Part 4d- Wave function

8- Wave function Ψ and its square in quantum theory

8(1) – Introduction

"Quantum mechanics is, at least at first glance and at least in part, a mathematical machine for predicting the behaviors of microscopic particles — or, at least, of the measuring instruments we use to explore those behaviors — and in that capacity, it is spectacularly successful: in terms of power and precision, head and shoulders above any theory we have ever had. Mathematically, the theory is well understood; we know what its parts are, how they are put together, and why, in the mechanical sense (i.e., in a sense that can be answered by describing the internal grinding of gear against gear), the whole thing performs the way it does, how the information that gets fed in at one end is converted into what comes out the other. The question of what kind of a world it describes, however, is controversial; there is very little agreement, among physicists and among philosophers, about what the world *is like* according to quantum mechanics. Minimally interpreted, the theory describes a set of facts about the way the microscopic world impinges on the macroscopic one, how it affects our measuring instruments, described in everyday language or the language of classical mechanics"[597] *Introduction.* The *HPPH* aims to find a correlation between the physical behavior of the microscopic and macroscopic worlds.

8(1)1-One particle in three spatial dimensions

The spatial wave function associated with a particle in three dimensions is "a complex wave function $\psi(x,y,z)$ defined over three dimensional space, and the square of its absolute value is interpreted as a three dimensional probability density function:

$$\mathbf{P}_R = \int_R |\psi(x,y,z)|^2 dV \qquad 8(1)1$$

The normalization condition is likewise

$$\int_R |\psi(x,y,z)|^2 dV = 1 \qquad 8(1)2$$

Where the preceding integral is taken over all space"[567] *One particle in three spatial dimensions.*

Principally ψ of Schrödinger's Equation, *Note 8(1)1a,* can be considered as amplitude for waves representing an H system, *Sec. 1(6),* and $|\psi|^2$, the average density of H particle-paths in that, *Comment 8(1)2,* during measurement, *Sec. 8(4),* instead of probability of finding a particle (i.e. H system): please refer also to *Sec. 2(4)2b,* and *Secs. 8(7)2, 8(7)6*. In case of free electron at rest state, according to *Eq. 3(28):*

$$|\psi|^2 = k\delta E_t \; dV \quad \text{or} \quad |\psi|^2 = k\, a_1 h \delta n_t \qquad 8(2)$$

According to *Eq. 2(86)* to *2(97):*

$$|\psi|^2 = k\, a_1 h \delta n_t = k\, a_1 h(\delta n_F + \delta n_B + \gamma \delta n_\perp) \qquad \textit{Note 8(1)1b} \qquad 8(3)$$

Where:

- a_1, constant of media coefficient, *Note 1(2)1* and *Sec. 7(4)3, part E.*
- n_t, the total frequency equivalent number of particle-paths constituting an H system e.g. electron
- $n_F, n_B, n_\perp$, are the frequencies equivalent number of forwarding, backwarding and perpendicular (respect to the direction of particle travel) H particle-paths in the particle main-body. Therefore, these can be interpreted as components of H particle-paths equivalent energies in its different aspect of motion. Moreover, $\delta n_F, \delta n_B, \delta n_\perp$, are their variations according to *Sec. 2(3)2a*.
- k, a dimensionless parameter
- δn_t *Eqs. 2(95), 2(97)*, is the total number variation respect to $n_\circ$, *Eq. 2(86),* the initial frequency equivalent number of H particle-paths of H system at rest
- dV, a partial volume that we can find an electron at probability density $|\psi|^2$

In fact, wave function, *Remark 8(1)1a*, that describes the temporal and spatial evolution of a quantum-mechanical particle can be visualized to some extent as a function of wave-like counter-current, H particle-paths, *Secs. 3(1)2, 3(2),* in an H system, e.g., electron in both spatial and mass media, *Sec. 8(1)5, Sec. 8(7)2, part F.* Moreover, $|\psi|^2$ in *Eq. 8(3)* can be considered as the population density of H particle-paths of the particle main-body confined in a limited path-limit, Γ *Sec. 1(12),* please refer also to *Secs. 8(4) to 8(6)*, and *Sec. 8(7)6* for complementary information. According to *HPPH*, $|\psi(x,y,z)|^2$ can be expressed as H particle-paths density in unit of volume in spatial medium. The real part of ψ is representation of particle track texture in spatial medium and its imaginary part within the mass medium, *Sec. 8(7)2, part F3*, related to both H hall package tunnels, *Sec. 5(9)3d, part c*, and reversons, *Sec. 7(5)3*. Therefore, the track texture densities in a location that is equivalent to medium coefficient a in that location, i.e. $ka_1 = a$, is interpreted as probability of particle travel on the track texture. Factually, according to *Simulation 7(4)2e1,* the particle track texture densities in spatial medium is proportional to total number of H particle-paths of the particle, *Sec. 7(4)3, part E1*. In case of many particles system, *Sec. 8(7)6,* $|\psi|^2$ can be representation of media coefficient $a_{(t)}$ in any location. According to this discussion, it depends on matter wave counterpart, *Sec. 5(6),* H particle-paths (or particle track-textures) densities at that location which is interpreted as the joint probability density associated with the positions of all of the particles. "Given a wave function ψ of a system consisting of two (or more) particles, it is in general not possible to assign a definite wave function to a single-particle subsystem. In other words, the particles in the system can be entangled"[567] *Two distinguishable particles in three spatial dimensions.*

Note 8(1)1a - According to first postulate of quantum theory, any system can be described by a wave function, $\psi(t,x)$, where t is a parameter representing the time and x represent the spatial coordinate of the system, function $\psi(t,x)$ must be continue single valued and square integrable"[158]. This postulate in quantum mechanics is consistent with H particle-paths according to which, any H system can be represented by wave-like H particle-paths, *Sec. 1(6),* that are moving at c speed as a function of space and time coordinates. "The wave function tell us not what a system is, but how it will appear to be in any conceivable experimental context"[346] *Coupled contexts.*

Note 8(1)1b- The *Eq. 8(3)* can be considered as variation of components of total frequency equivalent number n_t of H particle-paths in the main body of a moving object within spatial medium respect to that of the same object at rest state in unit of volume, i.e. H particle-paths-flow. According to *Sec. 7(4)2f, part A*, $\delta\, n_t$ is related to the frequency of expandon emission by the mass-body in spatial medium at K_Γ ratio. In other means, each point on track texture of the mass-body has its appropriate frequency related to its *WR & WL* expandon emissions, *Simulation 7(4)2e1*. There is also a similar scenario based on Loop quantum gravity. "As a consequence, the spacetime metric is replaced by an effective frequency dependent metric $g \rightarrow g(w)$" [589] the general argument; please refer also to *Sec. 5(16)3b, part J*, in case of similarity of spacetime with track texture. Factually, the track texture of a mass-body is developed in the background of normal vacuum track texture, *Sec. 5(16)3b, part A*. According to above statement, the latter has also its appropriate frequency. In other words, the metric of fixed background spacetime of vacuum medium, *Sec. 7(4)3, part A*, can be replaced by a frequency dependent metric. "In our picture, space-time, energy, and momentum have become intertwined. Even ignoring gravitation, we cannot talk about time and position without a particle being there. The properties of this particle's position and time depend on its energy. At low energies, the dependence is very weak, so we have the illusion that space-time exists independently of the (test) particles that might fill them."[590] *An example and some physical considerations*; please refer also to *Sec. 7(6).* Noteworthy, the track texture of a medium is defined by path-limit Γ, *Sec. 5(16)3b, part D2,* in a location that is comparable by some extent to energy-dependent spacetime invariant according to *DSR*. Moreover, according to *Sec. 7(6),* there is a correlation between space, time, and energy. Note that, based on *HPPH*, in addition to the track texture frequency introduces the track texture expanding and attenuating features that are not foreseen in energy-dependent space-time of the *DSR* theories as in reference [590]. Noteworthy, the track texture of a medium, Sec. 7(4)3, is defined by path-limit Γ that is comparable to some extent to energy dependent space=time invariant of DSR.

Remark 8(1)1a- This statement hold for an H system of mono-particle, but for an H system of many particles the problem is somewhat different. "The problem is that the purpose of any physical theory is to account for a pattern occurring in (ordinary 3-dimensional) space and time. However, the behavior of a wave function of many (*N*) particles Universe, a field on an abstract (*3N*-dimensional) configuration space, has in and of itself no implications whatsoever regarding occurrence in physical space, however sensible its behavior may otherwise be. As Bell has noted, it makes no sense to ask for the amplitude or phase or whatever of the wave function at a point in ordinary space. It has neither amplitude nor phase nor anything else until a multitude of points in ordinary three-space are specified [356]; please refer also to *Sec. 8(7)6*. For the comparison of wave-like H particle-paths configurations in real dimensions (or physical world), please refer also to *Sec. 8(1)3, Comment 8(1)3a.* Factually, the particles according to H particle-paths hypothesis based on its own postulates, *Sec. 8(7)4,* are not point-like. Moreover, the wave function of an H system in fact is the function of path-length variation.

