. This unit or state obeys generally from the uncertainty principle, *Sec. 7*, regarding energy, time and space, *Sec. 7(6).*

Remark 5(16)3a2- What has become very clear is that the phenomenon of gravity is only understandable once we have this unification of the quantum phenomenon of matter and the quantum phenomenon of space itself "[98], *Section 2-14.*
According to [244B], part related to *section 7.2, physical (node 26.html)*" The most remarkable physical result obtained from loop quantum gravity is, in my opinion, evidence for a physical (quantum) discreteness of space at Planck scale. Space comes in *quanta* in the same manner as the energy of an oscillator". According to [289], *part 6* – "Current theory is focused on the nature of space-time at the Planck scale. Loop quantum gravity, string theory, and black hole thermodynamic all predict a quantized space-time with agreement on the order of magnitude". From viewpoint of H particle-paths hypothesis H hall quantized units plays the role of quantized space-time with some intrinsic difference; please refer to *Sec. 7(4),* in this regards.

5(16)3b- Vacuum space quantized texture
A) Preliminary step

Factually, referring to *Sec. 5(16)3a,* the vacuum space quantized texture is constituted of H hall quantized packages and to any H hall quantized package belong at least a pair of negapa-posipa H particle-path i.e. quantized texture unit of matter, *Sec. 5(16)3d*. In other words, the simplest unification of the quantum phenomena of space and the quantum phenomena of matter itself; please refer also to *Sec. 5(16)1b, part A, paragraph 7, Fig. 5(8).* Thus, bending characteristic of H hall quantized package and related H particle-path along with superimposition of this package, *Sec. 7(2),* has the same formalism as curved space-time in *GRT*, *Sec. 5(16)3b, part D1*; please refer also to *Sec. 2(4)1, Sec. 2(4)2b.* This vacuum quantized texture can be challenged with ancient conception of Aether theory" [124]; thus, the propagation of forces and light through vacuum is no longer mysterious and almost inexplicable, *Note 5(16)3b, A1*. As a result, the presence of energy or mass in a limited space volume can be regarded as population density of H hall quantized packages each of path-length value h*, Sec. 5(16)3g*, as an immutable constant, i.e. Planck constant in that region. Remarkably, the space of right-handedly spirally expanding Universe, *Sec. 5(16)9a*, along with time's arrow can be assumed as a unique texture constituted of spirally right-handedly expanding correlated H particle-paths moving at c speed (i.e. better to say path-length). These are in steady exchange with H particle-paths of the mass-bodies dated from Big Bang up to now and in accordance to Mach's hypothesis. In other words, between the isolated mass-bodies and vacuum texture media there is an equilibrium stage in this respect, *Remark 5(16)3b, A1*, that can be disturbed by an external effect, e.g., in the quantum level by a measuring device; please refer also to part c of this section and *Sec. 8(7)2*. According to Mach's hypothesis, "inertial forces are due to interaction with the distant bodies of the Universe" [230]; please refer to *Sec. 5(9)3b*. Noteworthy any H system (e.g., photons, particles and mass-bodies) cannot be escaped from borders of the vacuum space quantized texture of our Universe; therefore, there is no correlation between our Universe and other Universes (if existed) except through the overlapped sections of their related textures in this regards; please refer to *Sec. 5(16)3h*. This unique H system (i.e. whole Universe) has a common internal motion as in, *Secs. 5(16)5, 9*, that leads to preferred reference frame, *Sec. 2(6)2b,* during study of relative motion of mass-bodies. The vacuum space quantized texture, *Sec. 5(16)3b*, spread uniformly on the very largest scales through the vacuum space; please refer also to *Sec. 7(6).* According to *Sec. 5(9)3, Fig. 5(5)1*, there is an equilibrated steady stream of H particle-paths between two mass-bodies regardless of their magnitude, or, in other words, there is a general correlation through the Universe; please refer also to *part B*.
According to *Sec. 2(4)2*, the path-length density in an expanding Universe is constant and independent of time. In other words, scale invariant; therefore, the vacuum quantized texture (or network) is woven uniformly and continuously, *Example 5(16)3b, A1*, through right-handed manner of SN_r configuration, *Sec. 3(1)2, Fig. 3(5),* and at a constant path-length density, *Note 5(16)3b, A2*. Please refer also to *Sec. 5(16)7h*. In case of curved vacuum quantized texture, please refer also to *Sec. 2(4)2*. Rest mass is constituted of reversible counter-current H particle-paths can also be considered as a dense vacuum texture. Therefore, its H particle-paths supposed moving at c speed similarly to that of normal vacuum, but the time interval in it is very much lower than background time of normal vacuum, *Sec. 5(16)7c*. Please refer also to *Sec. 5(16)1c, part A* in this regards.
The vacuum space quantized texture of the whole Universe that is composed of substructures (or space patches), *Sec. 5(16)3b, part H*, has both radial and rotational expansions during its extension, *Sec. 5(16)5,* and *Note 5(15)2c1*. Considering, the *4%* of the magnitude of the visible Universe, (i.e. galaxies, stars, atoms, etc.) respect to the dark matter and dark energy, of the whole Universe (i.e. reversible H particle-paths from viewpoint of this article), at the very large scale Universe (similarly to the lake case) can be regarded as uniform. Please refer to *Sec. 5(5)2*, *Consequence 5(5)2a*.

Example 5(16)3b, A1- Supposing an empty cylinder and a piston is moving back and forth as that is used for vacuum making in industry. Therefore, at the initial case, i.e. the piston is fully inside the cylinder, there is no vacuum space inner the cylinder. Through pulling out the piston, a vacuum medium is appeared inside the cylinder. According to H particle-paths hypothesis,

during this process the H particle-paths exit through the walls of the cylinder and piston head. In other words, a vacuum space with quantized texture in the lab is produced along with partially space expansion and time arrow, *Sec. 5(16)7a*. Noteworthy, this vacuum texture is constituted from both gravitational fields in the lab due to exit of gravitational sphere and free space that are stabilized at an equilibrium state, *Sec. 5(2)1b*. Factually there are counter-current H particle-paths flows through the walls; please refer to *Sec. 5(9)3*.

Note 5(16)3b, *A1*- "This web site postulates that matter is made of moving standing wave and that all forces are waves. Those waves need an aether". "Unfortunately, Lorentz was unaware of de Broglie's matter wave". "Standing waves actually undergo the Lorentz transformation"[357], *in the beginning of times*. Noteworthy, matter (or particle) from viewpoint of H particle-paths hypothesis is constituted of wave-like H particles paths moving at c speed through vacuum texture according to counter-current mode of motions, *Sec. 3(1)2*.

Note 5(16)3b, *A2*- Factually, the vacuum quantized texture of SN_r configuration can be compared to gravitational field at infinity (or ultra long distance), *Fig. 5(8)*. It is composed of both type *R*, and type *L* cells (or H hall quantized package of type *R & L*) with slight preference of the former ones, *Remark 5(16)1b, A1*. Any vacuum quantized H hall package (or cell) has a central reverson that is shielded by related axeon of type R or L as a singularity, *Sec. 7(5)3b;* please refer also to *Note 5(16)1, A6*.

Remark 5(16)3b, A1– The H particle-paths of a mass-body, and normal vacuum texture are in an steady equilibrium, *Sec. 5(2)1b*. In other words, the H particle-paths of a mass-body enter in vacuum texture (or vice versa) at equal rate. Therefore, the total energy and momentum of an isolated mass-body is conserved during the time at each location. This can be interpreted as a symmetry property of mass-body as a physical H system. "The Noether's theorem states that each symmetry of a physical system implies that some physical properties of that system is conserved and conversely that each conserved quantity has a corresponding symmetry" [408] *application of symmetry*. In other words according to H particle-paths hypothesis, the total path-length of the isolated mass-bodies is remained unchanged, *Secs. 2(4)1, 3*.

B) Particle track texture through vacuum

According to *Sec. 5(15)2b*, the vacuum quantized texture is generated by conversion of dark matter to dark energy through normal matter. Thus, similarly to a mass-body that contributes in space and time texture formation (i.e. path-length generation, *Sec. 2(1)2*) in the vacuum medium, a moving particle or mass-body traces a track texture, *Sec. 5(16)2c, part B*, on its trajectory in vacuum medium, *Consequence 5(16)3b, B1*. As an example, light emitted by a mass-body is guided through this trace (or path, track), *Sec. 8(7)4*, in one hand, and correlated to the source via H hall package tunnel, *Comment 5(16)2a1,* in the other hand. This trajectory can be regarded equivalent to a pilot wave hidden variables, *Note 8(7)5a*. As another example, the light beam bended near the sun, *Sec. 5(10)1,* can attributed to the curved track texture on the related Sun gravitational expanding spheres, *Sec. 5(16)1b, paragraph 7*. Noteworthy, the particle track texture takes the shape of its trajectory during its motion (or vice versa). In fact, the first photons of the beam extend the track texture for next successive ones up to reach equilibrium, *Sec. 5(2)1b, Fig. 5(2)* at the expense of dark matter. According to Bohm interpretation of quantum mechanic, Bohm called the hidden variable or pilot wave*, Sec. 5(16)3b,part I* , the quantum potential force or dark force, in comparison to dark matter and dark energy. He thought that it might probably be similar to luminiferous aether. "[335], *Background*. Noteworthy, to each point of the track texture we can refer a gravitational sphere, *Sec. 5(4)4a*, that expands accordingly, *Comment 5(16)3b, B1,* and *Experiment 5(16)3b, B1*. This phenomenon can be compared with propagation of diverging spherical waves (retarded waves), *Sec. 5(16)3f, part B*. Therefore, the whole trajectory (or track texture) is expanding, *Sec. 2(4)1, Comment 2(4)1b*. In other words, the main track texture is accompanied by these sub-tracks that attenuate as r^{-2} from the main texture, *Note 5(16)3b, B2*; thus, in microcosm the particles can choose this sub-texture at a low probabilities depending on r^{-2} respect to the main one or singularity, *Comment 5(9)3d2,* of H hall package of the particle, *item IV* of this section. Please refer to *Remark 5(16)3b, B1,* and *part C* of this section*, Sec. 7(4)3, E1, part B*, and *Sec. 8(3), Comment 8(3)2a*.

According to *Sec. 5(16)1b, paragraphs 3,4*, that specifies the rate of expansion both radially, v_r , and tangentially, v_t , are more higher than the rate of Hubble expansion at that region. The track texture by analogy with vacuum quantized texture has path-length characteristic, *Sec. 2(4)4a*. In other words, at quantum scale a particle can choose the main track texture, or, its sub-tracks depending on the density of their, or, the probability of their existence. Noteworthy, the path-length between source and target (detector) regardless of particle's trajectory are equal. In other means, the main, and each of its sub-track texture irrespective of their geometrical shape have the same path-length between source and detector (or, any two points *A, B*) in space. In the macro-world, due to the high inertia, mass-bodies move on well-defined track texture (or path) as discussed in *part c*.

As a result, in the quantum world, unlike the macro-world, there is not a sharp trajectory. In other words, from viewpoint of current theoretical physics, there is no well-defined and continuous space-time, *Sec. 2(3)2b*, analogous to macro-world through vacuum texture.

According to *Sec. 5(16)1b, Part A, paragraph 7D*, the expanding gravitational spheres (related to expandons, *Sec. 5(16)1c, part A3*) affects the track texture of moving particles (e.g., photon) that are passing in the gravitational field of a mass-body in the form of a curved trajectory. Noteworthy, the track texture of isolated particles and mass-bodies through flat vacuum quantized texture, *Sec. 5(16)3b, part A*, is straight due to rectilinear characteristic of vacuum texture. In other words, geometry of vacuum quantized texture, and gravitational field texture around a mass-body defines the geometry of track texture of moving particles and mass-bodies through their motions. Note that, from viewpoint of H particle-paths hypothesis, the concept of space-time in *GR* is equivalent to track texture through normal vacuum that is constructed by vacuum quantized texture of gravitational fields (due to expandons) of related mass-bodies, *Sec. 5(16)1b, part A, paragraph 7A*. The population density of the texture higher than flat

vacuum quantized texture defines the apparent velocity of photon lesser than c speed accordingly, *Example 5(16)3b, B1*. Moreover, the actual speed of the light (or photon) irrespective of the medium geometry, and population density is equal to c as an immutable constant, *Sec. 5(16)2c*. Factually, a particle during its motion stays successively, *Sec. 7(4)2f, part A*, in the combined H hall packages of its track texture, and the track texture of the medium, *Sec. 7(4)2f, part A*, e.g. vacuum, gravitational field, during $d\tau$ time intervals, *Sec. 5(16)1a*. It is leading to c speed of the light in case of massless particle, e.g. photon. Please refer also to *Sec. 5(16)1b, part A, paragraph 21*. Noteworthy, the generation of track texture of an isolated system of mass-bodies increases the velocity of the system in the co-direction of motion at a long period of time, *Note 5(16)3g, c1*.

In case of particle track texture during passing an aperture and double slits, please refer to *Sec. 8(3),* and in case of particle (or particles) in potential well or rigid box please refer to *Sec. 8(2)2,* and *Sec. 7(4)3, part E2*.

A particle during its motion on track textures chooses the denser ones from viewpoint of H particle-paths population densities. According to above discussion, and *Remark 2(4)1a*, the more populated ones between two points A, B of main track, *Note 5(16)3b, B3*, is the rectilinear in case of vacuum gravity free medium, and on the geodetic of curved space-time in case of gravitational medium. Therefore, the other tracks, i.e. sub-tracks, between A, B are the result of expansion characteristics of the main track to related sub-tracks, *Remark 5(16)3b, B2;* please refer also to *Comment 2(4)1b*, and *Consequence 2(4)1a*.

As the result, according to above statements and discussions held on other sections:

I) the sub-tracks obey the r^{-2} H particle-paths population densities attenuation from the main track, *Note 5(16)3b, B2*.

II) Each sub-track has a ΔT_T stay time analogous to that of the related particle, *Sec. 7(4)2f, part A*.

III) A main track texture of a specified population densities can be regarded as identical superimposed of, e.g. η sub-tacks, by analogy to *Sec. 7(2).* Where, the sum of their densities is equal to that of the main track. In other words, a particle chooses the main track at a probability of η times higher than each of its individual stored sub-tracks. The similar scenario is valid in case of expanded sub-tracks respect to its main track at a probability proportional to r^{-2} from the main track, *Sec. 7(4)3, part E1*. During the particle motion on a track, both its single direction H particle-paths, and the reversible one interacts with that of the track texture during particle stay time ΔT_P. As an example, please refer to *Eq. 7(29)3, Sec. 7(4)2f, part A,* according to that n_P is the frequency equivalent related to both H particle-paths reversible, and single direction motions. The factor $K_{\Gamma(gm)}$ is the effect of track texture in a medium (or environment) on particle. In other words, the particle changes its position from an H hall package to the next one successively along with handedness reversal of its single direction H particle-paths in every transition.

IV) In case of system of two identical particles in a rigid box, *Sec. 8(2)2*, the path-length of a particle respect to observer *A*, *Sec. 8(9)2,* in the origin of *CMPRF* of the system is equal to other one, but at opposite sign. In other mean, a particle that occupies an H hall package of type R, the other one occupies an H hall package of reversible handedness to type *R*, i.e. type *L*, but at slight preference of type *R* respect to type *L* in our matter Universe, *Sec. 5(16)9c*. As a result, a particle of type R spin is entangled, *Sec. 8(7)*, with the other one, i.e. type *L*; please refer also to *Sec. 8(9)1*. Therefore, the collision, *Sec. 6(2)1a*, of a particle with the wall can be regarded as a measurement, Sec. *7(4)2d*, or, spin reversal. Thus, a particle that emits an W_R expandon, the other one emits W_L one, and vice versa, *Simulation 7(4)2e1*. According to above discussion, the algebraic sum of path-length of the system is zero, i.e. zero path-length variation related to reversible kind of path-length, *Sec. 2(4)4*.

V) By analogy to vacuum quantized texture including gravity vacuum, any H hall package of track texture that is empty of related particle acts as new source of expandons generation each of path-length value $2\hbar$, *Comment 5(16)1a, B1*. Thus, the main track, sub-tracks emit expandon at the similar manner of particle as in item *IV*. Noteworthy, any kind of type W_R, or W_L expandon is accompanied by a type P_L, or, P_R contracton of path-length magnitude of expandon, but at opposite sign. Moreover, according to *Note 8(1)1b*, any H hall package of the track texture has related frequency of expandon and contracton emissions. In other words, the spatial medium has a frequency dependent metric.

VI) The particle H hall package at any energy level is the H hall package of particle at its singularity, or, in case of particle of rest mass (or mass-bodies), it is coinciding with Schwarzschild surface (or ground sphere, *Sec. 5(16)1a, part B*) at ground state. In other words, the particle reverson is shielded by its axeon, *Sec. 10(8),* as a singularity, *Sec. 7(5)2b*. Factually, the main track texture H hall package is the same as particle's H hall package at the moment that is occupied by the particle.

VII) The particle track texture after leaving by related particle through spatial medium, *Sec. 7(4)3, part A*, also has its own reverson that is shielded by an axeon as a singularity, *Sec. 7(5)2b*, nominating H hall package tunnel, *Note 8(9)2b*.

VIII) Any H hall package in spatial medium texture, e.g. medium of vacuum gravity free, (or vacuum gravitating, *Sec. 7(4)3, part B*), similarly to that of the particle has an axeon which its handedness are changing (e.g. from type R to L, and vice versa) during stay time ΔT_d (or ΔT_G) successively. This axeon surrounds the reverson of spatial medium H hall package analogous to case of particles as a singularity, *Sec. 7(5)2b*.

IX) The H hall packages of spatial medium are linked to each other through a network of H hall package tunnels, *Comment 5(16)2a1*, via the mass-bodies and ultimately to supermassive black holes, *Sec. 5(7)8*. Please refer also to *Simulation 8(7)2, E5a, paragraph 18*.

X) The particle track texture analogous to particle, *Simulation 7(4)2e1*, acquires type $R \,\&\, L$ configurations in spatial medium successively, *Sec. 8(3)4*. *Sec. 4(3)1, part B, item XXIII.*

XI) According to *Secs. 8(3)3, 4*, the track textures of interacting particles (or mass-bodies) at appropriate distance of each other combined or superimposed. Thus, a single common track texture that changes its handedness successively during stay time interval ΔT_i is obtained for particles (or mass-bodies). Moreover, a particle (or mass-body) depending on their total and kinetic energies obeys this combined track texture as its trajectory. In case of interaction of a particle with an external gravitational field; please refer also to *Note 5(2)1d, B1*.

Experiment 5(16)3b, B1- There is an experiment that despites of some other interpretations can be related to track textures formation due to motion of atoms at low temperature such as in a Bose-Einstein condensate. "Coherence of the Bose-Einstein condensate (*BEC*) is observed by creating two independent *BECs* in a special trap which uses laser beams and magnetic fields have two separate pockets. When the trap is switched off, the *BECs* fall down spread out and eventually overlap. In the overlap region, a high-contrast interference pattern was observed with an electronic camera. Such a pattern is possible only if each *BEC's* atoms cooperated to a single coherent wave, with the overall atom wave of one *BEC* interfering with the atom wave of the other condensate to produce a fringe pattern of light and dark fringes. The *MIT* team determined that the atom waves associated with each *BEC* had a wavelength of *30* micron, a million time larger that the wavelength of room-temperature atoms" [363]. These atom waves of long wavelengths can be regarded as track texture of the medium, *Sec. 7(4)3, part E*, according to H particle-paths hypothesis of the related atoms.