8(1)2-Complex-conjugate

According to *Sec. 3(1)2, Fig. 3(4)c; Sec. 4(4),* the negapa and posipa of photon are single direction; whereas, the negapas and posipas of a particle of rest mass are counter-current, *Fig. 3(4) a, b , Fig. 3(5)*; *Sec. 4(3)3*. On the other hand, "Einstein suggested that the square of the amplitude of the electromagnetic wave, epsilon square, could be interpreted as average number of photons per unit volume (wave intensity, energy density, photon density). Similarly, Max Born proposed something like a square de Broglie wave (the complex conjugate) gives a real, non-negative quantity that could be interpreted as a measure of the probability of finding a particle at a given time and place"[147]. From viewpoint of this article it can be interpreted as H particle-paths and its counter-current (conjugate) H particle-paths population densities; moreover, the conjugate of an H particle-paths means *time and direction reversal* characteristic of its counter-current partner respect to that, *Sec. 5(16)9*, i.e. its reversed handedness, *Secs. 3(1)2, 6(2)3.* Please refer also to *Sec. 8(7)4, item GII.*

The counter-current right-and left-handed H particle-paths, *Sec. 3(1)2, Comment 3(1)2a,* are time component and space components projections on the motion direction of each other. According to quantum mechanical language, they denotes by analogy with Ψ and Ψ^* ; therefore they are conjugate of each other. Considering this formalism., the product of these counter-current wave-like H particle-paths conjugates amplitude regarded as population density of their, i.e. analogous to $\Psi.\Psi^*$, *Note 8(1)2a*. In other words, counter-current posipa and negapa are conjugate of each other*, Sec. 5(16)9b*. Similarly, according to [156] *part 3.5.* "In particular, the quantum mechanic formalism makes extensive use of the operation of complex conjugate. Form simple system this operation is equivalent to the operation of time reversal [Wigner, 160], which transform retarded waves into advance waves". According to above statement the counter-currency of H particle-paths is visualized by a loose analogy with Cramer's retarded and advanced wave, *Sec. 5(16)3f, part B,* transactional model [156,162] differing in that the former dealing with reversal of handedness along with reversed time's arrow, *Sec. 5(16)9b*; whereas, the latter is simply time reversal, *Comment 8(1)2a*. Similarly, from H particle-paths hypothesis viewpoint, the H particle-paths along with its counter-current conjugates, *Sec. 3(1)2,* are considered as superimposed wave-like H particle-paths, i.e. $\Psi + \Psi^*$. In addition each H hall quantized package, *Sec. 5(16)3a,* (or its overlapped ones) along with its related counter-current H particle-paths constitutes a quantum state, *Comment 8(1)2b*. As an example refer to *Sec. 4, Fig. 4(4),* of free moving electron; moreover, the path-limit Γ, *Sec. 1(12)*, of each H hall quantized package (state) is obeyed the rule stated in, *Secs. 2(10), 7(2).*

Example 8(1)2a- Considering time variation of the probability of finding a particle over any arbitrary volume *V* enclosed by surface *S*, we obtain:

$$\frac{\partial}{\partial t}\int\left|\Psi\right|^{2}dV = -\int_{S}\frac{h}{2mi}(\Psi^{*}\Delta\Psi - \Psi\Delta\Psi^{*})dS = -\int_{S} jdS \qquad 8(3)1$$

If on the left side of *Eq. 8(3)1*, we have the change in the probability of finding an electron (or particle), inside the given volume, then on the right-hand side we must have the flux of the probability of it passing through the boundary surface *S* of the volume *V*. According to H particle-paths hypothesis, the probability density of finding a particle can be considered as H particle-paths population density. Supposing the volume *V* is large enough and finite so that the condition:

$$P = \int\left|\Psi\right|^{2} dV = 1 \quad \text{i.e. normalization condition can be used} \qquad 8(3)2$$

The physical results naturally, closed depend upon the arbitrary choice of volume. If on the left-hand of *Eq. 8(3)1*, we had the change in the probability of finding an electron inside the given volume, then, on the right-hand side we must have the flux of the probability of it passing through the boundary surface of volume V. According to *Eq. 8(3)1*, j can be regarded as the density of the probability flux; please refer to [36], *section 24, Pp260-261*, but according to H particle-paths hypothesis due to exit of gravitational sphere, *Sec. 5(16)1b, part A*, from boundary surface *S* as H particle-paths flux density j, it must have non zero value. Factually, instead of considering a particle as point-like (zero dimension, *Sec. 4(3)1, part B, item XXII*), we must consider the particle as a set of H particle-paths of varying densities. In other words, the normalization must be done in such a way that the probability flux density j becomes equal to H particle-paths population densities of gravitational spheres including H particle-paths of particle main-body at each point beyond the surface *S* of volume *V*, and at each instant. Please refer also to *Sec. 5(17), Example 5(17)1*. Alternately, in case of isolated particle in vacuum texture, *Sec. 5(16)3b*, there is a discontinuity at the scale of $V_{\min}$, *Sec. 5(8)2, Eq. 22,* on the surface of a particle H system. Moreover, in case of massif mass-body, it can be regarded as the surface of a sphere of Schwarzschild radius l_s, *Sec. 5(8)2, Eq. 5(31),* (as ground surface or surface) of gravitational expanding surfaces (or spheres) generation; please refer to *Sec. 5(7)1*.

Note 8(1)2a – As a result of path constancy, *Sec. 2(1)2,* the amplitude of a wave is proportional to its wavelength, *Note 3(1)2a, Eq. 3(26).* Thus, by considering the constancy speed of H particle-paths, i.e. c, amplification due to superposition of posipa-posipa and negapa-negapa as in *Eq. 8(3);* the final amplitude square is proportional to H particle-paths population density per unit of spatial volume, i.e. analogous to $\left|\Psi^2\right|$ or, $\left|\Psi\,\Psi^*\right|$; please refer also to *Note 2(3)2a1*. Noteworthy, denoting of finding a point-like particle by $\left|\Psi\,\Psi^*\right|$ or $\left|\Psi^2\right|$ is a conventional method, that is applied by Max Born in order to interpret the Quantum mechanical results; thus, reconciling it with the classical concept of particle as point-like. However, according to H particle-paths hypothesis, the probability concept at a location is replaced by H particle-paths population density at that location; please refer also to *Sec. 8(7)5.*

Based on, *Sec. 8(7)6, part B, paragraph III, item I,* Ψ, and Ψ^* can be referred to matter, and antimatter universes, *Sec. 5(16)9*, (or better to say type *R&L* universes) at an nearly equal probable of existence with the slight preference of the former one, *Example 8(1)2a.* According to [365], *part 2.1*, the product of $\Psi.\Psi^*$ (the probability density function) is therefore called the window of quantum mechanics to the <u>real world</u>. This can be referred to the counter-current mode of motion of H particle-paths, or, in other worlds, to two counter-current Universes.

Comment 8(1)2a- In case of particle of rest mass, to its H particle-paths (right-handed negapa) we can attribute a time's arrow, *Sec, 5(16)7*; whereas, to its counter-current conjugate (left-handed posipa) a reversal equivalent. In fact, the main time's arrow can be referred to the case of gravitational expanding spheres. Please refer to *Sec. 5(16)1c*; *Sec. 6(2)3, consequence 6(2)3a.*

Comment 8(1)2b – According to [317] "Wave packets are an important concept in quantum mechanics. For an electron, atom, molecule, or, any quantum system, an individual quantum state can be represented as a stationary or standing wave, whose point of maximum disturbance (peak and valleys) and points of minimum disturbance (known as nodes) stay fixed". This wave packet by a loose analogy from viewpoint of H particle-paths hypothesis can be regarded as an H system at rest, e.g. atom, molecule,… It constitutes an H hall quantized package, *Sec. 5(16)3a*, within that the H particle-paths moving at counter-current mode of motion, *Sec. 3(1)2, Figs. 3(4) a, b*; please refer also to *Secs. 8(7)4, 6.*

8(1)3- State Vector

A)- General aspect

"In quantum mechanics, the state of a quantum system (i.e. quantum state) is described using a mathematical representation such as state vector (also called a wave function for some quantum mechanical systems) or a density operator"[211]. "The *SV,* a function (usually complex), which depends on position, momentum, time, energy, spin, isospin variable, etc. The central problem of the interpretation of *QM* formalism is to explain the physical significance of the *SV*" [156], *part 2.1.* Remarkably, the states of a quantum system, *S*, are derived by vectors $|\Psi\rangle$, which are elements of Hilbert space, *V*, *Comment 5(15)3d, B1*, that describe, *S. S* having a role by a far analogy analogous to 4-vector potential, *A,* components, *Comment 8(1)3a*, in electromagnetism, *Sec. 4(6)3,* of an isolated H system, e.g., photon*, Sec. 4(4),* free moving electron, *Sec. 4(3)3*, in Minkowskian 4-dimensional space-time, *Note 8(1)3a*. The Maxwell equation is reduced to a wave equation of vector as:

$$\Delta A - \frac{\partial^2 A}{\partial t^2} = 0 \quad [163], part2 \qquad 8(3)3$$

Similarly, Ψ, has analogous formalism for free moving particles [163] *parts 10, 11*, and is comparable by far analogy with a 4-vector potential *A* in electromagnetism. Generally speaking, Ψ, and its, Ψ^*, complex conjugate in quantum mechanical formalism by a loose analogy have analogous role as 4-vector potential vector *A*, in an isolated electromagnetic field, *Sec. 4(6)3.* By the difference that the latter is applicable for single direction H particle-paths as singlet without accompanying conjugate (or counter-current partner) and the former along with its complex conjugate as H particle-paths and its counter-current, *Sec. 3(1)2,* partner (i.e. reverse handedness conjugate) from H particle-paths hypothesis viewpoint, *Remark 8(1)3a; Comment 8(1)3a*; please refer also to *Secs. 4(3), 4(4), Sec. 5(16)3e.* "The inner product between two state vectors is a complex number known as probability amplitude "[165] part related to *Mathematical formulation.* The latter is comparable with H particle-paths population density.

"A single state vector describes a physical system, no matter how many observers make measurements on it" [162], *part 3*, contrary to Copenhagen interpretation of quantum mechanics; moreover, "the state vector of the quantum mechanical formalism is a real physical wave with spatial extent"[156], *part 3.4,* that moving through space.

According to [156]; *part 2.2.1,* "Some insight into these questions can be gained from the observation that the time reversal operator of [Wigner 160] is the operation of complex conjugation, i.e. reversing the sign of the imaginary part, or, the complex phase of the *SV* elements. Thus, the complex character of the *SV* is a manifestation of its time structure. The real part of the *SV* is time-reversal even; and the imaginary part is time-reversal odd". Thus, Born's probability law implicitly tells us that the probability of a particular observation is obtained by taking the product of a component of the *SV* with its time-reverse"; please refer to *Sec. 5(16)9, Comment 5(16)9a2, 3,* and *Comment 8(1)3b*.