Example 5(16)3b, B1- The photon motion can be compared by some analogies to the motion of an electrical train on its railways geometrically on one hand. On the other hand, photon apparent velocity dynamically in a medium, *Sec. 7(4)3*, depending on the quantized texture density of the latter. It is similar to the velocity of the train that depends on the air density within its medium of motion, i.e. lower density of the air is related to higher velocity of the train at high altitude (or vice versa).

Consequence 5(16)3b, B1- The formation of track texture of a particle along with its expanding behavior can be considered as a consequence of time's arrow ordering in quantum mechanics, *Secs. 5(16)7c, e*, from view point of H particle-paths hypothesis.

Note 5(16)3b, B1-

Note 5(16)3b, B2- According to *Sec. 5(16)1b, part A, paragraph 12*, the population densities of H particle-paths on a unit area of a gravitational sphere are attenuating at the rate proportional to r^{-2} from the center of mass (or singularity) of the particles or mass-bodies.

Note 5(16)3b, B3- In this case it is supposed that between two points A, B merely an H hall package of h value is confined, i.e. a minimum possible distance AB between points A, B in the flat and curved spatial medium.

Comment 5(16)3b, B1:
I) A similar effect is valid for a beam of light emitted by a source in the vacuum medium during its propagation, e.g., Huygens's Principle. "All points on a wave front can be considered as point sources for the production of spherical secondary wavelets. After a time t, the new position of a wave front is the surface tangent to these secondary wavelets [4], *chapter 39, part 4*. As a result, based on celebrated Huygens principle of 17th century, we can have a schema of track texture of the light propagation in vacuum media. Similarly, the single direction H particle-paths of a beam of electron emitted by a source through vacuum trace trajectories in the latter by the difference that we must take into account the effect of reversible H particle-paths of electron, i.e. its rest mass, on its total motion according to *Secs. 2, 3,* of this text. Noteworthy, in case of particles of rest mass (e.g., electron, proton), the effect of γ^{-1} contraction, *Sec. 2(6)5b*, due to reversible motion of their H particle-paths at the both perpendicularly and parallel directions to the motion direction must be considered. As a result, the track texture of a particle, e.g., photon, electron, is not sharp, but it has an expanding wave-like trajectory that is constituted of H particle-paths. Please refer also to *Sec. 7(2), Comment 7(2)1a* in this regards.
II) Noteworthy, the correlation through the H particle-paths of the track texture with the slits and the incident point on the screen is preserved in such a way that the maximum expansion is taken place at the midway between slits and incident points on the screen. Therefore, it takes a spindle-like expanding track texture shape between the two regions (or points). Please refer also to *Sec. 2(4)1, Remark 2(4)1a*.

Remark 5(16)3b, B1– According to [341], *Conclusions*, "*dBB* (de Broglie-Bohm theory) predicts that in a double slit experiment, *Secs. 8(3)3, 4*, in which two identical particles (correlated photons), simultaneously cross each a precise slit, their trajectories remain in the semi plane of the crossed slits. Thus, no coincidence can be measured when two detectors are placed on the same side respect to the median axis. This result is at variance with *SQM* (Standard Quantum Mechanics) prediction. In our experiment we have clearly observed a coincidence peak when the detector are place in the same semi plane, conforming *SQM* prediction against *DDB* one". These experimental results confirm the sub-track textures (or subsidiary paths of the particles) in the same semi-plane as stated above from viewpoint of H particle-paths hypothesis. "We argue that in quantum mechanics it is the de Broglie wave that determines the trajectory along which an electron moves. Now, if de Broglie wave have a gravitational origin then it follows that an electron's own gravitational field determines the trajectory of its motion"[493].

Remark 5(16)3b, B2- "The dissipation of the interference components into the environment during decoherence behaves in a similar way. The environment can be considered a heat bath into which the interference terms spread and become completely disordered. At that point, the process is said to be thermodynamically irreversible. Interference is gone for good". "We therefore only see the collapse of the wave function operating the forward time direction"[553] *Decoherence and Entropy*; please refer also to *Sec. 5(16)9d, Sec. 5(16)7*, and *Sec. 8(7)1d*. The interference phenomenon in a medium can be considered as track texture of particle in that medium, *Sec. 8(3)4*. It has expanding characteristic in spatial medium. According to above discussion, the track texture of propagating particle get dissipated out into wider environment (or medium), and become effectively undetectable. According to *Secs. 7(4)2f, part A, E,* there is a mutual interaction between the H particle-paths population of vacuum medium with

that of the particle and its track texture that leading to expandons generation along with entropy increment within vacuum medium. However, the expandon generation by propagating particle renewed to some extent through r^{-2} attenuation of the particle track texture. Noteworthy, the contractons emission due to expandons generation conserve the correlation of particle with its source via common H hall packages tunnel, *Sec. 5(9)3d, part c*. up to a measurement, *Sec. 8(7)2*. Note that, the emitted contractons towards the mass medium are ultimately absorbed irreversibly by related supermassive black hole of the host galaxies or clusters, *Sec. 5(7)8*. Please refry also to *Sec. 8(7)1d,* and *Sec. 8(7)2, part E* in case of irreversible aspect of decoherence and measurement of a particle.

C) Effect of inertia on the trajectories of particles and mass-bodies through motion in vacuum texture

An isolated moving mass-body preserves its correlation with the vacuum texture through exchange of H particle-paths; thus, traces (or better to say, wowing) an expanding track texture (*part B*) during its motion apart from its gravitational expanding spheres (or texture). In other words, one must consider the superposition of these two textures. As a result, the moving mass-body disturbs the vacuum texture during its motion. Therefore, the trajectories of macro mass-bodies grace of its huge mass (or inertia, *Sec. 2(1)4*) respect to the vacuum texture seemed to be localized in the vacuum medium. However, in case of a zero mass or low mass particles, e.g. photon, electron, the trajectories of its motion is affected (or disturbed) by the vacuum texture through extended path-limit, Γ, *Sec. 1(12)*, of the particle, or, vice versa, *Experiment 5(16)3b, C1*. Factually, according to *Sec. 2(1)4*, the inertia of a mass-body is depends on number of its H particle-paths. Therefore, more inertia is equivalent to slight effect on the inner H particle-paths of the mass-body during their common (or external) motion, *Sec. 1(3)*, by vacuum texture's H particle-paths, or, vice versa. On the other hand, the path-limit Γ, of a macro mass-body is wrapped (or contracted) to a relatively small volume, *Sec. 9(3), Note 9(3)1a,* based on discussion held in *Sec. 5(16)1a*. According to above discussion, the massif mass-bodies have a geometrically well-defined, or sharp trajectories through their motion in vacuum medium as in classical theories, *Sec. 5(16)3b2, part G*.

As a result, the idea of applying our own observation of macro mass- bodies to that of particle at microcosm is not correct. Therefore, according to the discussion held in this section we concluded that:

a) A particle at quantum level has two different features as following when, *Comment 5(16)3b, C1*:

1) Moving through vacuum texture, *Sec. 5(16)3b*, in an entangled manner, *Secs. 8(7), 8(9).*

2) It is captured by a macro mass-body (i.e. measuring device) at its localized form, *Sec. 8(7)2, Example 8(7)2, B1*.

Therefore, the microstructure of the particle, *case 1,* is disturbed by the measurement, *case2*, *Note 5(16)3b, c1.*

b) In case of trajectories of a particle at quantum level:

1) The ratio of particle mass to the density of its track texture (or its trajectories H particle-paths) is a constant factor this a direct result obtained from discussion held in *Sec. 5(16)1b*, *Remark 5(16)3b, C1*.

2) The track texture geometrical form defines the motion of the particles. The inertia of particle of rest mass will affects this form.

c) Due to huge inertia of a massif mass-body respect to a particle, the measurement*, Sec. 8(7)2,* has nil effect on the former. "A quantum mechanical measurement is very different from a measurement in classical mechanics, where trajectories are generally accepted because of they can infer successive position of an object without disturbing its motion, for example by using light that scatters from the object [340], *section 2*.

The cases *b1, b2*, are analogous to quantum potential *Q* in de Broglie-Bohm interpretation by some authors, *Remark 5(16)3b, C2*. Thus, a low energy related to trajectories (i.e. vacuum track texture of particles) can conduct the high energetic particles through vacuum. "The basic idea of active information is that a form having very little energy inters into and directs a much greater energy"[345], *Active in formation, Vigierp 26*.

Experiment 5(16)3b, C1- As thought experiment of vacuum track texture of particle, *Sec. 5(1)3b, part B* that is analogous to pilot wave in de Broglie-Bohm approach, at quantum level, the three group of though experiments are proposed in a double slits, *Sec. 8(3)*, experiments as following:

I) A beam of cold neutron is directed towards the slits, after interruption of this beam, a beam of non-relativistic electrons is shot toward the slits in the same way, and comparing the pattern of electrons interference on the screen with and without application of neutron beam.

II) Neutron and electron beams are successively projected on the rotating screen through an oscillating reflector with the same frequency, and considering the pattern without application of neutron beam as blank pattern.

III) Electron is shooting directly by one by successively through time intervals δt , to the double slits, *Sec. 8(3),* and performing similar experiments at time intervals $1\,\delta t$, $2\,\delta t$, $3\,\delta t$.

IV) Performing the experiment *I &II* through the application of proton (or alpha particle) beam instead of neutron.

V) A heavy high density metal ball (preferably lead ball) of an pendulum moving parallel to the beam from source to the screen in an oscillating manner, and detecting the effect of its gravitational expanding sphere, *Sec. 5(4)1*, on the interference pattern (or its vacuum track texture) related to experiment *III*. Note that, in the experiment we are intended to test the disturbance due to trajectory of pendulum ball on the pilot wave of electron. Moreover, the half time interval between two oscillations must be adjusted according to time intervals $1\,\delta t$, $2\,\delta t$, $3\,\delta t$, etc, and so on.

Comparing the results of the above experiments and checking the track texture of neutron (or proton) beam probable effects on interference patterns.

Moreover, special care must be done in order to prevent entanglement with stray particles of cosmic ray and body of the apparatus. In other words, the environment effect will tend to couple, and suppress the interference, *Sec. 8(3)4*

Note 5(16)3b, c1:

A) "The measured quantum system *S* interacts with *M*, a macroscopic measuring apparatus for the physical quantity *Q*. This interaction is governed by the linear deterministic Schrödinger equation" [358], *the end of Copenhagen Monocracy*.

B) "The dynamics and the postulate of collapse are flatly in contradiction with one another. The postulates of collapse seems to be right about when we make measurement, and the dynamics seems to be bizarrely wrong about what happens whenever we aren't making measurements. Albert 1992, 79)" [358] *Preface*.

Comment 5(16)3b, C1– "One view is that quantum theory implies that the fundamental particles of physics cannot be regarded as individual objects in this sense [353], please refer also to *Sec. 8(7).*

Remark 5(16)3b, C2– "Bohm's Quantum Potential, *Q*, means that particles moving in empty space under the action of no classical forces need not travel uniformly in straight lines"[345], *Vigierp 18*. "The quantum potential *Q* is not changed when we multiply the field Ψ by an arbitrary constant. This is because Ψ appears in both the numerator and denominator of *Q*. This means that the effect of the quantum potential is independent of the strength (i.e. intensity) of the quantum field but depends only on its form"[345], *Form dependence, Vigierp 21*. "The purely quantum correlations between the particles are, in fact, brought about the quantum potential acting between them"[351], *page 4*. According to H particle-paths hypothesis, the motion of the particles through empty space are some extent to effected by this expanding track textures, *Sec. 5(16)3b, part B*. It can be to some extent analogous to quantum potential *Q* in *dBB*, with the difference that, there is no limitation of passing these expanding tracks from the symmetry (or median) axis. Moreover, the correlations between the particles are according to H particle-paths interchanging through vacuum space. Please refer also to *Sec. 9(2), Note 9(2)4*.

Remark 5(16)3b, C1– For the reason that the momentum of a particle in vacuum medium is independent of its kind, thus depends merely on its mass magnitude. Moreover, the track texture of a particle in vacuum after the passage of particle is expanding (or spreading) through the vacuum; please, refer to *Sec. 5(16)3b, part B*.

D) Geometrical shape

DI) General aspect

In fact, the geometrical shape of the vacuum quantized texture defines the path of motion of an H system (e.g., mass-bodies, particles, photons, *Sec. 1(3)*), *Sec. 5(16)2c, part B*. As a far analogy, we can refer to the path of motion, as straight or bent roads and streets role for driving a car. The motion of the H systems performed according to the mutual effect of single direction H particle-paths of the latter and the vacuum texture toward an equilibrium; please refer to *Sec. 2(4)2*; *Sec. 5(16)1b, part A, paragraph 7*c. Noteworthy, a particle obeys the track texture in the vacuum medium as a guiding entity during its motion *Sec. 5(16)3b, part B*. Therefore, besides the particle track texture, the expanding spheres of gravitational field are superimposed with the former in order to form a combined track textures for particle's trajectory, please refer also to *Sec. 8(7)4, paragraph F*. At the flat spatial zone, this texture is compared as a far analogy with a flat tissue, at the gravitational zone is wrinkled around the mass, and the latter can be regarded as tightly rolled tissue. In other words, the mass can be regarded as a dense texture in vacuum space, *Comment 5(16)3b, D1*, this texture is in its curved form in the gravitational field vacuum zone, and become flat in the vacuum space during an full expansion process in viewpoint of H particle-paths hypothesis. Resuming, this vacuum quantized texture that is the result of extension of gravitational field vacuum texture along with the latter determines the path of the motion of mass-bodies and particles through vacuum, or in other means, designs the geometry of space-time. Thus, explains why gravity capable of bending space. The vacuum quantized texture has path-length origin. In other words, it is constituted of H hall package, *Sec. 5(16)3*a, each of path-length value h. Therefore, the path-limit Γ, *part D2,* as a scale defines the geometrical shape of vacuum texture both in, and out of gravitational field. Note that, the vacuum quantized texture has SN_r configuration, *Proposal 5(16)3b, D1a,* in our right-handedly expanding Universe, *Sec. 5(16)9*a, please refer to *Sec. 5(16)1b, part A, paragraph 16*. Moreover, the vacuum texture which fills all space, by some analogy is liken the space-time in *GRT* in one hand, and in other hand it can be assumed as intervening intermediary or medium of transmission (e.g., analogous by some viewpoints to luminoferous ether. "Reason, common sense, logic, …demand the existence of such universally pervading medium by whatever name we may choose to call it"[321], *section 3*, *Explaining gravity*.

Proposal 5(16)3b, D1a- According to path-constancy, the geometrical shape of an expanding vacuum gravitating quantized texture (or track texture, *Sec. 5(16)3b*) medium, *Sec. 7(4)3, part A*, of SN_r configuration at a ratio K_Γ, *Sec. 5(16)1a, Eq. 5(52),* has an equivalent reversed handedness micro-structure geometrical shape of contracting SP_l configuration through mass medium, *Sec. 7(4)3, part D*. Moreover, during an interaction, e.g. gravitational, through spatial medium, its P_R & P_L contractons are released towards the related super-massif black hole of the host galaxies and absorbed (or measured, *Sec. 8(7)2*) by the black hole, i.e. a registration, *Remark 5(9)3d2*. Please refer also to *Example 7(5)1* in a similar case of reverson formation.

D2) Path-limit Γ as a scale of quantized vacuum texture medium

According to *Secs. 5(10), 5(11),* the path-limit Γ, *Sec. 1(12)*, can be regarded as an scale in the vacuum quantized texture, *Sec. 5(16)3b, part A*. It can be bended, contracted, dilated, *Fig. 5(7)*, based on vacuum texture geometry that is flat in non-gravitational medium, or, bended in gravitational field due to superimposition of H particle-paths of their texture, *Sec. 5(16)1b, part A, paragraph 16*. Noteworthy, according to *Sec. 8(9)1*, the common H hall package, *Sec. 5(16)3a,* of a pair of particle can be extended at c speed at two opposite directions through vacuum texture, *Sec. 5(16)3b*. Just during the measurement, *Sec. 8(7)2*, of one of the particle of the pair, the latter contracts spontaneously to nil dimension in the measurement side, *item V*. In other words,

the path-limit Γ at first stage is extended at c speed to unlimited length until the performance of a measurement process, *Remark 5(16)3b, D1*. Thus:

I) At the measurement side, the measured particle is contracted spontaneously within the common H hall package tunnel to a compact path-limit Γ in the main body of measuring device (detector), i.e. Γ_{mass}, *Sec. 7(4)3*, *part D*.

II) The unmeasured particle is reach to straight path-limit Γ through normal vacuum quantized texture excluded of gravitational field, i.e. Γ_d, *Sec. 7(4)3*, *part A*. Noteworthy, it bended, or, contracted in a gravitational field as stated above, i.e. Γ_G, *Sec. 7(4)3*, *part B* or dilated to unlimited length during extension of entangled pair of particle within abstract vacuum, *Sec. 5(16)3*h.

III) According to *Sec. 8(9)2*, the path-limit Γ is contracted, (or dilated) in approaching (or receding) motion of a moving source respect to an observer at rest frame, e.g., the Earth's lab, *Remark 5(16)3b, D2*. Whereas, it has its compact, *Remark 5(16)3b, D1*, value just during a measurement, *Remark 5(16)3b, D3,* and respect to the lab's detector (or target), *Note 5(16)3b, D1,* and *item V*. Please refer also to *Sec. 7(4)1*.

IV) According to *Sec. 8(7)2, part A*, the successive particles (e.g. photons electrons) emission in normal vacuum by a source before a measurement can be viewed as a succession of correlated particles up to the source each of constant path-limit Γ through vacuum texture. Based on this assumption, any particle acquires a path-length value h, *Sec. 5(16)3g*, just after a measurement, or, in other words, just after interruption of this correlation with the source irrespective of its medium, e.g. vacuum, mass. Moreover, during photons propagations, the light beam extended at quantized sequence of time intervals ΔT_Γ, *Sec. 5(16)7b, Example 5(16)7, B1*.

V) Noteworthy, $\Gamma = a^{-1}c,$ is the path-limit of a photon in vacuum texture that has a conjugate equivalent of contracted path-limit Γ_{mass} through the mass during the measurement (or absorption), please refer to *Sec. 5(16)11*. Moreover, the contraction of Γ is along time's arrow ΔT_Γ reversal, spatial contraction (or vice versa) due to handedness reversal, *Sec. 5(16)9b*, related to mass medium of contracting characteristic, *Secs. 5(16)10, 11*. The dilation and contraction of path-limit Γ through vacuum texture, and within the mass medium depends respectively on their H particle-paths population densities respectively. Noteworthy, the particle in the two media has equal magnitude $a\Gamma$, *Sec. 7(4)3,* of identical sign during particle absorption by the mass medium (detector), and at opposite sign during particle reflection. The latter is based on bi-Universe hypothesis, *Sec. 5(16)9*. By a far analogy, they are comparable to expandon, *Sec. 5(16)1c, part A3*, and contracton, *Sec. 5(2)1c, part c,* respectively. In other words, the dilation (expansion), or, contraction of the H particle-paths through vacuum and gravitational field textures is at c speed during time interval ΔT_Γ, and $d\tau$ *Comment 5(16)1c, A1*, respectively and through the mass is also at c speed within an infinitesimal time interval $d\tau_{mass}$, *Eq. 5(67)8c*.