Note 8(1)3a - In fact analyzing a time dependent wave function similarly to vector potential in a Minkowskian space-time give a reasonable aspect of its comparison with vector potential*, Sec. 4(6)3*. As a simple example, "a single electron in an unexcited atom is pictured classically as a particle moving in a circular trajectory around the atomic nucleus, whereas in quantum mechanics it is described by a static symmetric probability cloud surrounding the nucleus"[165]. This cloud can be regarded as H particle-paths moving at *c* speed in a counter-currency mode of motion*, Sec. 3(1)2,* the probability cloud represented the population density of H particle-paths, *Sec. 8(1)1*, *Eq. 8(3).* Factually, the electron cloud can be visualized as electron track texture, *Sec. 5(16)3, part B,* in atom, e.g. hydrogen atom, *Sec. 9(4)7.* As a vector potential according to *Sec. 4(6)3,* indicate the direction of H particle-paths as singlet, a vector in the direction of H particle-paths that is counter-current by its conjugate counterpart specify the forward-backward motion of H particle-paths at each point of space and related time. It can be considered as H particle-paths in form of contractons that emit in the direction of state vector towards the center of the mass medium, *Sec. 7(4)3, pat D*. According to above discussion, and by analogy to spin half quantum states as vector. The contractons emit normal (*Z*-component) to the direction of reversible motion (or closed-end) of H particle-paths, and in the direction of single direction (or open-end) H particle-paths. Noteworthy, the contracton emits mainly in the presence of particle in a state. According to *Sec. 5(16)1b, item 19B,* any state can be viewed as superposition of sub-states. To have a scheme of this kind of motions, please refer to *Fig. 5(8)* in this figure, each sphere constructs a quantum eigen-state of Ψ, and *Sec. 9(4)7, item 18*. Moreover, the contractons are emitted radially towards the center of mass *M* in *Fig. 5(8) of Sec. 5(16)1b, part A.*

Comment 8(1)3a- According to [156], *part 2.1*- " The early semi-classical interpretation of de Broglie and of Schrödinger attempted to make the obvious and straightforward analogy between the matter waves of quantum mechanics and the classical waves of Maxwellian electrodynamics. This approach asserts that the state vector of an electron, for example, is the *QM* equivalent of the electric field of an electromagnetic wave. Thus, the *SV* of an electron would be considered to start at the point of emission and to physically travel through space as wave. It would exhibit the properties of a particle only when (and if) it interacted with a scatterer or an absorber. In particular, severe problems were found with the intrinsic non-locality of such an interpretation. The *SV* is not analogous to the electric field of a classical wave or indeed to any other observable entity. Rather it is a mathematical representation of our knowledge of the system. The *SV* is approachable only through the results of a physical measurement"; please refer to *Sec. 5(16)3b, part c; Sec. 8(7)2, Example 8(7)2, B1*; *Sec. 8(4),* in this regards.

Comment 8(1)3b:

I) - The emitted photon during electromagnetical interaction of two moving charged particles, *Sec. 4(3),* is entangled with the related charged particle, *Secs. 8(7), 8(9),* in a counter-current mode of motion of negapa and posipa as a unique H system, *Sec. 8(5),* respect to the center of mass of the latter. Whereas the right-handed H particle-path, i.e. negapa, has time's arrow, *Sec. 5(16)7a,* the left-handed conjugate one, *Sec. 8(1)2*, i.e. posipa, has reversal time's arrow in our matter Universe, *Sec. 5(16)9.*

Therefore, during the photon measurement, or, interaction with the second charged particle, the photon acts as two co-direction negapa, and posipa, as in, *Figs. 3(4)c, 4(4);* please refer to *Sec. 8(7)2*, *Sec. 5(16)1c*.

II) - According to above discussion, the total time of the unique H system related to a photon pair is equal to zero due to negapa and posipa time's arrow and reversed time's arrow concept respectively. Thus, due to the equal number of negapa & posipa and their symmetrical contribution at this case, the measurement on one photon has instantaneous*, Sec. 7(4)2f, part c,* effect on the other one from this view point of a separating distance down to path-limit, Γ, *Sec. 1(12).*

Remark 8(1)3a – For any complex vector space V there is a conjugate vector space $\overline{V}$, which we get by making V into a complex vector space in a different way, such that multiplication by $+i$ now acts as what used to be multiplication by $-i$. Similarly, for any complex representation of a group on V we get a representation of this group $\overline{V}$, called the conjugate representation. In physics, conjugate representation describes anti particles.

B) Spin half Quantum states as vectors

Contrary to case of free moving particle, *Note 3(1)2a,* bounded electron*, Sec. 9(4)7a, item 18,* has half a path-length in one of the type *R* or *L* sub-cell (or sub-state), *Sec. 5(16)1b, part A, item 19*, i.e. half the path-length of type *R&L* cells in a complete beat, *Sec. 7(5)3d, part D.* "If we are to consider quantum states as vectors, then this very basic property must also be possessed by quantum states, i.e. we ought to be able to show that by taking a linear combination of two basis states, the result is a vector that represents a possible state of the system. To see how this comes about, at least in the case of spin half, we make use of the general expression for the state $|S\rangle$ *Eq. 8(3)4*:

$$|S\rangle = \cos(1/2\theta)|+\rangle + e^{i\phi}\sin(1/2\theta)|-\rangle \qquad 8(3)4$$

The atomic spin has been prepared in a state $|S\rangle$ where $S = S.\hat{n} = 1/2\hbar$ by passing the atom through a Stern-Gerlach apparatus with its magnetic field in the $\hat{n}$ direction, and the atom emerges in the $S = 1/2\hbar$ beam. What this equation is then saying is that the combination $\cos(1/2\theta)|+\rangle + e^{i\phi}\sin(1/2\theta)|-\rangle$, and $|S\rangle$ both represent the same thing – the atomic spin is in a state for which $S = 1/2\hbar$" [627] *part 8(3)3*. Alternately, according to *HPPH, Sec. 8(7)2, part G*, merely an state of all of the possible states of a system is in expanded form during an infinitesimal stay time interval, *Sec. 7(4)2f, part A*; while, the other possible sates are in contracted mode or nil. This idea based on causality instead of a particle been in all of its states at once, and using the normalization process.

8(1)4 – Quantum state

"Quantum state means the collective properties of the electron (or particle) describing what we can say about its condition at a given time". "The quantum state is described by its wave function Ψ" [370] *Schrödinger wave equation*.

"The wave function is not simply a description of the object's state, but that it actually is entirely equivalent the object" [154], part related to *relative state*. "The essence of an object is the quantum state of its particles and not the particles themselves". "In our construction $|\Psi\rangle$ object is the quantum state of an object in a definite state and position [329] *part 3.1.* According to H particle-paths hypothesis, an object is constituted of its wave-like H particle-paths, *Secs. 1, 2*, and its related counter-current conjugates, *Sec. 8(1)2*, moving at c speed. Therefore, at each instant and position an object is defined by its H particle-paths. Moreover, microscopic particles are in superposition of its H particle-paths, *Sec. 7(2)2b.* The time interval between two successive positions (or stay time intervals, *Sec. 8(7)2, part E2*) can be regarded as ΔT_Γ, *Sec. 7(4),* or $d\tau$, *Sec. 5(16)1c, part A4*. Because of their infinitesimal values, these time intervals are theoretical and have no practical application. The problem of the existence probability of a particle in a location is solved by H particle-paths population density of that particle at this location. "De Witte 1970 claims that the probability measure is proportional to the measure of existence" [329], *part 6.2*. Factually, the probability of existence has a hard link with the H particle-paths population density of that in vacuum medium relative to other ones. It can be visualized by mutual correlation of their H particle-paths through the vacuum texture, *Sec. 5(16)3b*. Noteworthy, the H particle-paths hypothesis is deterministic for a physical universe; thus, it explains, why an entity behavior appears to be deterministic at quantum level for an observer; please refer to *Remark 8(1)4a*.

According to bi-Universe hypothesis, *Sec. 5(16)9,* any state of a system in matter Universe has a conjugate state in antimatter one with the slight preference (or abundance) of the former. Please refer also to *Sec. 8(7)2, part c*.

Remark 8(1)4a - Some discussions on deterministic approach are listed as following:

1) "The most logical domain of physics where one may expect quantum mechanics to become replaceable by a more deterministic scenario is the Planck scale [331]. Please refer to *Sec. 8(7)4, paragraphs E, F,G,* the H particle-paths viewpoints to this approach.

2) "No concealed parameter can be introduced with the help of which the indeterministic description could be transferred into a deterministic one. Hence, if a future theory should be deterministic, it cannot be a modification of the present one but must be essentially different [359], *section 2*.

3) Many attempts have been devoted to build a deterministic theory reproducing all the results of Standard Quantum Mechanics (*SQM*), but where probabilities are epistemic; namely due to our ignorance of some hidden variables. These theories can be local. The formers are substantially excluded by Bell inequalities experiment. The latter include the de Broglie-Bohm (*dBB*) one, the most successful attempt in this sense [341] *Abstract.*

8(1)5- Is wave function a real wave?

"Whether the wave function is real, and what it represents, are major questions in the interpretation of quantum mechanics. Many famous physicists have puzzled over this problem, such as Erwin Schrödinger, Albert Einstein and Niels Bohr. Some approaches regard it as merely representing information in the mind of the observer. Some, ranging from Schrödinger, Einstein, David Bohm and Hugh Everett III and others, argued that the wave function must have an objective existence"[567] *Ontology*. One of the aims of *HPPH* is to approach to this problem at an alternate way.

"De Broglie matter wave satisfied with probabilistic (Copenhagen school) interpretation of quantum mechanics, and since 1924 he (De Broglie) kept working on his own idea of a next level (double solution) theory. The physical meaning of the Schrödinger ψ -function a probability amplitude of particle waves has been debated for decades, the nature of the de Broglie waves and so-called *entangled state* being the central issue" [495] *Introduction*.

"In the Copenhagen Interpretation, the wave function is treated as nothing more than a useful mathematical measuring tool, used for calculating the probabilities of finding a particle. The wave function is not considered to have any reality, i.e., it does not exist in this universe in the same way that a light wave, say, exists. It is purely a mathematical entity. But maybe the wave function is more than that. Based on this discussion so far, may be we should now understand the form of the wave function as describing reality before observation. Certainly, it would appear that the wave function is more just a simple probability wave giving the probability of finding a particle in a particular position". "The wave function appears to have a structure - it's certainly more than a simple probability. So now we're considering the wave function as describing reality before observation". "So now we have an answer to the last nasty implication of the Copenhagen Interpretation: there could, indeed, be an objective reality which exists in the absence of observation, and that reality would be described by the wave function. Which leaves only one problem: if the wave function is the true description of reality, then that reality is described in complex space"[557] *Beyond Copenhagen*. "Firstly, it requires the peculiar collapse of the wave function which apparently relies on observation. This might be taken to be a real physical process, or an "increase in our knowledge", but these precise details were left unexplained. Secondly, the interpretation effectively denies the existence of a deeper, objective reality that exists in the absence of observation"[557] *The Copenhagen Interpretation.* There is a proposed mechanism according to *HPPH* before measurement of a particle; please refer to *Sec. 8(7)2, part G*, *item B*.

Noteworthy, According to *Sec. 8(7)2, part E2,* the wave function of a particle cannot be separated from its medium. Moreover, the wave function ψ is accompanied with its non-separable conjugate ψ^* as a single entity that specifies the states (of an observable) of the related system. "If the wave function is a mathematical model it must be a mathematical model of an underlying mechanism. It model something real"[557] *Beyond Copenhagen*. As an example according to *Sec. 2(4)2,* in case of gravitational field of an isolated particle, the wave function specifies the path-length density in a *4*-space volume $d\Omega$ that is equivalent (or proportional) to the number of expandons and contractons in volume $d\Omega$ of an isolated system from viewpoint of *HPPH*. Moreover, its variations respect to time and position specify the energy and momentum flow densities in a location. As a result, it can give a schema of H particle-paths flow densities in a *4*-space volume of an H system. Please refer also to *Sec. 8(1)2,* and *Consequence 8(1)5a*.

Consequence 8(1)5a- Noteworthy, based on *HPPH* wave function in a medium, *Sec. 7(4)3*, can be regarded as particle and its track texture, *Sec. 8(2)3*, that evolves during the time in the medium; please refer also to *Simulation 8(7)2, E5a*. Factually the particle wave function is evolved during infinitesimal stay time interval ΔT , *Sec. 8(7)2, E5a,* in each point of expanded mode of particle position (or state) up to a measurement (or interaction). In other words, via particle detection by the huge inertia of measuring device, its track texture is no longer existing. Thus, dissipates in the huge wave function of particle-measuring device system, *Example 8(7)2, B1,* based on history of past events, *Note 2(1)4a.* Therefore, the sub wave function of a particle, e.g. free electron, expandon, contracton, is inserting in growing wave function of the Universe as entropy increment. Therefore, the local time arrows (or stay time interval, *Sec. 7(4)2f, part A*) are accumulated in background time arrow, *Sec. 5(16)7c, case II,* of the whole Universe. According to *Sec. 5(15)3d, proposal 4*, The expandon branch of the wave function that is prevailing in spatial medium, *Sec. 7(4)3, part A*, equal or lower than c speed cannot be escaped to a world of the worlds of multiverses through abstract vacuum. Thus, remaining in our real Universe (or world); while, its contractons branch can be transferred mutually with contractons of the multiverses via related H hall package tunnel, *Sec. 5(9)3d, part c* and abstract vacuum, *Sec. 5(16)3h*, spontaneously; thus, induces a gravitational attraction, *Note 5(15)3d, B4*. In other words, the contracton transfer is responsible for Universe splitting. Therefore, the remote universes share in the wave function of our real Universe.

8(2) – Particle trapped in potential well

8(2)1 - Electron trapped in a potential well (one-dimensional motion)

Considering:

I) An insolated free particle, *Fig. 4(4),* of N_{0e} initial H particle-paths (e.g. electron H system) and path-limit Γ_d , *Sec.1(12),* moving through normal vacuum texture, *Sec. 5(16)3b*, at v_0 speed of N_α single direction (returned) H particle-paths, *Eq.2(22);* thus, particle matter-wave, *Sec. 5(6),* wavelength λ is obtained according to *Eq. 2(77).*

II) Supposing the same particle at the same speed v_0 moving in one dimensional path, and trapped (i.e. its path P , *Sec. 3(1)1,* wrapped) between two potential barriers, i.e. $U=\infty$, infinite potential well at length D , [8].

Thus, the following conditions must be established:

$$P=nD=K_p\Gamma_d \text{, Note 3(1)1c} \quad 8(4)$$

In other words, path P must be folded n time to reach length D ; therefore:

$$\lambda = \frac{h}{m v_0} \propto \frac{2D}{N_\beta} = \frac{P}{N_\alpha}$$ 8(5)

Where:

- Γ_d , the path-limit of particle through normal vacuum
- N_β , number of the H particle-paths at back and forth motion through length D.
- *P*, is the path according to *Sec. 3(1)1*. It is proportional to path-limit Γ_d by K_P factor.
- D , can be regarded as path-limit Γ_w of the particle in the potential well medium. Please refer also to *Sec. 7(4)3*.

According to *Eq. 8(4),* we have:

$$N_\beta = 2n\, N_\alpha$$ 8(6)

In other words, N_β is equivalent to n times the single direction H particle-paths N_α of particle motion through spatial medium; moreover, n, N_α , N_β , are integer numbers. Therefore, N_β can be regarded as single direction H particle-paths of particle through the well medium. Please refer also to *Remark 8(2)1a*.

By comparing the cases *I* and *II:*

A) Free moving electron (case *I*) as an isolated H system

B) Trapped electron (case *II*) accompanied by the external barriers constitute a unique H system.

C) Base on Mirror Image Effect, *Sec. 6(2)3,* H particle-paths of the particle in the case *II* are interchanged (or reversed back) with that of barrier, *Sec. 1(11),* at the two end points (or wall) of barrier D. Please refer to *Sec. 6(2)2*.

D) The wavelength of matter-wave forwarding motion of free moving electron (case *I*), *Sec. 2(3)1, Eq. 2(53)*, is shorter than that of backwarding one, *Eq. 2(54), Comment 8(2)1a.* Whereas at the case *II*, the forwarding and backwarding wavelength are the same, i.e. at equal wavelength and amplitude, as a result of Mirror Image Effect, *Sec. 6(2)3,* but propagating at two opposite directions (stationary wave), *Note 8(2)1a.* Thus, a state with real wave function is represented as the superposition of two states with opposite momenta, these states having equal amplitudes. We can say that the mean momentum is equal to zero for quantum motion [36], *part 25, page 265.*

E) The single direction H particle-paths N_β through length D (or fixed path) constitute the spatial axeon, *Sec. 10(8),* of trapped electron (case *II*). Moreover, for reason of existence of axeon, electron cannot be at rest in the potential well. The lowest energy state, related to the axeon called the ground state that corresponds to *n=0*; thus:

$$E_0 = \frac{h^2}{8m D^2}$$ 8(7)

Where, E_0 is the ground state energy, or, zero point energy for the infinite well.

F) The length D (case *II*) can be assumed as trapped electron H hall quantized package, *Sec. 5 (16)3,* of path-limit Γ_d . Thus, by increasing D (case *II*), up to infinity or, simultaneous removal of the barrier of free electron, this H hall quantized package will be extended accordingly up to a measurement, *Sec. 8(7)2* (or collision, *Sec. 5(2)1a*). In other words, the reversible N_β H particle-paths as mass formalism is converted to non reversible, i.e. energy related to N_β single direction H particle-paths; since mass can be attributed to reversible motion of H particle-paths, i.e. rest energy, and kinetic energy to that of non reversible one, *Note 2(1)3b*.

G) Considering the reflection process, the number of single direction H particle-paths (in this case N_β) remained unchanged but its direction changes during H particle-paths exchange of incident particle and the barrier walls, *Sec. 6(2)3.*

H) The probability of finding particle at each point location can be considered as population density of its H particle-paths at that location, *Sec. 8(1)1*; thus, the whole length D constitutes a single quantized H hall quantized package of value h, *Sec. 5(16)3g*, (i.e. a quantum state), *Sec. 8(1)2.* The total number of H particle-paths in this statement at each instant and energy level [including related kinetic energy as its additional H particle-paths, *Sec. 2(2), Eqs. 2(35), 2(40)*] constitutes the single particle.

Proposal 8(2)1a- Factually, a free electron is moving freely through vacuum texture at v speed, but in case of a potential well, equilibrium is established. In other words, according to *Sec. 5(16)11*, the electron initially at v speed inside the well perforated a tunnel through the barrier. The time travel of electron through this tunnel is infinitesimal, *Sec. 5(16)11*. Noteworthy, according to path-length constancy, *Sec. 2(1)2*, path-length of electron in case of $U = 0$ is equal to the path-length of that in the case $E < U$. From this inequality, the penetration depth of the stated above tunnel through barrier can be obtained by analogy with *Sec. 5(16)11,* please refer to *Remark 8(2)1a*.

Note 8(2)1a - At the case of $U \neq \infty$, if:

1) E > U: only a percentage of incident wave (at the equilibrium state) will be reflected similar to the case, *Sec. 6(2)1a, Eqs. 6(13), 6(14),* i.e. dynamical case respect to the former statically one and the remainder ones will be passing the barriers.

2) E < U: in this case, we encountered with successive attenuating action-reactions of entering H particle-paths with that in the *U* region that depend on the H particle-paths relative densities of the both. Thus, some H particle-paths path-length extend exponentially down through the length D , as if a wooden ball dropping in a water vessel as a far analogy, and imaginary example only for the reason of comparison, *Proposal 8(2)1a*.

Since the concept of potential energy, *Sec. 5(4)1*, *Note 5(4)1b,* of a medium on the basis of H particle-paths hypothesis depends on the interaction of H particle-paths of that medium with that of interacting objects; thus, it differs completely with that of potential

energy assumption in classical physics as a continuous medium. Moreover, the penetration depth, Δx besides of H particle-paths population densities is depended on the time duration, Δt of interacting H particle-paths of incident particle wave at v speed with that of potential medium. In fact if the potential barrier width, a, is narrow enough, i.e. $\Delta x > a$, some portion of H particle-paths of incident matter waves are transmitted through the barrier without more interactions.
Please refer also to *Sec. 5(16)10,* in case of H particle-paths traveling through a barrier.

Comment 8(2)1a- Similarly, according to *Sec. 2(3)1*, *Eqs. 2(73), 2(74),* the frequencies equivalent of the forwarding motion n_F is higher than backwarding one n_B at a ratio of K_Γ factor of related matter wave frequencies.

Remark 8(2)1a- Based on *Sec. 8(2)3*, N_β the single direction H particle-paths of a trapped electron constitutes its track texture in potential well. According to *Remark 2(4)1a,* the moving electron is guided by its track texture (or matter wave counterpart, *Sec. 5(6)*) in a medium during its travel.

8(2)2 – Particle trapped in a closed rigid box

Considering the volume *V* of a rigid box, that is containing *N* particles instead of free vacuum space. Therefore, a quantized texture constituted of *N* H hall packages, *Sec. 5(16)3a*, each of path-length of h value, and paths $\Delta l = \Delta x, \Delta y, \Delta z,$ that is confined in a volume $V_{BP} = \Delta x.\Delta y.\Delta z$, *Sec. 11(2), Eq. 11(4),* thus according to [36], *Sec. 25, Pp266-8,* we have:

$$N = \frac{V}{V_{BP}} = \frac{V}{\Delta x.\Delta y.\Delta z} \qquad 8(7)1$$

To each of H hall packages, one can attribute a momentum interval $\Delta P_x, or, \Delta P_y, or, \Delta P_z$, which obeys the relationship $\Delta P_x.\Delta x \approx h, or, \Delta P_y.\Delta y \approx h, or, \Delta P_z.\Delta x \approx h$, according to three spatial directions. The stated above quantized texture in the box of spatial volume *V,* determine the track-texture of the *N* particles, *Sec. 8(2)3*, i.e. similarly to that of free vacuum with analogous behavior, *Sec. 5(16)3b, part B*. As the result, each of the *N* moving particle constitute a pseudo unique *H* system as in right-hand side of *Eq. 20, Sec. 7(4)2b*, along with the same characteristic given in *Sec. 7(4)2a*. In other words, between H hall packages of parent H system and its baby counterpart, *Sec.7(4)*, the equilibrium relationship $E_p.\Delta T_p = \Delta E_w.\Delta T_w \approx h$ is holding. Please refer also to *Sec. 7(4)3, E2, item E*.