VI) According to relationship $a\Gamma = c,$ supposing $a = 1\ s^{-1}$, *Note 1(2),* in a medium, Γ is equal to c. Therefore, in the abstract vacuum, *Sec. 5(16)3h*, a becoming infinitesimally small; whereas, Γ tends to infinity. Similarly, in a black hole, by increasing the mass of black hole a tends to infinity, and evidently Γ becoming infinitesimally small, *Note 5(16)3b, D2*. Moreover, the product of a, and Γ has a constant value in any reference frame respect to arbitrary observer.

The global path-length value of magnitude $a\Gamma$ (or c) has identical equivalent value h, *Sec. 5(16)3g,* (the Planck constant) for all of the particles in any medium. By analogy to the case of particle, the vacuum quantized texture can be constructed of global path-length blocks. Similarly, the gravitational field medium also is constructed of the same blocks each of constant value h. Therefore, it can be regarded as Universal unit of path-length. In other words, the path-length is transferred through units of its global value h, *Note 5(16)3b, D2*.

According to above discussion, coefficient a depends on the medium, (e.g. normal vacuum, gravitational field, the mass-body, etc.) at its different location, *Sec. 7(4)3, parts A, B, C, G*. Moreover, the coefficient a varies also with the time's arrow in a medium at a location. Therefore, path-limit $\Gamma,$ is varied accordingly, *Sec. 7(4)3, part I.* As a result, coefficient a (or Γ) besides the medium is also depends to the time in a location of that medium.

The center of mass of a particle, or, its path-limit Γ is the origin of *CMPRF, Sec. 2(6)2b*, of this particle in the related medium. Please refer to *Sec. 8(9)2* in this regards.

In an expanding Universe, the media coefficient a_{past} is related to the medium of emitted photon by atoms (e.g., hydrogen atom) of far (or past) galaxies are higher than $a_{present}$ related to present (or near) ones that is based on Hubble law. In other words, at the longer distance there is higher media coefficient a due to denser vacuum quantized texture, *Sec. 5(16)3b, part A*, in the past respect to present one. Therefore, the Γ_{past} is shorter than $\Gamma_{present}$ according to *Eq. 7(31)* of *Sec. 7(4)3*. As a result, the wavelength of photons emitted by atoms in past is red-shifted linearly, and proportional to the separating distance respect to present atoms. Please refer to *Sec. 7(4)2e.*

As the result, the path-limit Γ taking the form of the medium that its related particle travels through it, *Sec. 7(4)3, part G.* Moreover, the path-limit Γ of a free moving particle affected by the spatio-temporal geometrical shape of its propagating medium. Noteworthy, coefficient a, *Sec. 1(12), Eq. 1(3),* based on H particle-paths hypothesis has with a far analogy an equivalent parameter such as expansion parameter according to General Relativity. Particles irrespective of their energies having a common characteristic of equal magnitude, and identical geometrical shape in the same medium, *Sec. 7(4)3*, from viewpoint of H particle-paths hypothesis, i.e. mono-dimension particle of path-limit Γ along its trajectory. It can be comparable through some similarities with a string in string theory, *Sec. 8(8)2*. "A zero-dimensional object described by a one dimensional worldline in spacetime. We can easily generalize this construction to a string, which is one-dimensional object by a two-dimensional worldsheet that string sweeps out as it moves in time with coordinates τ, σ. Here $0 \le \sigma \le \pi$ is the spatial coordinate along the string, whereas

$\tau \in \Re$ its propagation in time" [456] *The Bosonic string*. Noteworthy, by a far analogy a^{-1}, Γ can be comparable to τ, σ , *Note 5(16)3g, B1*. Moreover, a particle that is moving through quantized texture of medium, e.g., normal vacuum space texture, *Sec. 5(16)3b, part A*, sweeping path-length area respect to an observer at the origin of *CMPRF* of the particle-detector system from viewpoint of H particle-paths hypothesis. It can be equivalent to some extent to the worldsheet that a string sweeps through spacetime, *Sec. 2(3)2b*, please refer to *Sec. 5(9)3d*, and *Sec. 8(9)*.

Note 5(16)3b, D1- "The essential difference between these two theories (special relativity, *SR*, and Lorentz relativity, *LR*, which make identical prediction of observable phenomena in any one inertial frame viewed from any other) is the lack of reciprocity in *LR* because one frame (the local gravity fields) is special. In *SR* of course, all inertia frames are equivalent. The only consequence of this difference of importance here is that *SR* has a universal speed limit (c), whereas *LR* does not. This happens because in *SR*, time and space are changed by motion, whereas in *LR*, only clocks and rulers are changed, but this time and space are unaffected. The physics of these two theories is quite different, even though the math is the same". "However, Lorentz developed his theory in the context of an aether. Einstein hypothesizes that aether was unnecessary" [439] *second Round of Responses*. Factually, the path-limit Γ plays the role of natural ruler in the above discussion. Noteworthy, the aether theory according to H particle-paths hypothesis (which is based on Delta Effect, *Sec. 2(1)1b*, and path-length constancy, *Sec. 2(1)2*) is substituted with vacuum quantized texture, *Sec. 5(16)3b, part B*, whereas the light speed is regarded as a universal immutable constant, i.e. c.

Note 5(16)3b, D2- During an interaction (or measurement, *Sec. 8(7)2*), e.g. photon striking a mass-body, the path-limit Γ_d of the photon (confined in H hall package) through vacuum texture is contracted to its path-limit Γ_{mass} within the mass-body (or detector) at infinitesimal time interval ΔT_{mass} regardless of their relative spatial magnitude. However, photon has equal path-length $a\Gamma$ (or h, the Planck constant) value in the both media, *Sec. 7(4)3*. As a result, there is an infinitesimal time's arrow, *Sec. 5(16)7*, reversal through the particle transfer from vacuum medium to mass medium, e.g. through collision, *Sec. 6(2)1a*, as following:

$\Delta t = \Delta T_{vac} - \Delta T_{mass} = a_{vac}^{-1} - a_{mass}^{-1}$ (per second) please refer to *Secs. 5(16)10, 11* 5(70)3a3

It is along with spatial contraction of particle's H hall package in the range of $\Gamma_d - \Gamma_{mass}$, and vice versa.

Where:

1) $\Delta T_d = \Delta T_\Gamma = a_d^{-1}$, *Sec. 7(4)1*, and $\Delta T_{mass} = a_{mass}^{-1}$, are time intervals in the vacuum, and mass media respectively.

2) Γ_d , Γ_{mass} , are the path-limits of the particle related to two media coefficient a_d, a_{mass} , of vacuum, and mass (or detector) respectively.

Comment 5(16)3b, D1- According to *Sec. 2(4)4a*, in the gravitational field of a mass-body *M*, δN_g at *4*- space value $d\Omega$ is the flow variation number of expandons each of path-length value $2\hbar$, and of population density n_g through *3*-space volume dV during time dt . δN_g depends on curvature of space-time at the 4-space location $d\Omega$. Based on Mirror Image Effect, *Sec. 6(2)3*, the expandons flow of a mass-body through spatial medium, *Sec. 7(4)3, part A*, has an equivalent δN_m contracton flow, *Sec. 2(4)4c*, each of path-length value $2\hbar$ and opposite sign of that of expandon, *Comment 5(2)1c1*, through mass medium, *Sec. 7(4)3, part D*. Noteworthy, according to this phenomenon, the spatial medium is expanding due to expandons' H hall package formation; while, the mass medium is contracting due to overlapping of contractons' H hall packages accordingly. Moreover, the H particle-paths within the mass medium of mass-body *M* have an equivalent geometrical Mirror Image shape of related spatial medium at the microscopic scale in magnitude of Γ_{mass} / Γ_d . Please refer also to *Sec. 5(16)1a, part B*.

Remark 5(16)3b, D1- Factually, a particle, e.g. electron, during its motion through vacuum texture has a wave-like counter-current H particle-paths in the framework of n neutropa cells within path-limit Γ_d , *Sec. 4(3)1, part B, Fig. 4(4),* and *Sec. 4(3)3, Fig. 4(7)b*. Since during a measurement (or detection), its n neutropa cells are compacted to electron's axeon at the detection stage, *Secs. 10(6), 10(8)*, i.e. Γ_{mass} . Therefore, electron acts as a point-like (nil dimension) particle during the measurement. In other words, electron is revealed in its detected form of path-length value h, *Sec. 5(16)3g*, just after the measurement. So, the path-limit of electron attaining its contracted form in the latter stage along with time's arrow ΔT_Γ , reversal due to linking characteristic of its H hall quantized package, *Sec. 5(16)3a*, with that of measuring device, *Sec. 7(4)1*, i.e. mass medium. Moreover, according to *Note 2(6)4b1,* it must not confused the light traveled paths P , *Sec. 3(1)1*, with path-limit Γ in this case, *Sec. 8(9)2, Fig. 8(2)*.

Remark 5(16)3b, D2 – According to *Sec. 8(9)2,* respect to observer *A* of a *CMPRF* reference frame, the problem of contraction, and dilation of path-limit Γ of a photon (or a particle) respect to observer *B* of an inertial reference frame, is cancelled respect to observer *A*. It is leading to a path-limit $\Gamma = a^{-1}c$, *Sec. 1(12),* of constant value in related vacuum medium, and at a limited spatial region of constant value of coefficient a , e.g. Source-particle-Earth's lab target *CMPRF*'s of System *A* for all of the particles such as photon, electron, proton, etc. regardless of particle velocity just during a measurement, *Sec. 8(7)2*. The discussion held in *Sec. 3(1)* is based on this assumption, according to that, the emitter source and target of system *A* are both the Earth's lab. Therefore, the system *A* must be studied respect to the centre of mass of the Earth's observer, which coincides, with the origin of *CMPRF* of system *A* due to huge inertia of the Earth.

Remark 5(16)3b, D3 – According to *Sec. 2(6)5c, proposal c*, at the moment of measurement, or, reflection of a particle by a detector, the both particle and detector reveal as a single object.

E) - Pair production in vacuum space

E1) Preliminary step

According to bi-Universes hypothesis, *Sec. 5(16)9*, any pair production of matter and antimatter particle can be related to interaction of single photon, i.e. single direction H particle-paths, and an intermediate macro-mass body media, i.e. fully reversible H particle-paths at all directions, *Sec. 1(1).* Therefore, without the latter, there is no pair production due to a single photon from viewpoint of H particle-paths hypothesis. In fact single direction H particle-paths of photon interact with fully reversible H particle-paths of medium (as a target) according to *Mirror Image Effect, Sec. 6(2)3*, in order to produce moving mass-bodies (or non zero mass particles), e.g., electron, positron, as H systems composed of single direction and reversible H particle-paths, *Sec. 1(3)*. In special cases such as *PVLAS Experiment* discussed in *part E2*, and laser photon propagation, an external magnetic field constituted of directional close-end reversible H particle-paths, *Note 5(16)3b3*, in order to produce a non zero mass particle.
As a result, the vacuum medium has no significant role (as zero point energy) in pair production from viewpoint of H particle-paths hypothesis, *Sec. 5(16)3c*. In a similar manner, there are pair production through photon propagation in strong magnetic fields such as that of neutron stars and black holes. In this case, the counter-current H particle-paths of gravitational field, *Sec. 5(16)1b, part A*, can be viewed as target, *Proposal 5(16)3b, E1*. Please refer also to *Sec. 4(7), Example 4(7)1*. According to *Sec. 4(3)1, part D,* the magnetic flux quantum is an electromagnetical equivalent of path-length value h. In other words, any group of reversible close-end H particle-paths of the magnetic field are confined in an H hall package, *Sec. 5(16)3a*, of path-length value h. Similarly, photon as a particle is confined in an H hall unit of path-length value h. Therefore, their interactions based on Mirror Image Effect lead to two entangled, *Sec. 8(7)*, pair. "One idea comes from Edward Masson and Javier Redondo of the University of Barcelona in Spain. They suggest that the particle (axion) detected at Legnaro could be made of two as yet unknown quark-like particles that are loosely bound together" [378], *Invisible light*. Please refer also to *Comment 5(16)3b, E1,* and *Sec. 5(16)3i*, in this regards.

E2) Axion-like particle generation scenario

"The *PVLAS* team at the National Laboratories of Legnaro in Italy announced as slight shift in the polarization of a laser beam fired through a strong magnetic field. The shift was 10000 time larger than expected by standard physics, but could be explained if a tiny fraction of photons from the laser hard turned into axions" [373], *Note 5(16)3b, E1*. "Physicists in Italy have demonstrated that empty space can cause light to rotate in the presence of a large magnetic field can cause the refraction index of space to vary with the polarization of light passing through it."[374]. According to above statements, that the polarization of light rotation is due to dark matter, *Sec. 5(1)2,* e.g., axion, the total vacuum quantized texture [including texture related to gravitational expanding sphere in *Sec. 5(1)*] geometry and density, *Sec. 5(16)3c*, may be altered. It is both locally and directionally through H particle-paths of magnetic field *Sec. 4*, respect to its initial isotopic configuration (equilibrium) in all direction. Please refer to *part E1*. It can be regarded as an interpretation based on H particle-paths hypothesis. In other words, the H particle-paths of initial photon are affected by induced mono-direction external magnetic field constituted of reversible H particle-paths texture that its track is regarded expanding based on *part B*. The *PVLAS* results attribution to axions detection are suspected by some experimenters, "Semerlzidis spoke about a *PVLAS*-type experiment that was performed at Brookhaven more than 15 years ago with most of the *PVLAS* collaborators as major payer. They also observed large signals, which they attributed however to the laser light motion at the magnet frequency. He went to suggest that laser motion at the magnet rotation frequency might also produce signals at the second harmonic that would look like axions signals" [375], *Light polarization*.

"The classical gravitational field is not the only classical field that seems to be able to cause a production of particles from the vacuum. The classical electric seems to be able to produce particle-antiparticle pairs by a mechanism similar to the gravitational alone." [410] *section 9F*. In this case, a mechanism similar to exit of expandon, *Sec. 5(16)1c, A3*, from black hole along with irreversible trapping of its contracton conjugate, *Sec. 5(2)1c, part c,* within the back hole, *Sec. 5(7)8,* can leading to pair production. It is because of the fields, e.g., electromagnetical, gravitational, have a unique stuff, i.e. H particle-paths at different configurations. Thus, vacuum has no role in pair production according to H particle-paths hypothesis, or, in other words, it is far from the concept of Hawking's radiation. According to *Sec. 5(2)1d,* one of the particles of the pair will be escaped instantaneously from the black hole's event horizon, whereas the other will capture by black hole, *Note 5(16)3b, E2*. Moreover, the escaped pair is correlated through the H hall package tunnel with the black hole (or its collapsed counterpart). Factually, according to *Secs. 8(7), 8(9),* the escaped particle during an interaction (or measurement, *Sec. 8(7)2*) reveals as a particle of rest mass.

Note 5(16)3b, E1- "Though small, the detected rotation was around four orders of magnitude larger than predicted by *QED* (Zavattini et al. 2006). One possible interpretation involves *ALP's* (Axion-like particle) produced via the coupling of photons to the magnetic field. Combining the *PVLAS* result with upper limits achieved 3 years earlier by the *BFR* Experiment at Brookhaven National Laboratory (Cameron et al 1993) yields values of the *ALP's* and its coupling strength to photon of roughly $1MeV$ and $2\times10^{-6}GeV^{-1}$, respectively (Ahlers et al. 2006)" [380], *Introduction.* The deviation of four orders of magnitude may be interpreted from viewpoint of H particle-paths hypothesis of weakly binding of dark matter to photons that prevent the escape of the former from normal matter. Therefore, leading to supplying a source of gravitational spheres generations through participation of the normal matter, i.e. dark matter conversion to dark energy, *Sec. 5(15)2*. Moreover, this coupling characteristic of axion to normal matter through protons solves:
I) The problem of energy loss, which without that stars would appear older than they are today.
II) Halo of dark matter appearance around normal matter, i.e. stars or galaxies beside of gravitational attraction.

Note 5(16)3b, E2- Factually, the escaped particle has a type *R* path-length through spatial medium, while the captured one of type *L* one within mass medium at equal magnitude and opposite signs of each other, *Sec. 5(16)11,* and *Sec. 7(4)3*.

Comment 5(16)3b, E1- "Whenever the angle between the light and the magnetic field was $\pm 35^o$ or $\pm 135^o$, the authors observed that the light polarization angle rotated with altering sign and with a magnitude of 4×10^{-12} radian per meter of rotation path" [377]. The stated above angles related to maximum reversibility (or indeterminacy) of the photon-magnetic field system, *Secs. 1(1), 1(15).*

F) Constancy of the light speed in normal vacuum

F1) Normal vacuum texture excluding gravitational field

According to H particle-paths hypothesis, the speed of light merely depends on vacuum quantized texture density, *Sec. 5(16)3c*. The vacuum density is homogeneous, and constant in the spatial direction of the lab (or Earth) excluding gravitational, or, electromagnetical field) because of isotropy of physical. Therefore, the light in vacuum space has a constant speed c in all inertial systems regardless of the speed of the source. The 4-volume $d\Omega = dxdydzcdt = constant$ in all inertial reference frame, nominated as constancy of vacuum texture density. Therefore, the vacuum texture density is also invariant due to isotropy of space and uniformity of time in such a vacuum texture considered locally non-expanding (or stationary).

As a result, in an expanding Universe at each location respect to its own observer the light speed is also the same as stated above or Earth's lab, i.e. c. But, it is apparently higher than c respect to Earth's observer due to false density of a remote expanding vacuum texture drop respect to the latter observer, *Sec. 5(16)7b, part B*. In other words, the vacuum texture in this case tends to abstract vacuum, *Sec. 5(16)3h*, i.e. nil texture density, that is depended linearly on the rate of expansion (or receding velocity of galaxies). Moreover, the rate of expansion is uniform due to the uniformity of spatial expansion and related time's arrow, *Sec. 5(16)7*. Please refer also to *Sec. 5(16)2b*. It has been proved through observation of superluminal receding velocity of galaxies that are measured through Doppler shift. Consequently, the speed of light at these regions has assumed falsely higher than c as stated above. Therefore, the true light speed is equal to c, *Sec. 7(4)2e*. It is another example of constancy of light speed through normal vacuum, *Consequence 5(16)3, F1*. Noteworthy, the vacuum space is not a unique continuum, but it is constituted of a set of vacuum spatial patches; please refer to *part H* of this section.

F2) Normal vacuum texture including gravitational field

In the local normal vacuum gravitational texture, the light speed is apparently in gravitational field analogous to light speed in transparent medium. In other words, the apparent light speed c_g in gravitational field is lower than that of vacuum texture excluding gravitational field, i.e. c. However, the true light speed is c in the gravitational field medium, i.e. the same as in vacuum gravitational field free medium. Thus, the rate at which clock ticks slowed accordingly.