Where:

- $E_p, \Delta T_p$, are total energy, and internal time interval of the particle, *Sec. 2(10)1*
- $\Delta E_H, \Delta T_H$, are energy and time according to relationships of *Eq. 7(10), Sec. 7(1),* H hall package of the particle. Please refer also to *Sec. 8(7)6*, the many particles system.

According to *Sec. 7(4)2e,* and *Sec. 7(4)2f, part A*, ΔT_p is interpreted as particle stay time in its H hall package; please refer also to *Sec. 7(4)3, E2,* for more information.

8(2)3 – Ground state and track texture of a particle

The background energy of ground state is another characteristic of the particle, e.g., electron, photon. It is a self-induced energy related to the particle axeon, *Sec. 10(8),* which is independent of the normal vacuum medium. It is misinterpreted as zero point energy of the vacuum. Factually, during collision, *Sec. 6(2)1a*, force application, *Sec. 6(2)1b*, to a mass-body at rest, a single direction motion of H particle-paths, *Sec. 2(3)1*, induced in the latter in the form of H hall packages each of path-length value h, *Sec. 9(4)7, item 15*. In case of particle, e.g. electron, from viewpoint of H particle-paths hypothesis. This single direction H particle-paths can be regarded as particle axeon of path-limit Γ, *Sec. 1(12),* and minimum path-length value h, *Sec. 5(16)3g* that surrounds a reverson as a singularity, *Sec. 7(5)3b,* nominating reverax, *Sec. 7(5)3b*, *item II*; please refer also to *Sec. 5(16)3b, part D2*. Moreover, its energy variation is quantized in a non-continuous manner; please refer to *Sec. 4(3)1, part B*. Noteworthy, the axeon is the central symmetrical axis of the particle (or molecules) from viewpoint of energy exchange during the motion of particle as linear oscillator. This axeon reveals as $h\upsilon/2$, a lowest energy level, i.e. ground state in one of its types *R & L* configuration (or conjugate), *Note 8(2)3a* and *Note 9(4)6a*. Factually, during a period of stay time ΔT_p of particle motion, according to Mirror Image Effect, the axeon is replaced by its conjugate of equal energy, and opposite direction, *Note 8(2)3b*; please refer also, to *Sec. 7(5)3b*. "The zero point energy itself does not appear in any expression. The field energy is always measured from the ground state". "One can by no means assert that the field amplitude is equal to zero in the ground state of an electromagnetic field (i.e. in the absence of quanta) [36], *section 27, Pp288-9*. Factually, the closed box volume of a rigid mass-body, according to *Sec. 8(2)2* defines the track texture of the particles inside that box. This track texture can be viewed as axeons structure of the *N* particles that take form due to mutual interaction of the particle with rigid walls of the box because of Mirror Image Effect. According to *Sec. 7(4)2b, Eq. 20,* each particle constitutes a pseudo unique H system of path-length value h, *Sec. 7(4)1*, can be to some extent refer to the returned energy of a moving mass-body in the macro-world; please refer to *Sec. 2(1)4, Note 2(1)4a,* case *II*. As a result, the attribution of zero point energy (or background) energy to the vacuum space that is considered as non closed expanding medium is not correct due to the absence of Mirror Image Effect that is governed in closed box medium. Factually, the theoretical prediction of zero point energy of vacuum space based on ground state calculation is 10^{120} more than observed one, *Sec. 5(16)3c*. Please refer also to *Sec. 5(16)3i.*

Noteworthy, based on *HPPH*, the singularity of ground state is imposed by related particle's axeon, *Sec. 10(8),* and its H hall package tunnels, *Sec. 5(9)3d, part c*, and mass-bodies reversons, *Sec. 7(5),* (or track texture) not on other entities such as zero point energy, *Sec. 5(16)3c,* of vacuum medium. "If a finite number of non-relativistic particles are moving in an infinite potential well, then the combined system has a non-degenerate ground state, regardless of the symmetry of the Hamiltonian. There is probably some sort of fancy entropic argument that you could use to get this result, if that is your thing. If the potential was bounded above, I cannot see immediately why this should create degeneracy on the ground state --- so it is plausible that the theorem holds in this case as well. Systems containing infinite systems of particles can, and often do, exhibit degeneracy in their ground state" [634]. Resuming, according to *Sec. 8(3)4b,* and stated above discussion, a system of more than one particle construct a combined track texture (or a combined H hall package tunnel, *Sec. 5(9)3d, part c*, as a singularity) related to a single ground state.

Note 8(2)3a - Supposing a hydrogen molecule, the $\lambda_d = \frac{c}{\upsilon_d}$ is the vacuum wavelength of its matterwave, *Sec. 5(6),* wavelength counterpart. It is equivalent to internal motion of H particle-paths wavelength of its bonding. In other words, according to *Comment 5(16)1c, A1,* and *Sec. 5(16)3b, D2, paragraphs V, VI,* the following relationships are holding in the media of vacuum, and mass (of hydrogen) based on *Eq. 5(67)8b,* ($a_d \cdot \Gamma_d = a_{mass} \cdot \Gamma_{mass} = c$):

$$a_d \cdot \lambda_d = a_{mass} \cdot \Lambda_{mass} \qquad 8(7)2$$

Please refer also to *Remark 2(3)1b*.
Where:
a_d, a_{mass}, Media coefficients a in vacuum, and hydrogen molecule's mass media respectively, *Sec. 7(4)3, parts A, D.*
Λ_{mass}, The wavelength of the Hydrogen axeon within its mass medium due to H particle-paths counter-current motion in the hydrogen molecule bonding
- λ_d, The matterwave wavelength of hydrogen molecule through vacuum medium

Note 8(2)3b- The track texture in a closed box related to the *N* particle in the box. This track texture define the motion of particles, *Sec. 5(16)3b, part B*, in the box. It is an intrinsic characteristic of the particles during its motion in vacuum medium. Moreover, the total path-length related to this texture is Nh; Where, h is unit of the minimum path-length value, *Sec. 5(16)3g*. Moreover, according to *Sec. 7(4)2f, part A*, a particle in an H hall package position (or state) changes its positions during stay time to an H hall package of reversed handedness, and so on.

8(3) – Particle passing through the circular aperture and double slits

8(3)1- Electron fired through the circular aperture

According to [147], in the experiment in which electron (or photon) are fired through the circular aperture one-at-time there is no need to hypothesis any sort of interference from *shadow particle* (of parallel universe). In other words, there is three possibilities as following:

I) The Airy disk can simply be described as a probability distribution of particle destination resulting from interactions of the particles with the aperture medium, *Sec. 7(4)3, part c*. The fact that size of the Airy disk is due to the size of the aperture is persuasive evidence for particle aperture interaction being the cause of the distribution that looks like an interference pattern.

II) At high energies the de Broglie wavelength of electron, become too short to diffract at the slit.

III) Based on *Sec. 7(4)3, part c*, a medium of concentric circular stationary waves (due to interaction of expandons of type R_e path-length generated at any part of the aperture with the mass medium of aperture of type L_c path-length) is taken form.

At the three cases *I, II & II*, there are a correlation between fired electron and the gun in one hand, and between electron and aperture on the other hand up to the screen (i.e. measuring device) through exchanges of H particle-paths of electron with that of gun and aperture. Thus, electron acts as a bridge between them; please refer to *Sec. 8(6), Remark 8(6)1a*, *Remark 8(7)4,* and *Sec. 8(9).*

8(3)2- Discussion

According to *Sec. 8(3)1*, and H particle-paths hypothesis:

A) Considering *case I* each neutropa cell of, *Fig. 4(4),* axeon, *Sec. 10(8)*, can randomly collide during passage of electron from aperture with its related constituting atoms of the latter and scattered regarding the quantized position of the related neutropa in the axeon.

B) Considering *case II* and dependence of radius of axeon rotation on wavelength of electron, *Sec. 3(1)2, Eq. 3(26), [Note 3(1)2a] and Eq. 3(17)2,* the interaction of electron diminished by decreasing the radius of rotation (or electron wavelength); refer also to *Sec. 4(4), Note 4(4)1.*

C) Considering *case III*, a particle during its travel within aperture medium acquire type R_e path-length, or, type L_c one accompanied by time's arrow, *Sec. 5(16)7a*, and its reversal respectively according to the texture of aperture stationary waves medium. Therefore, we encounter with time's delay of particle travel in type R_e respect to type L_c of the aperture medium structure. As a result, the type R_e expanding track textures of a particle (pilot waves, *Sec. 5(16)3b, part B*) during the passage of the latter through the aperture induce pattern of stationary waves of aperture medium. It leading to Airy disk just during interaction (or measurement, *Sec. 8(7)2*) of the particle (or particles) by the screen as detector, as if, the stationary waves pattern at aperture medium is projected on the screen, and by a far analogy to the projection of the film frame in movie on a screen. In other words, according to cases *I & II, Sec. 7(4)3, part c*, a combined texture comprising of particle track texture (particle effect) and aperture medium texture (Gap Effect) is obtained. Noteworthy, the particle track texture at the dark region related to contracting type L_c path-length has nil effect. In other means, the combined texture has an expanding type R_e characteristic at the light regions and a contracting type L_c characteristic at the dark regions, *Sec. 8(3)3*. Therefore, an electron shooting through aperture obeys a path on the combined texture (light region) randomly, *Sec. 8(7)2, part E4,* based on H particle-paths population densities on this texture, i.e. there is a higher probability that an electron passes through a path on this combined texture at higher density respect to the lower one. Resuming, this set of co-axial pilot cone surfaces, *Comment 8(3)2a*, which their apexes are on aperture medium standing waves circles of maximum amplitude, and their bases on related light circle of Airy disk pattern on the screen define the track textures. These textures have expanding type R_e path-length, and of SN_r configuration related to a particle (or particles) that is passing through aperture up to the screen. The H particle-paths population density of the combined texture defines the probability of passing the particle on a pilot track cone in light region. Similarly, adjacent to any cone of type R_e path-length in light region, there is a conjugate cone of type L_c path-length of SP_l configuration at dark region, *Sec. 5(16)11*. Therefore, in case of labeled polarized light beam, the latter cone will be cancelled *Experiment 5(16)6a*. In other words, there is nil Airy disk, or, a uniform disk of light on screen. Moreover, a particle during its travel on a pilot cone has a constant path-length value h , *Sec. 5(16)3g*, that obeys the *Eqs. 7(5), 7(10)* just at the moment of interaction (or measurement) on the screen as detector, *Note 8(3)2a*. Please refer also to *Sec. 7(4)3, C2*.