In the two above cases, the path-length value, *Sec. 2(1)2,* of H hall package value is h, *Sec. 5(16)3a*. But, the geometrical shape of these packages are straight (or flat) in the *case F1*, and curved in the *case F2*; please refer to *Sec. 5(16)1b, part A, Sec. 5(16)3b, part D2.*

"In physics, the Einstein field equation or the Einstein equation is an equation in the theory of gravitation, called general relativity, that describes how matter creates gravity and, and conversely, how gravity affects matter". "In the equation, gravity is given in terms of a metric tensor, a quantity describing geometrical properties of four-dimensional space-time. Matter is described by its stress-energy tensor, a quantity which contains the density and pressure of matter". "The strength of coupling between matter and gravity is determined by the gravitational constant" [475]. According to H particle-paths hypothesis:

Any gravitational sphere generation (or expandon, *Sec. 5(16)1c, part A3)* of irreversible, *Sec. 2(4)4*, expanding type R_e path-length of SN_r configuration, *Sec. 5(16)11*. It is accompanied by a irreversible contracting type L_c path-length of SP_l configuration of equal magnitude, and opposite sign, *Sec. 5(16)1c, part A1, Eq. 5(67)6,* in related mass (or mass-medium, *Sec. 7(4)3*). It is based on path-length constancy, *Sec. 2(1)2*, and gravitational constant. Moreover, any expandon interaction with a particle or mass-body through vacuum medium, *Sec. 5(9)3d, part c*, is leading to contracton, Sec. *5(2)1c, part c*, generation through mass medium. Please refer also to *Sec. 7(4)2e.*

During gravitational interaction, and falling of a mass-body m in gravitational field of mass M, the total energy of mass m is remained unchanged, *Sec. 5(2)1b*, by the difference that the inner geometrical shape of its H particle-paths is curved in gravitational field of mass M at any stage of equilibrium *Figs 5(2), 5(3).* In addition, vice versa in case of mass M in gravitational field of mass m.

The generated expandons as in case of paragraph *II* defines the geometry of vacuum gravitational field texture, or, track texture through vacuum medium, *Sec. 5(16)3b, part D* around the related mass. Moreover, the geometry through vacuum medium is linked to that of the mass medium at reversed handedness.

Consequence 5(16)3b, F1- The local speed of light, c_{loc}, of receding galaxies respect to the observer on the Earth (lab) based on Hubble Law is apparently higher than c due to the false vacuum texture density dilution, *Example 5(16)3b, F1*, respect to the Earth's observer. Therefore, the light speed is constant, i.e. c, as following:

1) Respect to local observer due to constancy of local vacuum texture density.

2) The light speed from receding galaxies detected by a local Earth observer due to constancy of local vacuum (i.e. on the Earth) texture density. Thus, according to above discussion, we have:

$D_{app}.C_{app} = D_{loc}.C_{loc}$ 5(70)3a4

Where:

- D_{app}, D_{loc}, The apparent, local vacuum quantized textures respectively
- C_{app}, Apparent light velocity
- C_{loc}, Light speed that is equal to c

The same argument is also valid for local spatial distance and background time's arrow, *Sec. 5(16)1c, part c*.

As a result:

A static Universe is equivalent to appropriate expanding one from viewpoint of light speed and local background time's arrow:

The velocity of light depends on vacuum texture (or propagating medium) density.

Tendency of local normal vacuum to an apparent abstract vacuum (i.e. texture density dilution of vacuum medium) depends linearly on separating distance (or speed of recession) in an expanding Universe.

Example 5(16)3b, F1- As a comparative example of H particle-paths population density dilution at the receding case, please refer to *Fig. 4(4)* of *Sec. 4(3)1, part B*. The counter-direction H particle-paths population density of a free moving electron is dropped and dilated according to Delta Effect, *Sec. 2(1)1b*, based on path-length constancy, *Sec. 2(1)2*. In other words, the counter-direction H particle-paths population respect to co-direction one, and electron at rest state is decreased (dilution).

F3) Normal vacuum texture formation via gravitational field

"If a piston capping a cylinder of vacuum is pulled-out, producing more vacuum, the vacuum within the cylinder then has more energy which must have been supplied by a force pulling the piston." [515] Einstein static cosmology. However, according to H particle-paths hypothesis, in the above though experiment, the gravitational expandons are formed by the mass of the walls of piston and cylinder, *Sec. 5(16)1b, part A*, during the piston pulling. At the moment that the piston is stopped the expandon generation are reaching to an equilibrium, *Sec. 5(2)1b*, of constant density. In other words, there are an steady exchange of expandons between the wall of the piston-cylinder system. Moreover, each of expandons that is nominated main expandon is split to more sub-expandons, *Sec. 5(16)1a, part B*, along with related H hall packages. The latter generating H hall packages having similar role as that of main expandons. This equilibrium is also extended to the vacuum medium outside the system with the equal vacuum energy density contrary to conclusion obtained in reference [515]. "Of course the politically correct terms are false vacuum in the cylinder and true vacuum outside, but physics is the same."[515]. As a result, at equilibrium state there are H hall packages of expanding type R_e of expandon in spatial medium that are compensated by the equal number of contracting type L_c by its contracton conjugate within mass medium, *Sec. 7(4)3,* regardless of the vacuum volume inside the system. Therefore, a mass-body during generation of any expandon absorbs a contracton from other mass-bodies that is ultimately transferred via common H hall package to the related black hole of the host galaxies and clusters, *Sec. 5(7)8*, during their mutual gravitational interactions; please refer also to *Sec. 5(9)3d, part c*.

G) Vacuum quantized texture in micro-world

As a far analogy, considering a toy truck moving on a rough expanding surface, e.g., Cobblestones, between two points *A, B*, at each time it follows a different path between two points *A, B*, randomly, *Sec. 8(7)2, part E4*. Now, considering a real heavy truck, it is moving on this surface without any deviation, and on a rectilinear path between *A, B*, because of its huge inertia respect to toy truck. Please refer also to *Sec. 2(4)1, Remark 2(4)1a, Consequence 2(4)1*, and *Remark 5(16)3b, C2* of this section. Alternately, supposing a toy ship is floating on its rectilinear path on a rippling lake. The water ripples can be considered as vacuum texture by a far analogy. Now, supposing a heavy ship is departing straightly forwards on the same rippling lake. Thus, there is no shaking of the ship hull due to high inertia of the heavy ship in the latter case. Factually, particles, e.g., photon electron, through their motion, reveal the vacuum quantized texture of the vacuum, *Sec. 5(16)3b*. In other words, particles can probe this texture (or vice versa). Note that according to H particle-paths hypothesis, the particles are not point-like, *Sec. 8(7)4*. Moreover, the interaction of particles is performed according to *Secs. 2, 3*.

According to above discussion:

A) A particle of rest mass, e.g., electron, that is classically assumed at rest, is jiggling (analogous to the toy ship floatation on the lake surface) around is rest region (*Simulation 8(7)2, E5a, item23*) due to its H particle-paths mutual effect with that of vacuum quantized texture, *Sec. 5(16)3b, part A*. Please refer also to *Sec. 10(5).*

B) A heavy particle of rest mass, e.g. proton neutron nuclei, etc. respect to lighter one, e.g., electron, is lesser affected by the vacuum quantized texture due to their relative inertia. Entangled photon pair before measurement, *Sec. 8(7)2*, due to countercurrent configuration of their H particle-paths in the motion direction acts as particle of rest mass, *Remark 5(16)3b, G1*. Please refer also to *Sec. 8(9).*

C) A high-speed electron respect to low speed one is lesser effect with this texture.

D) A moving part obeys the combined track texture of the external gravitational field with that of the normal gravity free vacuum medium, *Note 5(2)1d, B1*, during particle motion. This track texture nominating vacuum quantized texture of gravitating vacuum medium, *Sec. 7(4)3, part B*, in micro-world.

Remark 5(16)3b, G1– "Vigier, in his recent work, has given list of new experiment which suggest that the *U(1)* in variant massless photon assumed properties of light within the standard interpretation, are too restrictive and that the *O3* invariant massless massif photon causal de Broglie Bohm interpretation is now supported by experiment"[352] *introduction*.

H) Individual vacuum quantized spatial texture

According to *Note 5(1)2a,* and *Sec. 5(16)1b, part A*, each of the mass-bodies and dark matter halos has its own gravitational field texture. In other words, the space and time in the Universe is not a unique continuum, but they constitute of correlated (*Secs. 8(7), 8(9)1*) individual patches that are composed of microstructure of correlated expandons, *Sec. 5(16)1c, part A3*. Therefore, space quantized texture is formed of a set of expanding patches that is analogous to cosmic microwave background remnant, *Sec. 5(5)2*. Noteworthy, to any independent spatial patch is related a degree of freedom. Factually, the magnitude of a patch is linearly proportional to the amount of the related matter. Therefore, the Universe seems uniform at large scale as a result obtained from Friedman's Equations, *Sec. 5(5)2, Note & Consequence 5(5)2a*. By a far analogy, the whole space of the Universe can be compared with the skin in a living body. Therefore, the spatial textures of patches and related masses are similar to the cells of skin and their related nucleuses. As a result, each patch of the subspace has its independent and individual expansion. Thus, the sum of expanding correlated patches constitutes the spirally expanding, *Sec. 5(16)5*, feature of the whole Universe, *Sec. 5(16)9a*. Please refer to part *F1* of this section, and *Sec. 5(7)7, Example 5(7)7a.*

"Few years ago many people believed that the Universe is topologically connected. Of course, it was possible to speculate about the Universe to have any practical consequences since it was assumed that topologically disconnected pieces of the Universe could not influence each other. However, recently it was understood that topologically disconnected Universes may have a non-local interaction with each other, which may help us to solve the cosmological constant problem" [455] *Introduction*. Factually, as stated above, the Universe is constituted of individual spatial patches are correlated through interchanging of H particle-paths analogous to the particles, *Secs. 8(7), 8(9)1*, and mass-bodies, *Sec. 5(9)3c*, therefore, constituting its whole structure as if it is a unique spirally expanding H system, *Sec. 8(5).* Any patches (or pieces) at its ultimate right-handed expansion, i.e. mass free de Sitter space, losing its related mass in the matter Universe. Therefore, each patch contracted left-handedly up to equivalent antimatter mass prior to the new Big Bang era in a reverse spirally handedness phenomenon of contraction related to Big Crunch, *Sec. 5(15)3b*. Please refer also to *Notes 5(16)9d1, d2*, and *Sec. 5(15)3d, part B, proposal 2.*

I) Track texture dependence to the deBroglie matter wave

The deBroglie matter-wave, *Note 2(3)2a1*, in spatial medium can be assumed as pilot wave in this respect. Therefore, it is nominating deBroglie-Boehm pilot wave. At microcosm, the matter-wave, *Sec. 5(6),* is the non-separable wave counterpart of a particle, *Sec. 7(4)2e*. It plays two main roles as following:

A) The track texture formation of a particle through spatial medium during particle successive beats, *Sec. 5(16)2a, part A*.

B) Formation of gravitational field of a particle, or, mass-body, *Sec. 5(16)1b, part A, paragraph 24*, via expandon and contracton emission during beats, *Sec. 7(5)3d, part D.*

The track texture and gravitational field are constituted of discret types *R&L* expandons configuration each of path-length value $+2\hbar$. The track textures are resulting from mutual interaction of H particle-paths of gravitational field, i.e. *WR & WL* expandons, *Simulation 7(4)2e1*, with H particle-paths of the particle (or mass-body), *Sec. 7(5)3d, part D*. Each of the track textures is attenuating after passing or travel of the particle in an expanding mode, i.e evolving, Please refer also to *Sec. 5(16)1b, part A, paragraphs 26*, *27*. "The first is kwon as background independence. Thids principle says that the geometry of spacetime is not fixed. Instead the geometry is an evolving, dynamical quantity" [585] *A big loophole*; please refer also to *Sec. 5(16)3b, part D1*."The pilot wave is also a "real" wave (i.e., more than just a mathematical tool like the wave function, it is as real as a light wave - albeit undetectable!). So both the pilot wave and the electron are real objects which together can describe quantum behavior with no need for quantum superpositions". "The pilot wave guides the electron (or a particle) through just one of the two slits in the double slit experiment (see here) - none of this going through both slits at once" [557] *Hidden variables theories*; please refer also to *Note 8(7)5a*. According to *HPPH*, the particle track texture through spatial medium play the similar role of pilot wave. In other words, the particle, e.g. electron, or photon, prefer the track textures depending on the densities of the latter as a road that a vehicle (analogous to particle) can drive on it. The identical choice of a track or sub-track of equal path-length, *Sec. 7(4)3, part E1*, between two points A, B along with bi-Universe hypothesis to some extent solve the problem of random, *Sec. 8(7)2, part E4,* choice of a path from viewpoint of *HPPH."God does not play dice"*, said Einstein, believing that quantum physics was incomplete, some deeper theory being able to predict outcomes with certainty. Maybe one day Einstein will be proved right"[557] *A return to determinism?*

J) Track texture and space time comparison

The track textures are attenuated gradually by removable of the related masse at a position. "People before me believed that if all the matter in the universe were removed, only space and time would exist. My theory proves that space and time would disappear along with matter" [587] *Einstein's resolution.* The track texture differs from the concept of *GR* spacetime, *Sec. 2(3)2b,* because of its expanding characteristic, *Note 8(1)1b*. "Gravity and space time are the same entity. Spacetime is still understood as a non-dynamical entity which provides an arena for the law of physics but doesnot itself take part"[586] *Introduction*. A mass-body generating its track texture stedily in a discrect manner of successive type *R&L* confiruration at an expanding mode. Noteworthy, the track texture is evaluated through path-length, *Sec. 2(1)2, Sec. 5(16)3g*. In recent decades based on quantum gravity, thespacetime is assumed discret. "The picture of quantum spacetime geometry which emerges is to many compelling, independently of the fact that it has been derived from a rigorous quantization of general relativity. The basic structure that emerges is of a new class of quantum gauge field theories, which are background independent, in that no fixed spacetime metric is needed to describe their quantum dynamics"[588] *Introduction*; Please refer to *Sec. 2(4)2a*. The track texture of a medium also is discrete of two types *R&L* H hall packages blocks successively each of path-length value h, *Sec. 5(16)3b*. As stated above, the track texture has both expanding and attenuating characteristics; it can be generated by mass-bodies or particles. Therefore, it has also a moving ability. According to Loop quantum gravity, "A background independent theory is one whose formulation does not assume or require the existence of any single preferred spacetime metric or connection. Instead, all the fields that define the geometry of space-time are fully dynamical, none are fixed"[588] *the four basic observations*. According to *Sec. 5(16)3b, part* A,

the spatial medium also has a discrete structure, it is constituted of vacuum medium H hall packages of path-length limit Γ_d , *Sec. 7(4)3, part A*.

5(16)3c – Vacuum energy density

According to [80] "Modern physical theory, especially quantum electrodynamics *(QED),* tells us that the vacuum can no longer be considered a void". "Nature repeatedly indicates that cosmic (vacuum) is not only not empty, it actually is a very rich medium giving birth to all possible observable fields"[496] *section 1-2*. Moreover, zero-point energy as in a harmonic oscillation of quantum theory, i.e. $h\upsilon/2$ is not depends merely on vacuum but to the partially induced reversible internal H particle-paths motion, *Sec. 7(4)4,* of the interacting field-lines *CF*, *Sec. 5(2)1,* of the external gravitational field with the oscillator bodies components of the related H system, *Remark 5(16)3c1*. In other words, it can be regarded as axeon, *Sec. 10(8)* of the oscillating H system that surrounds the related reverson as a singularity, *Sec. 7(5)3b;* please refer to *Secs. 5(4)6, 5(16)3b, Sec. 7(5)3b, Sec. 8(2)3, and Consequence 9(4)6 a.*

"We normally think of the vacuum as empty a massless, and we can determine that the density of the vacuum is less than $10^{-29}\, gm/cc$ now"[267], *Note 5(16)3c1*. Please refer also to *Remark 5(16)3a2, Sec. 7(4)3, parts A, H*, and *Comment 7(4)2f, E1*.

By the way, on the basis of dark energy assumption, according to [145], part related to *challenges for models of cosmic acceleration,* we have:

I) - If the source of cosmic acceleration is some dynamical matter (quintessence field) then it has to acquire the value:

$$\Lambda \approx 10^{-120} M_p^4 \approx \left(10^{-3} eV\right)^4$$

II) - If the acceleration is produce by a scalar field (quintessence), the latter must have a mass:

$$m_Q \le 10^{-32}\, eV \qquad 5(70)3b$$

Moreover, supposing m_Q is the equivalent mass of an H particle-paths; thus, according to *Eq. 1(1),* $a_1 \le 2.4\times 10^{-18}\, s$ .Where, a_1 , constant of media coefficient, *Note 1(2)1*.

Referring to *Note 1(2)1*and considering the equivalent mass of H particle-path, $\mu = m_Q \approx 10^{-68} kg.$, the total number of H particle-paths per one cubic centimeter of vacuum will be $N \approx 10^{36}$. In other words, *N* is the population density of block making the texture of vacuum space quantized texture.

"The only theory (if one call it that) which leads a vacuum energy density of approximately the right order of magnitude without suspicious fine-tuning is the antropic principle"[273], *part 2.1*. According to [273], *part 1.2*, " there is clearly a mismatch between the theoretical prediction and observed value of total vacuum energy, i.e. $\rho_{Vac}^{(theory)} \sim 10^{120}\, \rho_{vac}^{(obs)}$, *Remark 5(16)3c2*. Please refer also to *Sec. 5(15)2, Sec. 5(16)7a, Sec. 5(16)7b, Sec. 5(16)9c, Sec. 5(15)2c,* and *Sec. 7(4)2f, part D*.

Note 5(16)3c1- According to *Remark 2(3)1b*, the ratio of frequency (or energy) emitted by a particle or mass-body respect to its frequency equivalent (or its energy) is $K_\Gamma \approx 2\times 10^{-34}$. Similarly, the ratio of density of free vacuum to a mass-body, e.g. water, is approximately 10^{-29} that is comparable with K_Γ factor by *5* order; please refer to *Sec. 5(16)1a, part B*, and *Sec. 7(4)2f, part A*.

Remark 5(16)3c1 – Considering the small oscillations of a pendulum, its frequency is equal to $\sqrt{g\, l^{-1}}$, where g is gravity acceleration and l the pendulum length" [36], *section 7*, *equation 7.3*. Now, referring to *Sec. 5(4)4*, the single direction gravitational field-lines *CF*, *Sec. 5(2)1*, undergo an induced reversible motion as in case of light beam (i.e. a single direction H particle-paths H system) passing through a transparent medium that depends on the refractive index η of that. Therefore, the ground state energy $\varepsilon_0 = h\upsilon/2$ of a harmonic oscillator with one degree of freedom can be interpreted regardless of zero point energy of the vacuum; please refer to *Sec. 8(2)3,* and *Consequence 9(4)6a*. Noteworthy, zero point energy of the vacuum at $T = 0k$ in viewpoint of H particle-paths hypothesis, *Sec. 5(16)3b*, differs from that based on virtual particles, *Sec. 7(5)3b*. Factually, according to *Sec. 7(5)3b*, the ground state is restricted by a singularity related to reverson that is shielded by particle's axeon. According to [287] "the particle originally has negative and imaginary mass and then makes a virtual transition to positive mass becoming real particle" that has not conformity with H particle-paths hypothesis.

Remark 5(16)3c2 – According to [328], *part 4*, "It is some what unfair to characterize this discrepancy as a factor of 10^{120} , since energy density can be expressed as a mass scale to the fourth power. Writing $\rho_\lambda = M_{vac}^4$, we find $M_{vac}^{(Theory)} \sim 10^{18}\, Gev$, and $M_{vac}^{(obs)} \sim 10^{-3}\, ev$, so a more fair characterization of the problem would be $M_{vac}^{(Theory)} / M_{vac}^{(obs)} \sim 10^{30}$ ". "Solution of equation $E^2 = p^2c^2 + m^2c^4$ for the energy has a sign ambiguity which has so far ignored:

$$E = \pm\left(p^2c^2 + m^2c^4\right)^{1/2}$$

"Feynman suggested that a particle with four-momentum $\underline{P}$ is equivalent to the corresponding antiparticle with four-momentum $-\underline{P}$. Thus, we interpret a particle with momentum P, and energy $E<0$ as an antiparticle with momentum $-P$ and energy $-E>0$. Antiparticles are known to exist for all particles"[426]. Therefore, the negative energy is applied to the existence of antiparticles, and not to theoretical enormous total vacuum energy density that is inconsistent with observed results.

5(16)3d - Vacuum background energy

Since 1976, a new phenomenon nominated Unruh Effect [132] is discovered. "This effect is the prediction that an accelerating observer will observe black-body radiation where an inertial observer would observe none, that is, the accelerating observer will find themselves in a warm background"[133], *Remark 5(16)3d1*. In other words, the inertial observer is traveling through a thermal bath, somehow he got not feeling friction from the vacuum; moreover, the observer should see no particle since he is in the vacuum.

According to H particle-paths hypothesis, an accelerated H system will observe the counter-current, *Sec. 3(1)2,* wave-like quantized H particle-paths of vacuum space, *Secs. 5(4)4, 5(16)3c*, in an accelerated non-equilibrium manner, i.e. the rate of adsorption is higher than rate of desorption; thus, at non-accelerated inertial motion there is an equilibrium between absorption and desorption process, *Sec. 5(16)2c, part B*. The same thing is valid when a mass body falling in a gravitational field constituting of successively gravitational sphere with increasing field strength, i.e. counter-current H particle-paths, *Sec. 3(1)2,* flow rate. Thus, according to *Sec. 5(1),* at each stage of falling there is an equilibrium state based on *Fig. 5(2*); please refer also to *Secs. 5(9), 5(18).*

As a result, if Unruh Effect is confirmed experimentally [135], somehow it resemble to Hawking Radiation[134], *Remark 5(16)3d2*, Sonoluminescence Effect, *Sec. 6(2)4,* in which some part of counter-current H particle-paths converts to non reversible single direction H particle-paths, e.g., photon, electromagnetic waves. Factually, the Unruh Effect as a new kind of interaction reveals the effect of H particle-paths of the vacuum space and gravitational field in a medium empty of particles and photons nominated vacuum space on the accelerating mass-bodies rather than metaphysical aspect of vacuum fluctuation or zero point energy extraction, etc. By the way, the uniformly accelerating mass-body sweeps the H particle-paths of the vacuum quantized texture, *Sec. 5(16)3b,* dark matter, *Sec. 5(1)2,* and gravitational field, *Sec. 5(16)1b, part A*, at a non-equilibrated manner; so, converting them to thermal excitation or radiation.

Remarkably, the slight acceleration of an isolated mass-body moving at linear uniform path according to *Sec. 5(15),* due to the exit of its gravitational sphere in vacuum can be simulated as falling of an object in a gravitational field in the direction of its motion. Thus, subjected to an Unruh Effect in an ocean of free flying H particle-paths with a quantized H hall vacuum space units texture, *Sec. 5(16)3a.* Factually, any mass body in the real world has acceleration; thus, Unruh Effect. On the other hand, there is no empty space at all, please refer also to *Sec. 5(16)1c, part A2*.

Remark 5(16)3d1- According to [133] *calculations*, "The equivalent energy kT of a uniform accelerating particle is:

$$kT=\hbar A/2\pi c \qquad 5(70)3c$$

Where: *k, T, A*, are Boltzman constant, Kelvin temperature degree, acceleration of the particle respectively.

Referring *to Sec. 2(1)3, Eq. 2(30), 2(34), 2(35),* and *Sec. 2(1)4, Note 2(1)4b,* the *Eq. 2(70)3c* can be writhen as following:

$$kT=\frac{m_0 c}{4\pi^2}\cdot\frac{d\alpha}{cdt}\left(\frac{a_s}{u^2}\right)=\frac{h}{4\pi^2}\cdot\frac{d\alpha}{cdt}\cdot\left(a_s^{-1}\right) \qquad 5(70)3d$$

Where, $a_s=1s^{-1}$, *Note 1(2)1,* $b=1kg^{-1}, u=1m^{-1}$ of inverse dimensions based on units of dimensions in *SI* units.

Comparing the *Eq. 2(30)3d* with that of *Sec. 6(1), Eqs. 6(2), 6(3),* the energy kT is equal to energy per mass unit ($m_0=1$) during a unit of time travel of an accelerating mass-body m_0 divided by $4\pi^2$ proportionality factor. In other words, the equivalent number of H hall vacuum quantized units of path-length h value, *Sec. 5(16)3a*, swept in a path cdt by unit of mass during its uniform acceleration prior to reach an equilibrium, *Sec. 5(2)1b, Fig. 5(2),* i.e. sweeping is more than releasing. Noteworthy, according to *Sec. 2(4)2*, the path-length density of the particle increases along with mono-directional time's arrow reversal in the expense of path-length density loss of the vacuum texture along with mono-dimensional time's arrow, *Sec. 2(1)1b, Consequence 2(1)1b1, part c, case II.*

According to *Sec. 5(16)1c, part A2*, there is an additional gravitational field texture due to mass-body at uniform acceleration of *SP* and *SN* configurations, as in *Sec. 3(1)2, Fig. 3(4)a & Fig. 3(4)b* respectively. Considering the co- and counter-direction respect to the gravitational texture (or fabric) at non-accelerating case, there is an anisotropy according to *Eq. 2(70)3d* in this respect. In other words, at co-direction case, the *SP* configuration of uniform acceleration, part *A2* combines with *SN* configuration of non accelerating part *A1*; thus, resulting *SM* configuration, *Fig. 3(4)c*, as in case of electron magnetic radiation, *Sec. 4(4), Fig. 4(8).* In fact, the acceleration is an aperture towards the antimatter universe based on handedness reversal, *Sec. 5(16)9b*. "An even greater related challenge for a particle interpretation of QFT is the Unruh effect. The Unruh effect is a surprising result which seems to show that the concept of a particle is observer dependent. The Unruh effect is the striking phenomenon that a uniformly accelerated observer in a Minkowski vacuum will detect a thermal bath of particles, the so-called Rindler quanta (Unruh 1976 and Unruh & Wald 1984). Whereas the number of particles in the Minkowski vacuum is 0, an accelerated observer suddenly detects a thermal bath of particles. A mere change of the frame of reference thus leads to a change of the number of particles. Since basic features of a theory should be invariant under transformations of the referential frame the Unruh effect constitutes a severe challenge to the concept of particles as basic objects of *QFT*. Teller tries to show, in Teller 1995, that the Unruh effect is not a

fundamental problem for a particle interpretation. Further extensive studies have been done by H. Halvorson, partly together with R. Clifton, reprinted in Butterfield & Halvorson 2004 together with various other important papers"[598]*Further problems for a particle interpretation of QFT* .

Remark 5(16)3d2- According to [306], "The creation of virtual particles near the event horizon of a black hole has been hypothesized by physicists Stephan Hawking to a mechanism for the eventual evaporation of black hole". Nevertheless, according to H particle-paths hypothesis the mass-bodies, e.g., black holes, loses energy in the form of expanding gravitational spheres, *Sec. 5(4)*, (or Expandon), *Sec. 5(16)1c, part c*; thus, producing gravitational field [gravitational potential energy, *Sec. 5(2)*]. As a result, the evaporation of black hole is related to this mechanism; please refer also to *Sec. 5(16)3b, part E2*.

5(16)3e- Concept of distance and time in vacuum medium

Assuming an isolated inertial reference frame R' (x', y', z', t'), and origin o' attached to a mass-body of nil mass (or energy) in vacuum far enough from other interacting mass-bodies and related field. Therefore, its time's arrow, *Sec. 5(16)7a*, is the background time, *Sec. 5(16)1c, part c,* respect to an observer in an inertial reference frame *R (x, y, z, t),* with origin o at rest respect to reference frame R'. Referring to *Sec. 7(6),* assuming path-limit Γ unit of length and gravitational time's arrow unit $d\tau$, *Sec. 5(16)1c, part A4*, as unit of time as two characteristics of H hall quantized package, *Sec. 5(16)3a*; please refer also to *Sec. 5(16)2a, Sec. 5(16)1c, part A4.* Now, supposing each H hall quantized package contains n H particle-paths units according to H particle-paths population density in vacuum space, *Sec. 5(16)3c*, or, in other words, n H particle-paths moving at c speed can be found in path-limit Γ during time interval ΔT_{Γ} in an H hall quantized package. These H particle-paths moving at counter-current of *SN* and *SP* configurations, *Sec. 3(1)2, Fig. 3(4)a, b*, and constant path-length, *Sec. 2(1)2.* This mode of counter-currency can be simulated to Ψ and its conjugate Ψ^* , *Sec. 8(1)3, Remark 5(16)3e1*; moreover, the proper length, *Sec. 2(1)1a*, between two points *A, B*, is increased (or receded) according to *Sec. 5(16)2b*, due to split of H hall quantized package in an expanding Universe. Noteworthy, there are also counter-current flow of H particle-paths between the mass-bodies as in *Fig. 5(5)1*of *Sec. 5(9)3*, or, in other words, the mass-bodies are related by H particle-paths network; please refer to *Sec. 2(4)1*, *Remark 2(4)1a*, *Consequence 2(4)1*.

In case of light or signal propagation from o' as emitter with nil mass to o as observer (or receiver) the time interval $\Delta t'$ between two point o', o, is obtained according to *Sec. 2(1)1b, Eq. 2(15),* as following:

$$\Delta t' = \int_{o'}^{o} dt' = \frac{1}{c}\int_{o'}^{o} dl' = \frac{1}{c} l' , \quad \textit{Remark 5(16)3e2} \qquad 5(70)3e$$

Where:

$\Delta t'$, total time travel between oo'

dt' , partial time travel on the light trajectory related to partial proper length dl' (e.g., *AB* proper length) and l' the total distance between the emitter and observer.

Therefore, $\Delta t'$ is the background time, *Sec. 5(16)1c*, *part c,* of light travel between two point $o'o$ at proper length l'. Now supposing the emitter o' is a galaxy and receiver o as the Earth; thus, to the light travel time of $o'o$ path obtained according to *GRT* of an expanding *FLWR* Universe, we must add the stated above background time's arrow correction. Please refer also to *Sec. 5(16)7c*.

Thus, traveling of the light between $o'o$ (galaxy-Earth) through each of the three regions (galaxy, vacuum, the Earth) and surrounding effective medium obeys the related law according to their quantized vacuum texture, *Sec. 5(16)3b*. The background time rate is missed in both *SRT* and *GRT*, especially in the former case we have a single time rate as in the frame of the observer (detector) that is resulting to superluminal recession of galaxies, *Sec. 5(16)7b*, *part B*. According to [283], *part 2*, "In the ΛCDM concordance model all objects with redshift greater than $z \sim 1.46$ are receding faster than speed of light". According to *Sec. 5(16)7c*, the background time will be superimposed with the time scale in each of the reference frame *R, R'*. In other words, in the presence of gravitational field the flat texture of quantized vacuum related to background time combined with the curved texture of related to gravitational effect. Alternately, there is a space expansion along with a time's arrow at each partial trajectory dl' of the total light beam trajectory between emitter and detector (observer o), i.e. in the vacuum. Thus, the extent of that is depended on the local vacuum energy density, *Sec. 5(16)3c* during the light travel at that location, *Sec. 5(16)3b, part F*. Therefore there will be a Doppler shifted, *Sec. 5(16)3f,* at each section l' of trajectory at each instant of light travel accompanied by related time's arrow dt', *Eq. 5(70)3e*. In other words, there is no superluminal recession, if we consider this background time's arrow at all, according to that we receive their emitted photon at c speed; please refer to *Remark 5(16)3f* , and *Sec. 7(4)2e* in this regards. In fact the light time travel in the regions of galaxy and the Earth depend on gravitational field time's arrow, *Sec. 5(16)7c*, the second one (i.e. normal vacuum, *Sec. 5(16)3b, part A*) is related to background time's arrow as stated above. Thus, regardless of the latter, the light travel in the third region (i.e. analogous to abstract vacuum, *Sec. 5(16)3h*) must be regarded spontaneous as in case of *EPR* paradox, *Sec. 8(4),* that leading to superluminality. Please refer also to *Sec. 5(16)3b, part F1*; *Sec. 8(7), 8(9)1.*

Remark 5(16)3e1- Now supposing singlet H particle-paths, *Note 4(1)1,* induced by an electromagnetical effect; the same argument as above can be referred to H particle-paths without conjugate, i.e. only negapa or posipa, *Sec. 1(5),* that is characterized by vector potential *A, Sec. 8(1)3*; please refer also to *Sec. 4(6)3.* Moreover, considering [1], *part 32*, for the replacement of generalized

coordinates components q that determine the mechanical states of the related system by field 4-potential components A, in the integral of action, *Sec. 2(4),* in case of electromagnetical field in order to obtain its related energy-impulsion tensors.

Remark 5(16)3e2 – It is assumed that reference frame R' moving with the light signal along its trajectory, whereas its origin o' is coincide with that signal. In other words, reference frame R' is considered as a locally fixed reference frame, i.e. *LFRF*, *Sec. 2(6)2c*.

Remark 5(16)3e3– Noteworthy, $+\delta T$ is the mono-directional part of time in observer reference frame region and the time related to vacuum space background time, *Sec. 5(16)1c*.

5(16)3f - Photon travel through space

A) General aspect

The single direction H particle-paths of the light beam moving on the bed of expanding vacuum quantized texture, *Remark 5(16)3f, A1*, during its travel constitute a combined H system with this texture. Thus, undergoes expansion according to the expansion of the latter, or, in other words, the H hall quantized package, *Sec. 5(16)3a*, of photon imparts some of its H particle-paths during expansion as new generated H hall quantized packages of combined vacuum texture and photon, i.e. time's arrow generation, *Sec. 9(4)7c*. It is along with handedness reversal, *Sec. 5(16)9b*, according to mirror image effect, *Sec. 6(2)3*; thus, according to *Sec. 3(1)1, Fig. 3(2), 3(2),* its total H particle-paths decrease in the constant path-limit Γ and the photon red-shifted accordingly, *Sec. 7(4)2e*. Similarly, photon entrance toward the higher gravitational field is performed through space contraction, i.e. path-limit contraction, and time's arrow reversal, i.e. blue shifting, and vice versa. In other words, the single direction H particle-paths of photon interact with expandons of quantized texture of gravitational field that is superimposed with that of vacuum space in each location of photon trajectory; *Sec. 7(4)2f*. Factually, in this case photon obeys the geometrical shape of this texture, *Sec. 5(16)2c, part B*, in order to keep its path-length density extremum, *Sec. 2(4)2,* during its travel; please refer to *Secs 5(10), 5(11).* Photon through its entrance in a gravitational field undergoes an interaction with gravitational field texture, *Comment 5(16)2c4*, according to mirror image effect, *Sec. 6(2)3,* in order to reach equilibrium without interaction, *Sec. 5(2)1b, Fig. 5(2),* at each location of its trajectory.

According to above statement, the traveled time by no means depends simply on time dilation during recession, *Sec. 5(16)3e*; please refer also to *Sec. 2(1)1b, Comment 2(1)1b2, part B*. This is in comparison with the case of considering the Universe expansion as adiabatic at constant entropy. Whereas, the entropy of the Universe is increasing in spatial medium that resulting to inflation theory based on superluminal expansion, *Sec. 5(2), Note 5(5)2a*, i.e. an expansion with time's arrow accompanied by a contraction and time's arrow reversal that compensate each other with the preference of the former, *part B*, and *Sec. 5(16)11*. In other words, a right-handedly expansion with left-handed contraction and the preference of the former*;* therefore*,* the total time's arrow is the background time, *Sec. 5(16)7c,* in vacuum medium; please refer to *Sec. 5(16)8b, Sec. 5(16)9b*, and *Sec. 7(4)3*. Noteworthy, we must consider merely time's arrow due to gravitational field at low distance of light travel, since background time's arrow is nil in such a short distance from the related mass-body. In addition, photon traveling through vacuum medium traces an expanding track texture, *Sec. 5(16)3b, part B*.