Note 8(3)2a - The source emits a particle of path-length value $+h$ of type R_e at the instant of detection. At this stage, the source receives from the detector as a mass-body a path-length of $-h$ value of type L_c at equal magnitude, and reversed handedness, *Sec. 7(4)2d*. In other words, the total path-length of source-particle-detector system from emission to detection remained unchanged. Noteworthy, at the above process, the type R_e path-length of SN_r configuration is transferred by the particle at c speed through normal vacuum (or vacuum texture, *Sec. 5(16)3b, part A*) to the detector. Whereas, at the instant of detection (or measurement) a path-length of type L_c of SP_l configuration is transferred from the detector to the source through the abstract vacuum, *Sec. 5(16)3h,* of the H hall package tunnels perforated in the normal vacuum to the detector instantaneously, *Sec. 7(4)2f, part c* i.e. superluminality, *Sec. 5(16)11,* due to contracton emission. Please refer also to *Sec. 5(9)3d, part c, Sec. 7(4)2d,* and *Sec. 8(9)* in this regards.

Comment 8(3)2a - Factually, due to expanding characteristic of the pilot cone surface, there is no sharp and smooth surface in this case. In other words, according to *Consequence 2(4)1a*, any two points *AB* on the pilot cone can be regarded as expanding, i.e. a track texture (or path) for particle travel. As a result, there is an attenuating track texture, *Sec. 5(16)3b, part B*, densities from main surface of the cone related to main trajectory of the particle of light track texture density. Noteworthy, the track texture density defines the probability of particle travel on a trajectory.

8(3)3 – Photon's diffraction track texture

The combined track texture has expanding-forwarding characteristic from the source to a measuring device, e.g. screen, and contracting-backwarding characteristic from screen, *Sec. 5(16)7g, Fig. 5(10),* to the source with the slight preference of the former characteristic, *Sec. 7(4)2e*. Factually, the interference track texture can be extending in different media, *Sec. 7(4)3,* e.g. vacuum space, *part A*, gravitational field, *part B*, slit gap, *part c*, and mass medium, *part D*, without destructive measurement. At the destructive measurement by measuring device, *Sec. 8(7)2,* e.g. screen, the diffraction track texture (or wave pattern) of measured photons is collapsed, *Sec. 8(7)2, part E2*. In the latter case, the photon acts as a particle, please refer to *Sec. 8(7)2, part D*. In other words, photon's main-body interacts with the screen. While, its wave counterpart, *Sec. 7(4)2e*, extends its track texture through media from source up to the screen at finite speed, *Note 8(3)3a*. It is concordant with complementarity principle. "The principle of complementarity state that two complementary physical observables cannot both be measured for any given particle without one measurement disturbing the other". "The application of complementarity in this case states that we cannot observe and measure the purely wave and particle-like behavior of a single photon (the particle of light) at the same time [474] *Overview*. Factually, in the Afshar experiment [146,474], the transparent lens acts as a mass medium of contracting type path-length characteristic, *Secs. 5(16)10, 11,* for transition of diffraction track texture of photon. Therefore, photon constituting of single direction H particle-paths obeys this mass medium track texture as its pilot matter wave during its transition. As a result, Afshar experiment is an example of such a transition through mass medium. Finally, the H hall packages (or cells) of the track texture of a particle acquire types R & L configurations in spatial medium during stay time interval ΔT , *Sec. 8(7)2, part E2*, successively, *Sec. 8(3)4a.*

Note 8(3)3a- The particle track texture can be regarded as a property of particle, i.e. particle wave counterpart, *Simulation 7(4)2e1*, from viewpoint of *HPPH*. A system composed as particle main-body and its wave counterpart, by a far analogy is comparable to wave function ψ , *Sec. 8(1)5*, in quantum mechanics; while, the wave function is considered as mathematical or probability wave in complex space. "We might imagine the wave function for a particle as a strange entity spreading out through the whole of space. For the double-slit experiment, we could think of this wave function as being the entity which passes through both slits at once, creating the interference pattern"[555] *The wave function*; please refer also to *Sec. 8(3)4*, *Sec. 8(1)5*, and *Sec. 8(7)2, part E*. Factually, the particle track texture can be passed from the two slits at once; while, the particle main-body choose randomly, *Sec. 8(7)2, part E4,* at equal probability one of the two paths as a pilot waves in order to pass the slits, *Sec. 5(16)3b, part B*, from viewpoint of *HPPH*. Note that, the wave function is a mathematical estimation of wave-like behavior of H particle-paths in our matter Universe based on bi-universe hypothesis.

8(3)4- Interference in double slit experiment

8(3)4a- General aspect

The common H hall package, *Sec. 5(9)3d, part c*, can be analyzed to two types R & L H hall packages separated successively by stay time ΔT of particle-medium system, *Sec. 8(7)2, part E3*. In double slit experiment, the paths (or track textures, *Sec. 5(16)3b, part B*) that the particle took through the double slits also change their handedness from type R to L and L to R successively during stay time intervals ΔT . Therefore, the handedness of the particle faced with double slits obeys this configuration during its passage on any of the two paths (or track textures) that leading to interference pattern (to be filled out by additional incoming photons), *Comment 8(3)4*. As the result, according to *Simulation 7(4)2e1*, the particle cannot be separated from its wave counterpart (or its track texture). Thus, the particle and its wave partner constitute a single object, *Sec. 8(3)4b*. The same scenario is also valid in double slit experiment during interference. In other words, during any overall stay time ΔT , the entire combined track texture, *Sec. 8(3)3, Sec. 8(3)4b*, acquires handedness reversal of its previous configuration successively in spatial medium, *Sec. 7(4)3, part A*. It has also reversed handedness configuration respect to the particle main-body within mass medium, *Sec. 7(4)3, part D*. In other means, if the entire track texture has overall type, e.g. R (or L) configuration during stay time interval ΔT_d , the particle has overall type L (or R) configuration successively up to a measurement, *Sec. 8(7)2,* of particle, e.g. on the screen in double slit experiment, *Remark 8(3)4, b1*, It is due to summation of individual wave counterpart cell configurations as in *Simulation 7(4)2e1*. Moreover, stay time interval ΔT_d in spatial medium, *Sec. 7(4)3, part A,* is equivalent to decoherence, *Sec. 8(7)1d,* time. "In a response to the argument that at short distances interactions at the screen with slits in it might be compromised by knowledge of events that occur at the location of the detector screen, Wheeler is reported to have come up with a more elaborate thought experiment"[564] *Wheeler's astronomical experiment*. In fact, according to *Note 5(16)7, g2*, and *Sec. 8(7)2, part E3*, a contracton, e.g. of type PL (or PR) is emitted at a superluminal finite speed, *Note 8(9)1a*, from the screen towards the source via the slit that the photon is passed through it. It is because of equilibrium at the instant of measurement of the particle on the screen. In other words, a retarded wave related to expandons generation of wave counterpart towards the screen is accompanied by an advanced countercurrent wave related to contracton releasing towards the source during any stay time interval ΔT ; please refer to *Sec. 5(16)3f, part B*. "According to the results of the double slit experiment, if experimenters do something to learn which slit the photon goes through, they change the outcome of the experiment and the behavior of the photon. If the experimenters know which slit it goes through, the photon will behave as a particle. If they do not know which slit it goes through, the photon will behave as if it were a wave when it is given an opportunity to interfere with itself"[564] *Introduction*; please refer also to *Experiment 5(16)6a,* and *Sec. 8(3)4b.* The former case is equivalent to contracton of type PL (or PR) emission each of there is passing via the individual path that related photon is passed before, i.e. regarded as two independents track textures of related photons. If each of the photons and related contractons profit of either paths via the slits in an indistinguishable manner the interference pattern can be established. In other means, that photons and contractons must use the track textures of each other (i.e. a combined track texture, *Sec. 8(3)4b*) in a random manner, *Sec. 8(7)2, part E4*. Based on *HPPH*, the indistinguishability depends on degree of handedness D_h , *Note 7(4)3, J1*. In other words, according to *Sec. 5(15)2d*, the H particle-paths of *SM* configuration have a D_h of zero that increases to one by splitting of *SM* configuration to SP_l and SN_r H particle-paths, i.e. no interference.