Remark 5(16)3f, A1- Vacuum quantized expanding texture, *Sec. 5(16)3b, part F,* differs from old concept of aether as an intermediary medium with an unknown texture. The former is similar to some extent to space-time in Einstein's theories of relativity from viewpoint of H particle-paths hypothesis. Please refer also to *Sec. 5(16)1b, part A, paragraph 7c, Remark 5(16)1b, A3.*

B) Retarded and advanced wave's scenario

"Factually, the wave equation can be derived from Maxwell equations. One solution represents the field amplitude as determined by the source density at positions at times earlier than t. This is the retarded solution. The advanced solution characterizes field's amplitude in terms of the source density at later times. Advanced solution describes waves converging from the past onto the charges with which they are associated; retarded solutions describe waves diverging from charges to the future. The asymmetry thus appears to consist in the fact that there is only retarded and no advance radiation in our Universe. The puzzle, as it is usually stated, is why this asymmetry holds when the laws permit both kinds of radiation. In nature it seems that radiation is always retarded rather than advanced" [432] *the problem*, *Remark 5(16)3f, B1*. The problem is based on the bi-Universe hypothesis, *Sec. 5(16)9*, of matter and antimatter Universe with the slight preference of the former. In other words, the very slight preference of retarded over advanced radiation in spatial medium, *Sec. 7(4)3, part A*. Please refer also to *Sec. 8(7)2, part c*. "Frisch notes that the radiation of our Universe can be characterized by any linear combination of retarded and advanced solutions" [432] *Frisch's solution*. Moreover, the radiation density covers a combination of both retarded and advance waves at approximately equal magnitude, i.e. the product of their amplitude magnitude at any given region analogous to wave function density in *QM*. According to *Secs. 8(7)2, 8(9)1, paragraph 3*, and referring to *Fig. 8(1),* the radiation is correlated with the source in the form of counter-current H particle-paths, *Sec. 3(2)1, Fig. 3(5),* before the measurement process. In other words, there is a competition between retarded wave (emission through spatial medium), and advanced wave (absorption by mass medium, *Sec. 7(4)3*, *part D,* of the source) of the source with the slight preference of the former wave, *Sec. 5(16)11*. "Callender says the advanced solution describes the radiation sink's receiving waves, and this happen all the time, these misleadingly suggest that advanced solutions represent absorptions (and retarded solutions emissions). It is true that advanced solutions describe waves that travel inwards to converge on charges to waves that appear, from our time sense, to be absorbed" [432] *the problem*. Therefore, the counter-currency mode of motion of right, and left- H particle-paths in a radiation correspond to retarded, and advanced waves respectively can give a better

explanation in this regards, *Sec. 7(4)2e*. This preferential counter-currency of H particle-paths in a diverging spherical wave (retarded solution)is analogous to the case of gravitational expanding spheres (or surfaces), *Sec. 5(16)1b, part A*, constituted of counter-current H particle-paths with the preference of right-handed one, *Remark 5(16)3f, B2*. Therefore, it leading to gravitomagnetism phenomenon, *Sec. 5(2)1c, part A*. Noteworthy, any spatial expansion is along with time's arrow (retarded waves), and any spatial contraction is along with time's arrow reversal (advanced waves), *Note 5(16)3f, B1*. In other words, the expansion is accompanied by path-length generation, *Sec. 2(1)2*, and related H hall package population, *Sec. 5(16)3g*, increment (or vice versa) that is in accordance with asymmetry of thermodynamics, *Sec. 5(16)9d, part A*; please refer also to *Sec. 5(16)7f.* According to *Simulation 7(4)2e1*, the diverging retarded wave is related to types $WR \,\&\, WL$ expandon emission in spatial medium that is along with spatial expansion and time's arrow related to entropy (disordering) increment; while, the converging advanced wave is depending on type $PL \,\&\, PR$ contracton releasing towards the mass medium, e.g. emitting source, in a contracting manner. It is long with time's arrow reversal accompanied by negentropy (ordering) increment within mass medium, *Sec. 5(15)2b, Diagram 5(1).* Noteworthy, in our matter Universe, based on above discussion, there is a slight preference of the retarded wave over its countercurrent, *Sec. 3(1)2,* conjugate, i.e. advanced wave in spatial medium. This combination reveals as retarded wave during detection; please refer also to *Sec. 5(16)11*, and *Sec. 5(16)9d*. The mentioned above expandons and contracton emission giving raise an asymmetric aspect to the stated above mechanism from viewpoint of *HPPH*. "The conditions to produce a convergent wave require more order than the conditions for a radiative wave. Put differently, the probability for initial conditions that produce a convergent wave is much lower than the probability for initial conditions that produce a radiative wave. In fact, normally a radiative wave increases entropy, while a convergent wave decreases it. (See the Wikipedia article on the Arrow of Time). Hence, the reason we do not see convergent, advanced waves can be explained in terms of entropy" [558] *The Radiative Arrow of Time*. Factually, according to *HPPH*, the counter currency mode of motion put forward physically a retarded wave

Note 5(16)3f, B1-According to *Simulation 7(4)2e1*, the retarded wave is composed of successive expandons of types W_R, W_L, that are receding from the emitter. While, the advanced wave is constituted of its contractons conjugate of types P_L, P_R respectively that are conducting towards the mass medium of their emitter, e.g. source, and aggregated in its reverson, *Sec. 5(7)8, Sec. 7(5)*. Noteworthy, the expandon has expanding characteristic of type R_e path-length of $+2\hbar$ value; while, the contracton has contracting characteristic of type L_c path-length of $-2\hbar$, *Sec. 2(4)4c*.

Remark 5(16)3f, B1– "In quantum electrodynamics, we can distinguish normal retarded electromagnetic waves and photon as having positive energy eigen-values and a time dependence characterized by $\exp(-i\omega t)$, whereas exotic advanced electromagnetic waves and photons would have negative energy eigen-values and a time dependence characterized by $\exp(+i\omega t)$" [180]. Based on *Sec. 5(16)3c, Remark 5(16)3c2*, the negative energy is referred to antiparticle, or, according to bi-Universe hypothesis, *Sec. 5(16)9*, it relates to antimatter Universe conjugate.

Remark 5(16)3f, B2– Factually, an accelerating charges in our right-handed matter Universe can be associated with retarded waves of SN_r configuration, i.e. real photon, by analogy with gravitational field considering the equivalence principle in the latter one, *Sec. 5(3)1*, please refer to *Sec. 5(16)3b, part A*. In other words, the right-handedly expanding vacuum texture favorites the preferential propagation of retarded waves over advanced one. Noteworthy, in case of virtual photon, *Sec. 4(6)5*, that propagates spontaneously through an H hall package tunnel between two opposite charged particles there is preferential of SP_l configuration toward mass medium, *Sec. 7(4)2e,* of *E*-contracton types, *Sec 5(2)1c, partC3*.

5(16)3g – Path-length of an H hall quantized unit

A) General aspect

Referring to *Sec. 2(4)2, Eq. 2(103)2,* the action variations of δS_m and δS_g are equivalent to the exchange of a group of H particle-paths through exchange of H hall quantized units (or packages), *Sec. 5(16)3a* each of path-length value $2\hbar$, *Sec. 2(4)4a*, ($h = 2\pi\hbar$ is Planck constant). Thus, it may be regarded also as unit of quantum action, *Sec. 2(4)1*) between the interacting mass-bodies, and their gravitational fields. It is performed in such a manner that in a closed system the algebraic sum of *Eq. 2(103)2* is zero, please refer to *Note 7(4)2e3*. Moreover in case of equilibrium state, *Sec. 5(2)1, Fig. 5(2),* the acquired path-length $n.2h$ (through n H hall quantized package) is equal to the exit of that but with reversed handedness, *Sec. 5(16)9b*, between mass-bodies and their gravitational fields. Generally speaking, in any interacting closed system, the path-length is interchanged in the form of expandon, *Sec. 5(16)1c, part A3,* photon, *Sec. 4(4),* forces and collision, *Sec. 6(2),* interacting charged particles, *Sec. 4(3)1d.* It is exclusively through H hall quantized package of path-length value h (or $2\hbar$), *Note 5(16)3g, A1*, regardless of its H particle-paths number, *Sec. 7(2).* Please refer also to *Example 5(16)3g, A1*. Noteworthy, the interacting mass-bodies and their related gravitational field design the geometrical shape and density of the vacuum quantized texture, *Sec. 5(16)3 b, c*, according to their interaction. In other words, by peeling the constant $C_p = \dfrac{c^4}{8\pi G}$ from the *Eq. 5(70)3f* as stated below we encounter with a purely geometrical formalism, *Remark 5(16)3g, A1*. As a result, according to above statement the total (stored) path-length of an H system, *Part B,* constituted of H particle-paths (or groups of that, *Sec. 7(4)*) is integer number of path-length value nh (or $n.2\hbar$), *Sec. 2(4)1, Sec. 2(4)2b*. According to the definition of action integral, *Sec. 2(4)1,* the path-length of an H system in the total space

and between two time components can be considered as *S* value (or S/h its integer numerical value) accordingly, *Remark 5(16)3g, A2*; therefore, $S = nh$ during times t_1, t_2, or time interval $\Delta T = t_2 - t_1 = d\tau$ can be written as follows:

$$\Delta S = S_2 - S_1 = (n_2 - n_1)h = \delta n_{21} h$$

$$\Delta E = \Delta S/\Delta T = \delta n_{21} a_1 h$$

Where:

1) - a_1, constant of media coefficient, *Note 1(2)1*.

2) δn_{21} is the number of path-length units h between times t_2, t_1.

3) ΔE, energy variation, *Sec. 2(3)1, Eq. 2(34).*

4) h, The Planck Constant, please refer also to *Sec. 5(16)1c, part A1, Eq. 5(67)6* for its equivalent value .

Noteworthy, it must not confused the time intervals $\Delta T_F, \Delta T_B, \Delta T_0$ or ΔT_{FB}, *Sec. 2(10)1, Eqs. 2(117), (119); Sec. 5(16)1c, part A1, Eq. 5(67)6*, with an arbitrary time interval ΔT as stated above, in fact $\Delta T = \delta n \Delta T_{FB}$ in case of unique H system, *Sec. 8(5),* e.g. fundamental particle.

Example 5(16)3g, A1:

According to *Sec. 2(1)3, Eq. 2(35), and Note 2(3)1a, Eq. 2(56):*

$$\upsilon_p = K_\Gamma n_p = K_\Gamma a_1 N_p \qquad 5(70)3j$$

Where:

- υ_p, The photon wave frequency.

- n_p, frequency equivalent number of H particle-paths of photon main-body as particle, *Sec. 7(4)2e*.

- N_p, The number of H particle-paths of photon.

- a_1, constant of media coefficient, *Note 1(2)1*.

In the *Eq. 5(70)3j*, $N_p h$ can be regarded as hidden stored path-length of photon as particle (or main-body), *Sec. 7(4)1, item 3,* that is confined in an H hall quantized package, *Sec. 5(16)3a*, of the photon of energy *E*, frequency υ, wavelength λ. The *Eq. 5(70)3j i*s valid for H system at microcosm, e.g., photon, particle, nucleus, up to Planck mass, $\lambda = l_p$, Planck length, l_p, *Sec. 5(8)2, Sec. 5(8)1, Eq. 5(33).* As a result, according to *Sec. 7(4)1, item 3*, the stated above H system is confined in an H hall quantized package of path-length value h of its $N_p h$ stored path-lengths, and path-limit Γ, *Sec. 1(12),* in the range of de Broglie wavelength λ (or λ_α), *Sec. 2(3)1, Note 2(3)1a, Eq. 2(77).*

Supposing during the interaction, H hall quantized package (or package) loses some of its H particle-paths, i.e. its energy dropped. Therefore the time interval ΔT increases accordingly and vice versa, in such a manner that the total path-length of the whole system as isolated remain unchanged, *Sec. 2(4)*, whereas the path-length of individual interacting H system varies accordingly, i.e. an alternate interpretation of Heisenberg relationships, e.g., *Sec. 7(1), Eq. 7(10),* from viewpoint of H particle-paths hypothesis.

As another example, considering the package of an initial H system $E.\Delta T$, *Sec. 2(10),* of stored path-length unit Nh, *Sec. 7(4)1, paragraph 3* is split to n packages $E_1.\Delta T_1, E_2.\Delta T_2, \ldots E_n.\Delta T_n$ each of path-length unit of h value (*N=1*to n). In other words, an initial H hall quantized package is split to n ones that is accompanied by space expansion and time's arrow, i.e. entropy increasing through spatial medium and vice versa.

As a result, by no means (or experiment) one can reduce the path-length below its quantized h value, this result leading to uncertainty principle and relationship, *Sec. 7(1), Eqs. 7(5), 7(10).*

Note 5(16)3g, A1- In case of gravitational interaction, the path-length value of the close-ended H particle-paths related to expandon, *Sec. 5(16)1c, part A3*, (or contracton, *Sec. 5(2)1c, part c*) in an H hall package is $2\hbar$. While, in case of open-end H particle-paths, the path-length value of an H hall package is h. Thus, in this article, it is nominating, the H hall package of path-length value $2\hbar$ or h respectively.

Remark 5(16)3g, A1- According to [298], *principle of least action in general relativity,* "The action for the particle is:

$$S_p = C_p \int_1^2 R' \sqrt{-g}\, d\Omega \qquad 5(70)3f$$

Where, C_p is and unknown constant, this constant will be determined by requiring the theory to reduce to Newton's law for gravitation in the no relativistic limit". "The relationship, to within constant factor C_p between stress-energy and the curvature is:

$$C_p = \left(8\pi \frac{G}{c^4}\right)^{-1} \quad " \qquad 5(70)3g$$

Where, R', T' are 4-space curvature and stress-energy tensor respectively. Moreover, according to *Sec. 5(16)1a, Eq. 5(55)1*:

$$C_p = r_G = \pi L_G \qquad 5(70)3h$$

Remark 5(16)3g, A2- In case of $\Delta T = d\tau$, *Sec. 5(16)1c, part A1, Eq. 5(67)6*, the action *S* can be written as following:

$$S = n.h \qquad 5(70)3i$$

Where:

- n, is an integer number.
- $d\tau$, is the gravitational time's arrow unit, $d\tau$, *Sec. 5(16)1c, part A4*, *Example 5(16)3g, A1*.

B) Path-length variation of an H system

Based on *Sec. 2(1)2, Eq. 2(16),* the path (or path-length) of a free moving particle, e.g. photon, electron, consisting of N_0 H particle-paths is proportional to $N_0 c\int_0^t dt = N_0 ct$. Where, t is the proper time of the particle, which must be considered respect to observer *B*, *Sec. 8(9)2*, and at the origin of its common *CMPRF* with the detector, e.g. the Earth lab. This path-length is increasing with the time *t*, which depends on the medium, *Sec. 7(4)3*, consisting of particle-detector; whereas, the unit of path-length of h value is reveals just during an interaction (or measurement, *Sec. 8(7)2*). As an example of the latter case, please refer to *Sec. 9(4)4*. In other words, a free moving particle is confined in an H hall package, *Sec. 5(16)3a*, of path-length unit of h value, *Part A*, that is extended in path-limit Γ. As a result, the particle has two different aspects of path-lengths variation as following:

1) Path-length generation of a particle in a medium, *Sec. 7(4)3,* depends on its proper time, and its total number of H particle-paths in that medium

2) Path-length variation of a particle in a medium is an integer number of h units just during an interaction, e.g., absorption or emission of photon. Therefore, the stored path-length, *Sec. 7(4)1, item 3,* of particle is increased or decreased by units of path-length of h value accordingly. Please refer to *Note 5(16)3g, B1*.

According to above discussion, the *case 1* is related to successive generation of expanding track texture, *Sec. 5(16)3b, part B*, of a particle in a medium, e.g. vacuum, *Sec. 7(4)3*; whereas, the *case 2* to its measurement (or interaction) by a detector (or mass). Please refer also to *part c*, and *Sec. 7(4)2e*.

Note 5(16)3g, B1- The proper time (or the *LFRF* proper time, *Sec. 2(6)2c*) of a particle (or a mass-body) is depended on the medium, *Sec. 7(4)3*. It is based mainly on the gravitational time's arrow, *Sec. 5(16)7c, item 1*, in that medium (as in *case 1*). Therefore, the path-length of the particle is increasing according to this time's arrow. Whereas, the path-length of an isolated system (as in *case 2*) due to time symmetry, *Sec. 2(3)3*, contrary to the case of time's arrow is remained unchanged; please refer to *Secs. 5(9)3d*, *2(4)1,* and *Sec. 2(4)4b* in this regards. As a result, the world line of the particle, e.g. in a Minkowskian reference frame *R* (or *R'*), *Sec. 2(1)1a*, is related to the time's arrow. From viewpoint of H particle-paths hypothesis, the worldline, and path-length increment of a particle is due tom expanding characteristic of the whole Universe.

C) Particle motion from viewpoints of string theory and H particle-paths hypothesis

"The embedding $(\tau,\sigma) \mapsto x^{\mu}(\tau,\sigma)$ of a string trajectory into d-dimensional space-time. As τ increases, the string sweeps out its two-dimensional worldsheet in target space, with σ giving the position along the string" [456], *part 3.2, The Bosonic string, Fig. 7*. By a far analogy to this statement, the path-limit Γ of a particle in a medium, and time τ can construct a worldsheet in 4-dimensional spacetime. Similarly, here, $0 \le \sigma \le \pi$ is the spatial coordinate along the path-limit Γ . Please refer also to *Sec. 2(1)1b, Fig. 2(3), Sec. 5(16)3 b, part D2, and Sec. 8(8)2*.

The main part of the expanding track texture, according to *Sec. 2(1)1a* can be shown schematically in a reference frame of time, and *3*-space coordinates as particle trajectory, nominated particle worldsheet. Noteworthy, Minkowski *4*-vectors are merely a mathematical tool to help making correct calculation in *SRT, Remark 2(1)1a2*. Factually, the particle track texture is a non-separable characteristic of a particle in a medium that is extended from generation of particle up to its dissipation through a measurement, *Sec. 7(4)2e*. Moreover, "To solve the (string) equations of motion we write two-dimensional equation

$$\left(\frac{\partial^2}{\partial\sigma^2} - \frac{\partial^2}{\partial\tau^2}\right) x^{\mu}(\tau,\sigma) = 0 \qquad 5(70)3k$$

in terms of world sheet light-cone coordinates

$$\partial_+ \partial_- x^{\mu} = 0 \qquad 5(70)3l$$

where:

$$\xi^{\pm} = \tau \pm \sigma\,, \qquad \partial_{\pm} = \frac{\partial}{\partial \xi^{\pm}} \qquad 5(70)3m$$

The general solution of *Eq. 5(70)3l* is then the sum of an analytical function ξ^{+} alone, which we will call the left-moving solution, and an analytical function ξ^{-} alone, which we will call the right-moving solution

$$x^{\mu}(\tau,\sigma) = x_L^{\mu}\left(\xi^{+}\right) + x_R^{\mu}\left(\xi^{-}\right). \text{"[456] } \textit{part 3.3, String equations of motion.} \qquad 5(70)3n$$

According to above discussion, there is a similarity in this case with the counter-currency mode of motion of left- and right-handed H particle-paths, *Sec. 3(1)2*. As an example, please refer also to *Sec. 4(3)1, part B* related to the motion of an isolated electron of path-limit Γ through vacuum space. Moreover, according to path constancy, *Sec. 2(1)2*, the path-length of H particle-paths in the co-direction of a particle motion is equal to that of counter-direction of motion, but at opposite sign. In other words, the total path-

length variation is zero, *Note 5(16)3g, c1*. In the latter example, *Fig. 4(4),* supposing the electron's axeon with the string, and considering the left-handed H particle-paths (posipa) in the co-direction, and right-handed H particle-paths (negapa) in the counter-direction of electron motion around axeon as circulating wave-like entities. This model can be comparable with "The mode of expansion (of *Eq. 5(70)3n* in Fourier-type series) correspond to those of left- and right-moving waves circulating around the string in opposite directions."[456] *part 3.3*.

Note 5(16)3g, c1- In this case, there is a slight preference of right-handed path-length due to expanding particle-track texture, *Sec. 5(16)3b, part B*, of SN_r configuration in counter-direction of particle motion through spatial medium, *Sec. 7(4)3, part A*. It is accompanied by equal magnitude of left-handed path-length of the related SP_l configuration, *Sec. 3(1)2,* based on Mirror Image Effect, *Sec. 6(2)3,* in the mass-body (i.e. mass medium) of particle in co-direction of motion, *Comment 5(2)1c, B1*, and *Sec. 5(16)11*. It leads to a slight increment of velocity of isolated particle in the direction of motion, *Sec. 5(15)1, possibility II*, at a long period of time. The stated above model is comparable with the expandon generation along with its contracton conjugate cited in *Sec. 5(16)1b, part A, paragraphs 16, 17,* in a mono-dimensional direction, i.e. the track texture. Therefore, the track texture must be estimated to observer *A* in *CMPRF*, *Sec. 8(9)2*, of the particle-track texture system that is propagating in counter-direction of motion. Please refer also to *Sec. 5(7)8,* and *Sec. 7(4)2e*.

5(16)3h – Abstract vacuum

According to H particle-paths hypothesis, the time's arrow depends on the density and fabric of vacuum quantized texture (or normal vacuum), *Sec. 5(16)3b* during expansion process. Near a mass, this texture is dense and curved depending on mass magnitude. In the free vacuum space, it has a flatness along with constant density, *Sec. 5(16)1b*. Therefore, within an elongated H hall package, *Sec. 5(16)3,* during wave function collapsing, *Secs. 8(4), 8(9),* there is nil vacuum texture (or density), *Secs. 5(16)3b, c,* i.e. instantaneity, *Sec. 7(4)2f, part c*, or, zero time's arrow, *Sec. 8(9)1 paragraph 3*. An H hall package, *Sec. 5(16)3a*, with nil H particle-paths or low-density H particle-paths respect to vacuum texture, *Sec. 5(16)3b*, contract due to abstract vacuum at infinitesimal time interval, i.e. instantaneous collapsing of an entangled pair of particle wave function during measurement, *Sec. 8(9)1, paragraph 3*.

Resuming, a mass-body as emitter (through photon emission) tunnels in the normal vacuum separating media at light speed c to other mass-body as detector (or vice versa). In other words, the stated above photon can tunnel through gravitational field texture, vacuum texture*, Sec. 5(16)1b, paragraphs 7, 16* at light speed c, but with different time's interval in accordance with *Sec. 2(1)1b*. But just after interaction (or measurement*, Sec. 8(7)2*) due to the abstract vacuum that take form during photon pair propagation inside the related H hall package, at an infinitesimal time arrow (nearly spontaneous). It appears that measurement in one place have an instantaneous*, Sec. 7(4)2f, part c*, effect on the other place. Noteworthy, at the big-Bang era due to existence of abstract vacuum similar spontaneous effect (Inflation) take place at an infinitesimal time interval, *Sec. 5(15)3a*. Therefore, normal vacuum (texture) spread in abstract vacuum, please refer to *Sec. 5(5)1*. Noteworthy, the electric permittivity, ε_0, and magnetic permeability, μ_0, *Sec. 5(16)4*, in an abstract vacuum due to the lack of quantized vacuum texture has no sense. Moreover, a particle, if can penetrate from normal vacuum to the abstract vacuum, its path-limit Γ tends to infinity; please refer also to *Sec. 7(1), Comment 7(1)a*.

Generally speaking, an abstract vacuum can be regarded as a model with no quantized texture, please refer to *Sec. 5(16)7c, paragraph IV*. As the result, the Universe expand in an abstract vacuum, an entity with no dimension, space-time, *Note 5(16)3h1*, energy as we usually detect in normal vacuum that has energy density, *Sec. 5(16)3c*. In other words abstract vacuum devoid of H particle-paths and thus, out of our physical world. "The inflationary theory of the Universe even proposes that the Universe began at a state of no geometry (i.e. a Universe with nothing, not even time) and then a tunneling occurred, allowing the Universe to pass from the state of nothing to something (the false vacuum) by tunneling (Gruth 1997)"[481]. Noteworthy, the light propagates through normal vacuum texture, *Sec. 5(16)3b, part A*, gravitational field (i.e. its superimposition on vacuum texture, *Sec. 5(16)1b, part A, paragraph 16*) and within the mass medium as compacted form of the gravitational fields, *Sec. 2(1)3, Note 2(1)3b* at c speed,. However, the forces, interactions, *Sec. 5(2)1d*, virtual particle, *Sec. 4(6)5*, *Sec. 8(9)1*, propagate within abstract vacuum spontaneously (or at infinitesimal time interval, *Sec. 7(4)2f, part c*). Factually, mass can be regarded as a store of space and time's arrow, i.e. path-length, *Sec. 2(1)2,* generator along with entropy increment, *Sec. 5(16)7a*. Therefore, abstract vacuum has no role in this respect, i.e. time is meaningless in that medium. "In the literature in both physics and philosophy, description of the Big Bang often assumes that the first event is also a first instant of time and that space-time did not exist outside the Big Bang." [434] *part 4.6*.

Note 5(16)3h1- "**there is nothing outside the universe**. Hence, there are no absolute axes of reference for space or time outside the universe by which we can make our measurements (this principle - that there is nothing outside the universe - is described as the "first principle of cosmology" by Lee Smolin". "Instead, everything inside the Universe is defined relative to other objects inside the Universe"[560] *Quantum Gravity: The Wheeler-DeWitt Equation*. There is some exception to this principle; please refer to *Secs. 2(6)2b, f,* from viewpoint of *HPPH.*

5(16)3i – Vacuum polarization from viewpoint of H particle-paths hypothesis

The light speed in the inhomogeneous medium also is equal to c, i.e. the same as the normal vacuum. The reason is that during multiple scattering and reflections of its H particle-paths in dense media seems that its velocity is lower than c. Therefore, by no means the light velocity does not drop during its passage through a dense medium as gravitational field, i.e. the expanded form of the mass, *Note 2(1)3b.* In other words, the light travels at c speed in a lengthened (non-rectilinear) path; in addition, we must take

into account the absorption and emission by the atoms and molecules of that media. According to [87], Lomonosov discovers the deflection of a light beam in the atmosphere of the Venus long time ago.

In fact, the wavelength of the light [25] is indeed smaller in water than in air (Huygens's principle) by a factor of η . The refractive index of water, i.e. ratio of the speed of light in the air to its speed in water, that is analogous to decrease of wavelength of light in the gravitational field accompanied by contraction of path-limit, Γ , *Eq. 1(3),* in accordance with the speed of light in the dense media. Please refer to *Sec. 5(16)2c*.

Noteworthy, during light travel in a dense medium respect to empty vacuum (or a medium of refractive index $\eta = \frac{c}{v}$), the single direction H particle-paths of light, i.e. negapa, and posipa, tend partially to reversibility, e.g., analogous to a particle of rest mass at v speed ($v < c$) moving in empty (or normal vacuum). Supposing instead of light as an electromagnetical entity an electric field is passing through dense medium. Similarly, a pseudo-particle of the rest mass and partial electrical charge δe (the same sign as the electric field) taken form that is moving at v speed ($(v < c)$, through medium. In other words, the electric field strength according to *Sec. 4(3)* is weakened respect to empty vacuum. "The true vacuum, i.e. the ground state of the interacting theory, contains short-lived virtual particle-antiparticle pairs which are created in pair out of the Fock vacuum and then annihilate each other. Such charged pair acts as an electron dipole. In the presence of an electric field, e.g., electromagnetic field around an electron, these particle-antiparticle pair repositions themselves, thus partially counteracting the field (a partial screening effect, a dielectric effect). This field therefore will be weaker than would be expected when the vacuum would be completely empty. This reorientation of the short-lived particle-antiparticle pairs is referred to as vacuum polarization" [348]. Through this effect, i.e. vacuum polarization, from view of H particle-paths, there is no such pair production from empty vacuum as stated above, *Sec. 8(2)3*. An experimental verification of an analogous effect through passing laser beam (as an electromagnetical entity) in an external field, e.g., magnetic field, is leading to pair production, i.e. axion-like particles. Please refer to *Sec. 5(16)3b, part D2, part E1,* and *Comment 5(16)3b, E1*. Noteworthy, according to *Sec. 4(3),* a moving charged particle in vacuum medium have partial electric charge $-\delta e, +\delta e$ along its direction of motion respect to an observer at rest, i.e. lab. In other words, regardless of the particle charge, the particle can be supposed as a charged pair (or particle dipole). The magnitude of this polarization is depends on the particle velocity and its rest mass (or total number of its H particle-paths at rest state) and electric charge; please refer to *Sec. 4(6)2, Eq. 4(27).*

According to *Eq. 4(8) of Sec. 4(3)2, Note 4(3)3*, the partial charge δe :

$$\delta e = \alpha_1 e = \alpha^2 e \qquad 5(70)3o$$

Where:

α_1 - *Sec. 2(1)1, Eq. 2(7),* the deviation degree from reversibility related to the motion of charge e

α - The fine structure constant, *Sec. 9(4)6*

According to above statement, in case of an hydrogen atom, to each of electron and proton due to their sign of charge, rest mass, and velocity, one can attribute a pair of partial charges $-\delta e, +\delta e$; please refer to *Sec. 9(3)1, Note 9(3)1b*. Noteworthy, in the motion direction of electron, the δe has positive sign, but at counter-direction negative one. As if, one of the pseudo-particles of $+\delta e$ partial charge of the pair is attracted to the original (or bare) electron, whereas its conjugate of $-\delta e$ partial charge is repelled from it. Therefore, the bare electron is screened due to this polarization. Similarly, δe has negative (or positive) sign in the co-direction (or counter-direction) of proton motion respectively. Therefore, the same argument in case of electron will be applied for proton accordingly. "Since α is proportional to e^2, it is viewed as the square of an effective charge screened by vacuum polarization and seen from an infinite distance" [388]. Thus, the screening effect of these charged pairs related to electron and proton motion in an atom must be considered in evaluating of electron magnetic moment. "Since $g = 2$ (g dimensionless magnetic moment of electron) for a Dirac point particle, the dimensionless moment is often written as $g = 2(1 + a)$. The deviation a is called the anomalous magnetic moment of the electron or simply the electron anomaly. It arises from the vacuum fluctuations and polarizations that are described by QED with any small additions for short-distance physics that are well understood within the standard model, $a = a(QED) + a(hadron) + a(weak)$ "[386].

5(16)4- Electric permittivity and magnetic permeability as two characteristics of H hall quantized unit

The media coefficient a, *Sec. 1(2), Eq. 1(3),* and *Sec. 1(12), Note 1(2)1*, may be somehow related to the electric property of free space vacuum due to H hall quantized package, *Sec. 5(16)3a*, conception, i.e. the vacuum electric permittivity, ε_0. In other words, "the structure of the vacuum has been changing uniformly across the cosmos"[46]. Thus, supposing c, e, h, is constants, the fine structure increasing is accompanied by decreasing of vacuum permittivity; therefore, referring to the following equation:

$$\mu_0 \varepsilon_0 = c^{-2} = \text{constant} \qquad 5(70)4$$

The vacuum magnetic permeability μ_0 is increasing accordingly [50]. So, μ_0 *Note 5(16)4a,* is increasing according to the cosmological model of expanding Universe; please refer to *Sec. 5(16)5*. Noteworthy, both ε_0, μ_0 are depended on the fabric (or density and geometry) of vacuum texture, *Sec. 5(16)3b*. In other words, H particle-paths of electric or magnetic fields as singlet (i.e. posipa or negapa) propagate in a bed of H particle-paths of vacuum texture through an equilibrated manner that depends on vacuum energy density, *Sec. 5(16)3c*. Therefore, the propagation (or penetration) of the former fields in denser medium (or texture) have different values for electric permittivity and magnetic permeability for that medium. Based on stated above discussion, it is proposed that H hall quantized package geometry is related to the two vacuum constants ε_0, μ_0. In fact,

constancy of μ_0 according to *Sec. 2(1)1b, last paragraph*, can be related to the H particle-paths circular motion, *Sec. 2(1)1d, Sec. 2(1)1d*, respect to *YZ-plane* and ε_0 to the H particle-paths translational motion respect to *x-axis* (motion direction) at c speed respectively as H hall quantized packages, *Sec. 5(16)3a*, intrinsic specifications. In other words, the frequency of circular motion increased as the length contracts in the direction of *x-axis*; thus, if considering a cylinder that its base is the circle (or closed curved) on *YZ-plane* its high is Δx , proper length on *x-axis,* we have:

$S_c = f \times c_c \times \Delta x = constant$ *Remark 5(16)4a* 5(70)5

Where:

f- Frequency of revolution of a point on the circle or closed curve

c_c -the circumference of circle or closed curve

S_c - The lateral surface of a cylinder wrapped f time (overlapness).

By manipulation of *Eqs. 2(11), 3(23), 9(42), 9(43),* in case of an electromagnetic wave moving in the direction of common x, x' parallel axis of two inertial reference frames *R,R'* (moving at relative uniform motion at v velocity) and considering:

$$f \times c_c \times \Delta x = f' \times c_c^{'} \times \Delta x^{'} \qquad 5(70)6$$

The *Eq. 5(70)5,* [or *Eq. 5(70)6*] is a result of path-constancy, *Sec. 2(1)2.*

Alternately, by considering $c_c = c_c^{'} = constant$ in xz, and $x'z'$ planes, we obtain:

$$f \times \Delta x = f^{'} \times \Delta x^{'} = Const. \quad \textit{Remark 5(16)4b} \qquad 5(70)7$$

As a result, ε_0 and μ_0 are depend on $f \times \Delta x$ and c_c respectively in vacuum medium as two inseparable characteristics of H hall vacuum quantized package. Noteworthy, according to *Sec. 2(1)2, Eq. 2(26),* the *Eq. 5(70)7 [or Eq. 5(70)6]* is equivalent to the path-length constancy in an H hall quantized package.

Generally, in case of electromagnetic waves in a non-vacuum medium, the *Eq. 5(70)5,* is also valid, i.e. f, Δx , c_c are related to that of non vacuum medium respectively , or, in other words, electric permittivity and magnetic permeability in non vacuum medium depends on $f \times \Delta x$, c_c related to that medium respectively. The latter is proportional to radius of the circle by 2π factor and its magnitude is depends on the velocity of light in the related medium, e.g., c in vacuum; by the same analogy, $f \times \Delta x$ is also depends on light velocity in related medium, *Remark 5(16)4c*. Factually, $f \times \Delta x$ and c_c can be regarded as dimensional limit of an H hall quantized package, *Sec. 5(16)3a;* factually, these two different items has the same basis, i.e. integer number of h, that is independent of the kind of interactions.

Comparing the two sets of formal of electromagnetism and gravitomagnetism, "G replacing the Coulomb force constant $1/4\pi\varepsilon_0$"

[302] *Comparison.* According *to Eq. 5(70)4,* and *Sec. 5(16)1a, Eq. 5(49)*:

$$G = \frac{(2\hbar)Ac\,P_u^2}{2\pi\mu_0}.\frac{1}{4\pi\varepsilon_0} \quad \text{or} \quad G' = \frac{(2\hbar)c\,P_u^2}{2\pi\mu_0}.\frac{1}{4\pi\varepsilon_0} \qquad 5(70)7(1)$$

Where:

- $\hbar, c$ are reduced Planck constant, and light speed respectively.
- G, G' , the gravitational constant, and its modified form; please refer to *Sec. 5(16)1c, part A1; proposal 5(16)1c1*.

According to *Eq. 5(70)7(1), G* (or *G'*) also depends linearly on spin-2 of expandon*, Sec. 5(16)1c, part A3,* or its path-length unit value, *Sec. 2(4)4a*.

Note 5(16)4a- At the present time and the location of our Milky Way galaxy in our flat Universe, μ_0, is related to 4π , (π =3.1416…). Moreover, the circumference of circle at rest system in a plane to its radius measured by conventional tool is equal to 2π , *Note 2(1)1a1*. In other words, the length of a solid body, e.g. rod, or thread, can be considered as its reversible H particle-paths moving in a round trip path through a circle (tangential motion) divided by the length (radius) of reversible H particle-paths (radial motion) that is equal to 2π . Please refer also to *Sec. 2(3), Note 2(3)3b,* and *Sec. 5(16)1 b, paragraph3*. But at the closed space as the past time after Big-Bang, the above ratio is less than 2π that is growing as a function of time up to present time to reach 2π (i.e. till flat Universe [259]) in an accelerating mode of expansion. Therefore, vacuum permeability increased till 4π accordingly. On the other hand according to $\alpha = e^2/2\varepsilon_0 hc$, *Sec. 9(3)1, Eq. 9(31),* and *Eq. 5(70)4,* α is proportional linearly to μ_0; thus, α increase as μ_0 increase and "Time-varying fine structure constant requires cosmological constant "[284]. According to [285]"Many- multiplet (*MM*) method applied to large sample of quasar absorption lines resulted in the claim for small value of α in the past, $\Delta\alpha/\alpha = (-0.574 \pm 0.102) \times 10^{-5}$ for $0.2 \le z < 3.7$. Moreover, according to [284], "Webb et al. presented preliminary evidence for a time-varying fine-structure constant; we show teller's formula for this variation to be ruled out within the Einstein-de Sitter Universe, however, it is compatible with cosmologies which require a large cosmological constant". Factually, time-varying fine structure constant depend on cosmological model and the geometry of the Universe.

Remark 5(16)4a – In case of internal motion of H particle-paths of a fundamental particle as singlet, e.g., negapa (or posipa), S_c in the *Eq. 5(70)5*, can be related to the constancy of electric charge e of that particle and regardless of its mass. By condition, the latter is considered at rest respect to an observer in an inertial reference frame. In other words, the right-handedness (or left-handedness) of H particle-paths in this system that is confined in an H hall quantized package, *Sec. 5(16)3a*, is somehow leading to the constancy of electric charge, e^- (or e^+)in this package; please refer also to *Sec. 4(5).*

Remark 5(16)4b:
Considering the motion of H particle-paths is combined of two components, the translational and rotational, *Note 2(1)1d,* in such a way that the total speed is equal to c. Therefore, by decreasing the tangential speed, the translational one increased and vice versa. Now supposing during space expansion, the translational motion increased at the compensation of tangential speed up to c at de Sitter space after consumption of dark matter to dark energy, *Sec. 5(15)2b*. At this critical stage with no rotational motion, the H particle-paths handedness is reversed through opposite circular motion direction by compensation of translational one. In other words, the reversed handedness process along with time arrow reversal, spatial contraction and dark energy decrement begin. Therefore, right-handed and left-handed H particle-paths at critical point reversed to left-handed and right-handed H particle-paths respectively. According to *Sec. 4(3)2* by handed-reversal, positive and negative charges also returned to negative and positive charges respectively. As a result, space contract along with time arrow, *Sec. 5(16)7a*, reversal, i.e. handedness reversal, *Sec. 5(16)9b*, please refer also to *Sec. 5(15)3b*. Noteworthy, dark energy decrement at the end of expansion of matter world, and appearance of contracting antimatter, it can be considered as a negative energy concept, *Sec. 5(16)3c, Remark 5(16)3c2*. "Though the classical theory does not allow negative values for the energy of a particle, the case in which the particle carries energy in one direction, and in which its antiparticle carries energy in the other direction" [381], *Mass shell*.
As a result obtained of the mono-directional path-limit of an isolated moving particle, the constant value in the right side of *Eq. 5(70)7*, must be equal to Γ_d , *Note 1(2)1*, and *Sec. 1(12)* through vacuum medium as following assumption:

Considering, f , f' as $n_d, n_d^{'}$, the frequency equivalent number of H particle3 through vacuum medium respectively, and $N_d = a_1 n_d, N'_d = a_1 n_d^{'}$, *Sec. 2(3)1, Eq. 2(35)*, according to *Eq. 5(70)7*, we have:

$n_d.\Delta x = n_d^{'}.\Delta x' = Const.$ or

$a_1.N_d.\Delta x = a_1.N'_d.\Delta x' = Const.$

Considering, $\Delta x = c\Delta T, \Delta x' = c\Delta T'$ through H hall quantized package through vacuum texture medium, *Sec. 7(4)3, part A*, we have:

$c.N_d.\Delta T = c.N'_d.\Delta T' = c.\Delta T_{\Gamma d} = a_1^{-1}.Const.$, or 5(70)7a

$N_d.\Delta x = N_d^{'}.\Delta x^{'} = \Gamma_d$ 5(70)7b

Noteworthy, according to *Consequence 2(10)1b*, considering $K_m \approx 1$ in microcosm and referring to *Eq. 5(70)7a*, its $Const.$ value is the light speed c .
According to definition of coefficient medium through vacuum medium a_d , *Sec. 7(4)3, parts A, H*, we have:

$\Delta T_{\Gamma d} = a_d^{-1}$, *Note 1(2)1*
Therefore:

$$c.\Delta T_{\Gamma d} = \frac{c}{a_d} = \Gamma_d = Cons.$$

Where:
- $N_d, N_d^{'}$ are the total numbers of H particle-paths packed in path-limit Γ_d of the vacuum texture of frequency equivalent number $n_d, n_d^{'}$ related to time interval $\Delta t, \Delta t'$ of inertial reference frames R, R' respectively; please refer to *Sec. 2(1)1a.*
- a , media coefficient, *Note 1(2)1,* of time inverse dimension, in case of vacuum, $a = a_d$ .related to path-limit Γ_d
- a_1 , the constant of media coefficient*, Note 1(2)1*
- a_d , the media coefficient of vacuum medium

Considering vacuum as isotropic in tri-spatial directions, the third power of *Eq. 5(70)7b*, the vacuum texture density, thus ρ_d is obtained:

$N_d^3.\Delta x^3 = \Gamma_d^3$, or $\frac{N_d^3}{\Gamma_d^3}.\frac{H}{c^2} = \frac{N_d^3 a^4}{c^5} = N_d^3.a^4 \times 10^{-93} kg/cm^3 = 10^{-27} kg/m^3$ 5(70)7c

In case of supposing $a = a_d = 3.5 \times 10^{12} s^{-1}$, *Sec. 7(4)3, part H*, we have $N_d \approx 10^{16}$. In other words, the total number of H particle-paths, N_d, in one cubic meter of vacuum texture is equal to 10^{16} .
Where:
- *H*, the intrinsic energy related to an H particle-path.