8(3)4b- Combined track texture formation

Between the double slits and screen, the combined track texture (related to interference), *Sec. 8(3)3*, can be regarded as the common path of particle *1&2* that are passing from slits *1&2* respectively. In other words, each of the particles after its passage from slits *1* or *2* obeys its travel on the combined track texture (related to particle's matter wave counterpart, *Sec. 5(6)*) as its path. As if, the single particle is passing the both slits at once simultaneously; while, the particle matter wave counterpart, *Simulation 7(4)2e1*, that is by some analogies equivalent to particle wave function, *Sec. 8(1)5*, splitting during its passage from slits 1 & 2 simultaneously. Please refer also to *Sec. 5(16)3b, part B*. By a far analogy, supposing a network of rods that has two entrances *1&2.* Any car that enters in one of the two gates has access to all of the roads of the network beyond the gates. Noteworthy, the particle prefers the track textures that have the most H particle-paths densities, e.g. main-track, *Sec. 5(16)3b, part B*. Therefore, the particle *1* chooses mostly the share of path *1* in combined path (or track texture) rather than path *2*. Similarly, the same scenario is valid for particle *2*. By increment of total energy (or total H particle-paths number) of a particle, the share of its own path respect to second path is increased, or vice versa, in the combined path. According to *Proposal 5(16)3b, D1a*, the gravitational shape of track texture in spatial medium has a mirror image conjugate within related mass medium. Therefore, the geometrical shape configuration of expandons during its emission has equivalent contractons geometrical shape of reversed handedness within particle reverson, *Sec. 7(5)3*. In case of combined track texture formation, the photon *1* (regarded as observer) of path *1* , its emitted contracton *1* must not distinguishable in both H hall package tunnels *1* (path*1*) and tunnels *2* (path *2*), i.e. when contracton *1* passing the tunnels *2*, due to existence of a specified geometrical correlation. As an example, according to *Experiment 5(16)6a*, a right-handed polarized light cannot have contribution in interference pattern with a left-handed polarized light due to their distinct geometrical behavior during their propagations. Therefore, they preserve their specified configurations. In other words, for expandons of type *1*, the contracton of type *1* or *2* must have the same configuration or indistinguishable from each other in their geometrical behavior; please refer also to *Sec. 7(4)2f, part B*. Factually, the combined track texture of interference acts as a single entity, *Simulation 8(3)4, b1*. As the result, the track texture has no specified geometrical correlation due to stable equilibrium in all over the path in different allowed directions (analogous to case of *Fig. 2(1)* in *Sec. 2(1)1a*). It is related to no preferential motion of H particle-paths in different allowed directions of paths *1 & 2* that can be combined at appropriate distance of each other in order to establish a single-track texture. In double slit experiment, by analogy to *Simulation 7(4)3, E2a*, during passage of photons from each of slits simultaneously, the photons of opposite spins and at appropriate distance of each other constitute a combined track texture as stated above as a single interference entity. The latter changes its handedness during the combined stay time $\Delta T_{w(c)}$ by analogy to decoherence time, *Sec. 8(7)2, part E2*, successively up to photon strike on the screen, i.e. a destructive measurement, *Sec. 8(7)2*. In case of non-simultaneous photon or single photon passage, the photon track texture constructs a combined track texture with track texture of previous photon within stay time interval $\Delta T_{w(c)}$; please refer to *Comment 8(3)4, b1*. Noteworthy, any track texture combination, and its handedness reversal is along with expandons emission in spatial medium and contractons releasing by the screen towards the related mass medium, i.e. source, *Sec. 5(16)7g*. Moreover, according to *Sec. 8(2)3,* and above discussion, a many particles system, *Sec. 8(7)6,* constructs a combined track texture (or a combined H hall package tunnel, *Sec. 5(9)3d, part c*). According to *Sec. 7(4)2e, part A, last paragraph*, the photon appears as particle, when its released contractons construct a distinct path within its H hall package tunnel, *Sec. 5(9)3d, part c*, in its forward direction. Moreover, the released contractons by photon in forward motion are responded by equivalent mutual contractons of detector (or screen) in backward motion. Therefore, the photon in its wave behavior choices a combined track texture path as in *Simulation 8(3)4, b1*. In other words, the combined track texture is constructed by front wave (or expandon) propagation based on Huygens Principle, *Note 5(2)1e1*. Noteworthy, the backward contractons released in the same way (or path) of forwarded path, *Note 5(16)7, g2, Fig. 5(10),* i.e. detector to the source.

Simulation 8(3)4, b1- In case of two photons *1&2* of types *R* or *L* passing simultaneously from slits *!&2*, and attributing path *1* , path *2* to slits *1&2* respectively, *Note 8(3)4, b1*, there are four simulations as following:

A) $\frac{S1}{S2}\frac{R1P1}{\quad}\frac{\quad}{L1P2}\frac{R1P1}{\quad}\frac{\quad}{L1P2}\frac{R1P1}{\quad}\frac{\quad}{L1P2}$ B) $\frac{S1}{S2}\frac{L1P1}{\quad}\frac{\quad}{R1P2}\frac{L1P1}{\quad}\frac{\quad}{R1P2}\frac{L1P1}{\quad}\frac{\quad}{R1P2}$

C) $\frac{S1}{S2}\frac{\quad}{L2P2}\frac{R2P1}{\quad}\frac{\quad}{L2P2}\frac{R2P1}{\quad}\frac{\quad}{L2P2}\frac{R2P1}{\quad}$ D) $\frac{S1}{S2}\frac{\quad}{R2P2}\frac{L2P1}{\quad}\frac{\quad}{R2P2}\frac{L2P1}{\quad}\frac{\quad}{R2P2}\frac{L2P1}{\quad}$

Fig. 8(3)4a- Schema of photon travel between double slits and the screen

Where:
- R_1, L_1, are related to photon *1* at its type *R&L* configurations respectively.
- P_1, P_2, H hall packages in spatial medium that are occupied by photons in paths *1&2* respectively.
- S_1, S_2, the slits *1&2* respectively.

As an example, the symbol $R2P1$ represents photon *2* of type R configuration in an H hall package of the path *1*. Moreover, for the reason of simplicity, the schemas $A, B, C, D,$ can be shown in matrix representation.

In above configurations, the photons main-body *1* or *2* occupying successively the H hall packages of paths *1&2* based on *Simulation 7(4)2e1*. Therefore, the combination or superposition of four configurations $A, B, C, D,$ give a formal configurations of photons propagation from slits to the screen. The H hall packages (or track texture cells) related to e.g. $R_1P_1 \& L_1P_1$ erase each other; while, the H hall packages, e.g. $R_1P_1 \& R_2P_2$ or $L_1P_1 \& L_2P_1$ fortifying each other. Any photon in a vacuum medium H hall package, *Sec. 5(16)3b, pat A* (or position) during its propagation between slits and screen can be considered in one of its states. Therefore, a photon (or particle) at a R_mP_n (or L_mP_n, $m, n = 1 or 2$) state has a stay time interval ΔT, *Sec. 8(7)2, Part E2*. At the end of the latter time interval, photon is transferred to the other H hall package or state as in *Fig. 8(3)4a* of reversed handedness of the previous one successively up to reach and impact to the screen, i.e. a measurement, *Sec. 8(7)2*. According to *Simulation 7(4)2e1*, a photon (or particle) during its transfer from a state (or an H hall package) to other one emits a WR (or WL) expandon in spatial medium. It is along with spontaneous, *Sec. 7(4)2F, part c*, PL (or PR) contracton releasing, *Sec. 8(3)4a*, within a single common *Remark 8(3)4, b1*, H hall package tunnel, *Sec. 5(9)3d, part c*, towards the mass medium, e.g. the photon source.

*Note 8(3)4, b1-*According to *Consequence 2(4)1a*, a photon during its travel chooses different paths between two points A, B ($AB \geq \Gamma_d$). Therefore, the paths **1** (or **2**) can be regarded as the photon **1** (or **2**) main track texture in spatial medium, *Sec. 7(4)3, part A*, in the *Simulation 8(3)4, b1.*

Comment 8(3)4, b1- The formation of combined track texture in case of double-slit experiment is composed of two stages as following:

1- Formation of a track texture similar to circular aperture, *Sec. 8(3)*, via particle passing from each of the slits in spatial medium between slit and screen.

2- The combination of individual track texture (*case 1*) with each other, *Note 8(3)4, b1,* in order to construct a common track texture for particles that passing through slits *1 & 2* during interference phenomenon.

Remark 8(3)4, b1- Based on *Sec. 8(3)1*, the mutual interaction of particle, e.g. electron or photon, with H particle-paths flow of the slit gap medium, *Sec. 7(4)3, part c*, of slit 1 (or 2) constructs the path 1 (or 2). Thus, the mutual combination of the two paths*1&2* giving form to the interference pattern in spatial medium, *Sec. 7(4)3, part A*, i.e. arrangement of track texture cells in the spatial between slits and screen as a single entity. Factually, the two paths *1&2* are terminated to a single common H hall package tunnel towards the mass medium (screen) and ultimately to the supermassif black hole of the host galaxies and clusters, *Sec. 5(7)8*. In other words, the four possibilities A, B, C, D in *Fig. 8(3)4a* terminated to a single common H hall package tunnel. Noteworthy, any particle sharing a combination of paths, e.g. *R2P1, R1P2*, related to a common H hall package tunnel in four cases A, B, C, D, i.e. in *R2P1*, the particle nominating 2 of type *R* configuration profits of common H hall package of particle nominating *1,* (related to path 1) or vice versa in case of *R1P2* as a unique H system, *Sec. 8(5),* constituting of all of the possible track texture cells in the four cases. Please refer also to *Sec. 5(16)7g, Fig. 5(10),* in this regards.

Factually, any particle sharing a combination of paths, e.g. *R2P1, R1P2*, related to a common H hall package tunnel in four cases *A ,B, C, D*, i.e. in *R2P1*, the particle *2* profits of common H hall package of particle *1*, or, vice versa in case of *R1P2*. Factually, the two paths *I & II* are terminated to a single common H hall package tunnel towards the mass-medium of the screen and ultimately to the black hole of the host galaxies and clusters, *Sec. 5(7)8*. Generally, the four possibilities *A, B, C, D,* in *Fig. 8(3)4a,* are terminated to a single common H hall package tunnel. Please refer also to *Sec. 5(16)7g, Fig. 5(10),* in this regards. As the results:

The particle, e.g. electron, takes advantages of all of the track texture cells of two paths *I & II*, during passing the double slit at a probable manner.

The spatial medium, *Sec. 7(4)3, part A*, between double slit and screen contains the possible track texture cells of the two paths *I & II* due to interference.

According to *Fig. 5(10)* during striking of particle on the screen the particle path during particle travel in spatial medium and the slit that particle is traveled will be identified due to contractons releasing from particle to the screen within related H hall package tunnel accompanied with reciprocal contracton releasing by the screen, *Sec. 5(9)3d, part c*, i.e. a measurement along with irreversible path-length, *Sec. 2(4)4b*, or time's arrow, *Sec. 5(16)7g*.

According to *Sec. 9(4)7, item 15*, there is merely two track texture cells on a ground state analogous to states of the minimum path-length of reversed handed types *R&L* configurations related to electron before striking due to entrance to a different medium, i.e. from spatial medium to mass-medium (screen) related to $n = 1$, *Sec. 7(4)3.* In other words, in this case the track texture cells are diminished merely to two types *R & L* configurations on the screen. Thus, electron is merely in one of its type *WR* or *WL* track texture cell at its expanded mode, *Sec. 8(7)2, part G*, of half the energy $\frac{1}{2} h\upsilon$.

Based on *Simulation, 7(4)2e1,* the single accelerating charge emits electromagnetical *WL & WR* expandons, *Sec. 4(3)1, part c* successively. Moreover, two like or non-like charges during their interaction in spatial medium emit *WL & WR* expandons successively related to electromagnetical waves that differs from each other by related spins.