Remark 5(16)4c – Referring to *Eq. 5(16)4,* and *Remark 5(16)4b, part II,* we have:

$$f.\Delta x = c \qquad 5(70)7d$$

By multiplying the *Eq. 5(70)7d* by c, i.e. the light velocity, and referring to *Eq. 5(70)4*, we have:

$$c.f.\Delta x = c^2 = \frac{1}{\mu_0 \varepsilon_0} \quad \text{or} \quad f.\Delta x = \frac{1}{\mu_0 \varepsilon_0 c} \qquad 5(70)7e$$

5(16)5- Spirally expanding gravitational surface

According to *Proposal 5(16)1a1*, the radially expanding gravitational sphere, *Secs. 5(1), 5(4),* that is based on path-constancy, *Sec. 2(1)2*, and *Eq. 5(55),* any H particle-path of n_G groups during the process of expansion, *Sec. 5(16)2b*, moves on a helix shape path analogous to a watch spring, *Comment 5(16)5a*. In other words, the intersection curve of expanding gravitational spheres with the plane of motion of the related H particle-path that passing through the gravity center of mass *M* is a helix; thus, this helix, as a loose analogy can be compared with that of a compressed watch spring during its releasing. Similarly as an alternative comparison to peel an apple skin continuously and uniformly or, unrolled a skein of woolen yarn at c speed; please refer to *Sec. 7(6).* In the latter example, we encounter with woolen spheres during each period, unrolled up to complete unwrapping process. By combination of woolen coil with that of spring helix example, we can have a rough imagination of how expanding gravitational spheres generates successively. In fact, we encountered with a unique huge helix shape surface as a unique H system, *Sec. 8(5)* that can be simulated as correlated, *Sec. 8(7),* successive gravitational spheres at an acceptable approximation as in, *Secs. 5(1), 5(4),* till disappearance of the whole isolated mass *M*; Thus, the resulting gravitational surfaces, *Sec. 5(4),* with its twisting expansion is accompanied by internal rotation of H particle-paths of the related mass-body in opposite direction, *Sec. 6(2)3,* as impulsion,. Recently, according to the work down by Nodland & Ralston in an analysis of radio waves from *160* distant galaxies, that the radiation rotates as they move through space in a subtle corkscrew pattern unlike anything observed before. A complete turn of the corkscrew appeared every one billion miles the radio waves travel [117], i.e. anisotropy in electromagnetic interactions [119], please refer also to *Sec. 4(4).* "Since the new rotation, we find has such systematic directional dependence it is implausible that it is generated by cosmic ions and fields via some mechanism. Similar to the Faraday Effect, one may therefore surmise that it is the vacuum itself that flaunts a form of electromagnetic birefringence, or anisotropy- similar to birefringence inhibited by many crystals" [327]. So the vacuum space quantized texture, *Sec. 5(16)3b*, has a rotational expansion; moreover, the rotational velocity is proportional to the intergalactical distances traveled by the waves [118]. Therefore, the latter can be interpreted as rotational aspect comparing with translational aspect in Hubble law of Universe expansion, i.e. rotational expansion, *Remark 5(16)5a*. According to [114], *part related to fundamental interpretations,* "in particular, the rate of rotation plane caused by the new effect depend on the angle between the direction of travel of the polarized wave and a fixed direction in space pointing approximately toward the constellation Aquila from Earth". By extending and applying the latter result to the mass-bodies or particles, one can deduced that the generated gravitational expanding spheres of a mass-body at rest that has a randomless aspect and it has a preferential directional characteristic in nature, e.g., unwrapping of a fixed axis yarn spindle, *Comment 5(16)5b*. Factually, an isolated mass-body moving at uniform motion respect to our observer (lab) according to Newton first law has two slightly accelerations based on H particle-paths hypothesis due to exit of rotational expanding gravitational surface as following:

1) Linear (or translational) in the direction of motion*, Sec. 5(15).*

2) Rotational respect to axis passing from its center of gravity and opposite to the tangential exit of gravitational surfaces, i.e. unwrapping the wrapped H particle-paths according to mirror image effect, *Sec. 6(2)3*.

As a result, according to stated above discussion, we encountered with right- handed spirally expanding gravitational surfaces, (Expandon*, Sec. 5(16)1c, part A3*), *Experiment 5(16)5a*, accompanied by an inverse linear and angular momentum increase of the main mass-body respect to the momentum of exiting H particle-paths of related spirally expanding gravitational surfaces. Thus, the whole Universe from its earliest compact form is accelerated both radially, i.e. Hubble law, *Sec. 5(1),* and tangentially, i.e. increasing accelerated rotation along an axis, up to present time, *Remark 5(16)5b.*

Generally speaking, the self radial and rotational motion due to radial expansion (Hubble law) and rotational expansion in H systems extended from gravitational field, fundamental particles, atoms, molecules, stars, galaxies up to the whole Universe; please refer also to *Sec. 8(7)2, E5a, item 20*.

Finally, according to above statement space has two anisotropies, i.e. radially and tangentially.

Experiment 5(16)5a – An experiment performed by Hideo Hayasaka of a free-fall spinning gyro, according to that [322]"For ten runs of repeated fall experiments, in which each run consists of the fall-time measurement for the left hand (viewed from above in the direction of falling), right hand and no spinning about the vertical axis. The fall-acceleration $g_{(R)}$ of the right-spinning is significantly smaller than $g_{(L)}$ of left-spinning at 18000 rpm with the latter being almost identical with $g_{(0)}$ of spinning without exception". Therefore, in the former case, i.e. $g_{(R)}$, the spinning direction is the same as right-handed expansion of the Earth (lab) gravitational spheres, *Sec. 5(16)9b, Comment 5(16)9b1*. Therefore, making a correlation in this regards, *Sec. 5(9)3*; please refer also to *Sec. 5(16)1b*, *part A, paragraph 15*. In this case, the gravitational dome of falling object, *Sec. 5(2)1a*, due to lower purely reversible H particle-paths is seemed relatively lesser (lower acceleration) respect to the two other cases. Factually, the gravitational Dome in this case is due to fully reversible motion of H particle-paths of the rest mass. This equilibrium is broken if the rest mass undergoes a linear or rotational motion due to common motion of its H particle-paths, *Sec. 1(3).* Therefore, it lower the effect of gravitational on the related mass-body due to diminution of its H particle-paths pure reversibility of the mass, *Sec. 5(3), Sec. 5(3)2*. However, in case of left-handed rotation, this diminution is compensated relative to right-handed one due to mono-directional H particle-paths at left-handed direction (related to left-hand rotation of the mass). Thus, merely the right-handed rotation is affected respect to the two other ones.

Comment 5(16)5a – The *proposal 5(16)1a1* is fitting well with the assumption that according to *Sec. 8(7)2, part G*, and *Note 9(4)6a,* at any infinitesimal stay time interval Δt, merely a cell of n_s cells on the Schwarzschild surface is on expanded form (or state); while the remaing cells are in contracted form. In such a manner that during any time ΔT of emission of a gravitational sphere from the Schwarzschild surface, we have:

$\Delta T = n_s \Delta t$.

Comment 5(16)5b (proposal)-A yarn spindle can be unwrapped left- or right-handedly according to its initial wrapping; by analogy, the gravitational surface can be extended in two ways left- or right-hand respect to the main axis of gravitation of its mass-body. Remarkably, regarding the abundance of matter respect to antimatter we can attribute a right-handed spirally expansion (*type R*), i.e. matter; to our Universe and a left-handed spirally expansion to antimatter accordingly, *Sec. 5(16)9c.* This kind of expansion according to *Sec. 4(5),* gives rise to a negative electric charge related to right-handed feature of negapa, *Sec. 1(5),* e.g., in electron, and a positive electric charge related to left-handed feature of posipa, e.g., in hadrons, in our right-handed (type *R*) Universe. In other words, the magnitude of the charge depends on the rate of right- or left-handedness of spirally expansion of gravitational surface, *Sec. 5(16)6*, i.e. right-, or, left-handed of related H hall quantized packages, *Sec. 5(16)3a;* please refer to *Secs. 4(3), 4(4); Sec. 5(16)1c, part A*.

Remark 5(16)5a- Considering the expansion of the Universe as discussed above, the whole expansion can be regarded as a right-handed (corkscrew pattern) expansion i.e. *type R* of SN_r configuration; please refer to *Sec. 5(2)1c, c1*, and *Sec. 5(16)2a, Consequence 5(16)2a*. In other words, at each point of our Universe, the expansion can be viewed as right-handed helix and the rate of both radially and spirally expansion are increased due to spatial and tangential coordinates increasing according to *Sec. 5(16)5*.

Remark 5(16)5b – Factually, the internal spirally rotation increasing with time (or distance) along an axis of the Universe that is a direct result of *Sec. 5(15)*. Noteworthy, it must not imagine the rotation of the whole Universe along an axis analogous to that of the Earth. In other words, do not consider the whole Universe simply as a rotating object along an axis that is in accordance with observed isotropy of cosmic background radiation, *Sec. 5(5)2*.

5(16)6- CPT scenario [223]

According to *Sec. 4(5),* the negative or positive charge are the manifestation of the right- or left-handed H particle-paths spin, *Sec. 2(1)1d*, behavior regarding their selective spatial interaction in a reference frame at rest state, *Note 4(6)1a*. Thus, the negative or positive charge (symmetrical in charge) is a direct result of right- or left-handedly (symmetrical in parity) of H particle-paths in a counter-current forward and backward, *Sec. 3(1)2,* reversible mode of motions [symmetrical in time, *Sec. 2(3)3,* and *Note 5(16)6a*]. Therefore the reversible motion of these H particle paths of different handedness can be regarded as *CPT* symmetry, *Remark 5(16)6a*. At one point, *CPT symmetry* or *charge-parity-time* was considered one of the most fundamental laws of physics [129]. In other words, *CPT symmetry* is a fundamental symmetry of physical laws under transformation that involve the inversions of charge, parity [148] and time simultaneously; please refer also to *Sec. 5(16)9,* in this respect.

According to [142]; "In quantum field theory, time reversal, or, *T* is one of a trio of possible symmetric, the others being charge conjugation or *C*, which amounts to interchanging particles, and parity, or, *P*, which is related to spatial inversion". "The laws governing gravity, electromagnetism, and the strong interaction are invariant with respect to *C, P*, and *T* independently" [417] *C, P, T.*

The equality of negative and positive charges in the real world says that the total numbers of right- and left-handed H particle-paths are equal; so the question such impose why:

I) the right-handed H particle-paths as in electron field respect to left-handed ones as in nucleons are in low denser medium; thus, the time uncertainty according to *Eq. 7(10*), of the latter is shorter respect to the former one, *Note 5(16)6b*.

II) The Universe has been made preferably of matter through spatial medium, *Note 5(16)6b*, and not initially of equal matter and antimatter, *Sec. 5(16)9c*.

III) CP, *Comment 5(16)6a,* violates during decay process of the neutral kaon and neutral mesons, *Sec. 5(16)8.*

According to *Sec. 5(16)5*, and considering the above statements, we encounter with the questions "if there is a preferred right- or left-handed spiral expansion, *Sec. 5(16)5,* based on the right- or left-handedness assumption of H hall quantized units", *Sec. 5(16)3a*. Moreover, supposing there is a contraction after expansion of the whole Universe, *Sec. 5(15)3b*, "if the inverse process during contraction period will take place?", i.e. any mass body replace with its related antimatter; and H hall quantized packages handedness reversed accordingly as a direct result of *CPT symmetry*. Please refer to *Sec. 5(15)2b, Sec. 5(16)3, Sec. 5(16)7a, Sec. 6(2)3*, for complementary information. Factually, dependence of β decay to *CP* or *CPT, Comments 5(16)4, 5* can be interpreted as during such a process we can encountered with space expansion and time's arrow, *Sec. 5(16)7a*, generation. Similarly, time reversal means space contraction; or, in other words, during a space contraction we encountered with time's arrow reversal, i.e. handedness reversal, *Sec. 5(16)9b,* according to that, a type *R* Universe will be transformed to its type *L* and vice versa.

Experiment 5(16)6a - Referring to *Secs. 4(3)3, 4*, based on H particle-paths hypothesis; there are *2* types of labeled photons *R* and *L*, *Note 5(16)10a*. According to [173], part related to *deepening the quantum mysteries,* Chiao, R., [174, 181] performed a variation of Young double slits by labeling the monochromatic light by polarizing filter to left-handed circular polarization going through one slit and right-handed one going through other slit; thus, the interference pattern*, Sec. 8(3)4,* vanished, i.e. a quantum

eraser demonstration. A which-way measurement, as stated above in Youngs double slit, will destroy the interference pattern, *Sec. 8(3)4*. Therefore, the photon must be in its indistinguishable feature, *Remark 7(4)2e1*.

Note 5(16)6a - According to counter-currency mode of motion, *Sec. 3(1)2*, backwarding H particle-paths is the mirror image effect, *Sec. 6(2)3,* of forwarding one and vice versa, i.e. conjugate of each other; please refer to *Sec. 8(1)2.* Noteworthy, "The standard model of particle physics has three related natural near-symmetries. These state that, the Universe is indistinguishable from one where:

C (charged symmetry): every particle is replaced with its antiparticle.

P (parity symmetry): the Universe is reflected as in a mirror.

T (time symmetry): the direction of time is reversible (locally not globally)" [408] discrete symmetry. These are the result of right- and left-handed H particle-paths replacement (or transformation) at the same time as mirror image of each other.

Note 5(16)6b- According to *Sec. 5(16)11*, in our matter Universe, the expanding type R_e path-length is equal to contracting type L_c at equal magnitude, but at opposite sign. Therefore, the right-, and left-handed H particle-paths in electron and nucleus fields obeys such a processing. In other words, there is a preferential right-handedness through expanding spatial medium along with equally preferential contracting left-handedness through the mass medium, *Sec. 7(4)3*.

Comment 5(16)6a- During β decay through electroweak reaction of aligned Co^{60} nuclear spins along the direction of an applied magnetic field near zero Kelvin, the emitted electrons mostly have an *type L* spin, i.e. g*roup D type L, Fig. 4(14)a*. Moreover, the emitted electron's antineutrinos, $\overline{\upsilon_e}$ have right-handed configuration at opposite direction to magnetic field, i.e. parity violation, *Sec. 5(16)8*. The circulating single direction H particle-paths related to spin of Co^{60} can be considered as superposition of single direction H particle-paths related to Ni^{60} and electron spins; moreover, two single direction H particle-paths flows at opposite direction shared as impulsions of Ni^{60} and electron respectively during the decay process.

According to the decay process we are encountered with H hall quantized packages, *Sec. 5(16)3a,* appearance as space expansion *(type R), Sec. 5(16)7a, and Comment 5(16)5b.* The overlapped, *Sec. 7,* H hall quantized package of Co^{60} is separated into three H hall quantized packages, Ni^{60}, electron, and electron's antineutrino that can be depended on mass to energy conversion.

As a result, one of the necessary conditions of parity violation is space expansion, i.e. H hall quantized package generation as an irreversible process. Remarkably, the space expansion as above is accompanied by an arrow of time such as breaking a glass or burning fuel, in which the time reversal of these processes are never seen, *Sec. 5(16)3a, 5(16)7*.

$Co^{60} \rightarrow Ni^{60} + e^{-} + \overline{\upsilon_e}$ [148], *Example 5(16)9a1* 5(70)8*a*

According to *Example 5(16)8a,* and *Eq. 5(70)8a*, $\bar{e}$ and $\overline{\upsilon_e}$ H hall quantized packages have type *L & R* respectively*, Experiment 5(16)6a*; whereas, Ni^{60} H hall quantized package has the same type as Co^{60}, i.e. type conservation in β decay.

Comment 5(16)6a-

Remark 5(16)6a- The *C, P*, have the same spatial origin (i.e. H particle-paths handedness), and *T*, has time's arrow, *Sec. 5(16)7a,* origin in *CPT* triple symmetry. According to [227], "The triple symmetry of *CPT* that were once thought to be preserved in interactions at the atomic level. But then experiment showed that *C, P* and the combination *CP* were not sacred. And since the *CPT* is still though to be valid *T* by itself was though to be vulnerable. That is, it is now thought that physics does differentiate between the forward or backward movement of time. The two groups of researchers have now seen evidence of this *T* violation in the observed decay rates for neutral *K* mesons". Factually, according to *Sec. 2(4)1,* the time's arrow and its reversal are depended on the related irreversible path-length, *Sec. 2(4)4b*. Moreover, in our matter Universe, the parity violation is depended on irreversible spatial expansion, *Comment 5(16)6a*, along with irreversible time's arrow related to irreversible expanding type R_e path-length. Therefore, in a contracting type L_c Universe, parity violation is also depends on irreversible spatial contraction along with irreversible time's arrow reversal related to irreversible spatial contracting path-length at equal magnitude and opposite signs, *Sec. 5(16)11*. In addition, the electric charges are also reversed their sign depending on handedness reversal of H particle-paths, please refer to *Secs. 4(3), 4(5).* As a result, the *CPT* is conserved through the two stated above phenomena.