8(3)4c- Decoherence of combined track texture by thermal emission of photons

According to *Sec. 8(7)2, part E2*, a particle at any of its stay time interval is merely in one of its states. The transfer of a state to other ones is along with expandons and contracton generation, Please refer to *Simulation 3(1)2a*. Similarly, in case of molecules, especially molecules of sufficient complexity, the transfer of a state to the other state, e.g. vibrational, during stay time interval may be along with escape of thermal photon from the molecule H system. According to S*ec. 7(5)3c, part B,* it is leading to completeness of an interaction, i.e. decoherence, *Sec. 8(7)1d,* due to apparent wave function collapse. In other words, the interference pattern is interrupted at this stage or is shifted to a weaker one**.** "Large molecules are particularly suitable for the investigation of the quantum classical transition because they can store much energy in numerous internal degrees of freedom; the internal energy can be converted into thermal radiation and thus induce decoherence". "All large objects, but also molecules of sufficient complexity, are able to store energy and to interact with their environment via thermal emission of photons". "The energy in molecules may be equilibrated in many internal degrees of freedom during the free flight, and a fraction of the vibrational energy will eventually be reconverted into emitted photons. Therefore, the internal dynamics of the molecule is also relevant for the quantum behavior of the centre-of-mass state". "Decoherence by emission of thermal radiation is a general mechanism that should be relevant to all macroscopic bodies"[568] *Introduction*.

8(4) - EPR Paradox

Considering, a pair of isolated coupled particles, as in, *Example 4(7)1*, *Figs. 4(15) a, b*; *Sec. 8(9), Fig. 8(1),* whose quantum spins cancel out. As they are paired, they have a combined Schrödinger wave equation; thus, by measuring the spin one of the particles, e.g., spin up electron, that wave function (as formulated by John von Neumann) will be collapsed, *Sec. 8(1)4,* and affect the spin of the other, e.g., spin up positron, instantaneously*, Sec. 7(4)2f, part c*. "It appears that a measurement in one place have an instantaneous effect on something that may be light year away"[74]; i.e. non-locality, *Note 8(4)1.* In other words, from viewpoint of this article's model theory, the H particle-paths of the coupled particles Axeons, *Sec. 10(8)*, made a correlation between them independent of the distance that can separate these pair of particles. Therefore, we have a unique H system, *Sec. 8(5),* of a coupled of particles, the H particle-paths of them exchanges similarly as in, *Fig. 9(2).* Thus, we can not separately look to a particle independently of the other one, as in a discussion held in the framework of *EPR* paradox [74], based on the Einstein, Podolsky and Rosen *(EPR) gedanken* though experiment[75]. In other words, we have a pair of particles that cannot be treated as separate. In fact, H particle-paths mutually exchange between two particles at c speed regardless of the attenuation effect due to separating distance, *Note 8(5)1.* Therefore, we can not specified a point-like local or position to each of this pair of particles due to their extended wave-like structure as in, *Fig. 4(4),* in this respect from viewpoint of H particle-paths hypothesis. The non-locality is confined to the order of magnitude of H hall quantized package, *Sec. 5(16)3a,* i.e. Γ path-limit, *Sec. 1(12);* contrary to unlimited wave extension from $x = -\infty$ to $x = +\infty$ in space, *Sec. 7(3)*. In other words*,* there is $\Delta x \approx \Gamma$ instead of $\pm\infty$ within Heisenberg uncertainty relationship, *Sec. 7.* Factually, the wave function relating to this two-particles H system is confined to path length unit, Γ, i.e. *wave packet*, that collapsed by an interaction due to e.g., detection, *Remark 8(4)1*. In other words, the counter-current forward and backward motion, *Sec. 3(1)2,* of H particle-paths of this unique H system, *Sec. 8(5),* is occurred and connectivity between two particles is interrupted by the detection.

According to experiment performed by *Freedman-Clauser,* nominated *FC experiment* [179]; here, excited calcium atoms provides pair of photons, assumed to be emitted back-to-back; they must be in identical states of circular or linear polarization. "For this reason the *SV* [state vector, *Sec. 8(1)3*]*,* of the two photon system permits the photons to be in any polarization state provided only that both are in the same state"[156], *Part 2.4.1.* From viewpoint of H particle-paths hypothesis, the two photons, i.e. type *R* and type *L*, systems constitute a unique H system. In other words, the two single directions H particle-paths of the photons, *Sec. 4(4),* superimposed, e.g., schematically superimposition of *Fig. 3(4)a* and its mirror image, *Sec. 6(2)3,* at opposite directions. Therefore, the negapas and posipas of the two photons unique H system can be visualized in a counter-current mode of motion, *Sec. 3(1)2,* at c speed along with one-dimensional extension of that system, *Note 8(5)1*; moreover, the extent of this correlation must be fined experimentally rather than conceptually or theoretically. "Only when at least one of the two photons detected is the *SV* allowed to collapse into a definite state of polarization of the photons must remain in states which are connected but not specified, in a way which is inconsistent with locality"[156], *part 2.4.2*. Therefore, through the unique H system assumption the instantaneous state of the non-detected photon can be interpreted, *Comment 8(1)3b*; please refer to *Sec. 8(7).* Remarkably, according to H particle-paths hypothesis the subtleties of *EPR paradox* based on the fact of time's arrow, *Sec. 5(16)7a,* reversal aspect derived from uncertainty principle as one of the principal laws of nature that is not considered in *SRT* at macroscopic scale leading to misinterpretation such as faster-than-light or superluminal motion. Please refer to *Sec. 2(6); Sec. 5(16)9b, Secs. 7(1), 7(5).*

Note 8(4)1- " This spooky action at a distance, according to Albert Einstein and two colleagues, was a direct result of quantum mechanics if it failed to have more classical underpinnings"[219].

Remark 8(4)1 – We cannot obtain knowledge of the position of the particle without changing its wave function (Standard quantum mechanical collapse). This changing wave function leads to changing particle velocities leaving a disturbed system. The best example of this is the diffraction at a slit: the smaller the slit (i.e. better we try to get the initial position in the slit), the wider the scattering [340], *Section 2*. The latte is coincided accord to H particle-paths hypothesis the disturbance of H hall package, *Sec. 5(16)3a*, by environment to reach a newer one according to *Sec. 7(4).*

8(5)-Unique H system

An isolated fundamental particle has an individual H hall quantized package, *Sec. 5 (16)3*, and path-length h, *Sec. 5(16)3g*, nominated an H system, *Sec. 1(6),* that is extended through it up to path-limit Γ, *Sec. 1(12)*. As an example please refer to *Sec. 4(3)1, Part B, Fig. 4(4)*; similarly, a pair of isolated entangled particles also has an individual H halls package, nominated a unique H system, i.e. an entangled state according to Schrödinger, *Remark 8(5)1, part A*, along with a Unique wave function. In fact, in an isolated H system the H particle-paths of its ingredients, e.g., as here a pair of particle, are in an counter-currency mode of motion, *Sec. 3(1)2*, i.e. H particle-paths mutually exchanging, *Sec. 8(4),* at c speed between the particle couple within a path-limit, Γ, *Sec. 8(7)*; please refer to *Remark 8(5)1, part B.* The correlation between two particles is broken when one of them is going out of H system, e.g., absorbed by a photographic paper, *Sec. 8(6);* thus, we have the other particle, i.e. non-absorbed one, with its related H hall quantized package. In other words, if at each stage, we corrupt this connectivity through detection or observation, we can find the present position of the particles, i.e. the reality is created merely by act of observation. Alternately, if the pair of particles taking distance from each other, the counter-current H particle-paths connectivity between them is attenuated until zero. Therefore, during the separation the overlapped H hall quantized packages of them are separated accordingly at the end stage, i.e. far enough and each particle has its own H hall quantized packages, i.e. two separated H systems, each of path-length value h. In fact, during this separation space expand from one H hall quantized package to two ones, *Sec. 5(16(3), Eq. 5(70)3*, and related time's arrow generation, *Sec. 5(16)7a*, i.e. going forward with the time, or, better to say path-length, *Sec. 2(1)2*, generation. Similarly, space contraction, i.e. H hall quantized packages overlapping is accompanied by the reverse process, i.e. going backward in time, *Example 5(16)7a1*. To have an estimation of a unique H system; please refer to *Sec. 4, Example 4(7)1.*

There is also a special case of unique H system, e.g., intermediate state of absorbed photon by an electron at exited state that is nominated as pseudo unique H system, *Sec. 7(4)2b, Eq. 20*. It has a lifetime of the order of ΔT of the excited state. Please refer to *Sec. 5(16)8c* in case of sub-unique H system.

Remark 8(5)1:

A) The unique H system of a pair of particle has a unique H hall package. According to this uniqueness, there is an indistinguishability respect to the related particles (that are regarded as point-like). To this unique H system, one can refer a unique wave function the square of its amplitude is equivalent to the H particle-paths population density based on H particle-paths hypothesis. Factually, in this unique H system there are counter-current H particle-paths that can be described a unique wave function. In other words, through the unique H system the particles (and their position) are substituted by density flow of H particle-paths, thus make their indistinguishable; please refer to *Secs. 8(7)6, 8(9).*

B) Factually, through multiplication, addition, subtraction, etc. of supposed individual wave function one can simulates the single wave function of the particles with a proportionality factor, i.e. renormalization constant. As an example please refer to [352], *section2*. Moreover, the single wave function of physical system must obey the Schrödinger equation that is equivalent to counter-current mode of motion, *Sec. 3(1)2,* of H particle-paths in physical space of *3* dimensions.

In fact, an isolated ensemble of correlated particles can be regarded as a unique H system, i.e. a single wave function. In other words, this ensemble can be visualized as a distribution of H particle-paths within the whole space. "Is there a separate wave function for each particle? NO!, there is a single wave over the entire configuration space which is not what one expect intuitively, but it is the most general approach mathematically"[344], *section 1.*

8(6) - An interpretation based on right-and left-handed H particle-paths

8(6)1 – Preliminary step

During a measurement, *Sec. 8(7)2,* the unique H system *(AB)*, *Sec. 2(4)1, Note 2(4)1b,* of pair of particles is interrupted or collapsed, *Note 8(6)1a*. Thus, an alternate unique H system *(BM)* with a common H hall quantized package, *Sec. 5(16)3a,* is created by the contribution of measured particle *(B)* H system, *Sec. 1(6),* and the measuring device *(M)* H system, through equilibrated exchange of their related H particle-paths, *Sec. 8(6)2*. By the way, to any of stated above H systems, we can specify wave equation. In other words, according to the above statements:

$$(A \Leftrightarrow B)\cdots\cdots M \rightarrow A\cdots\cdots(B \Leftrightarrow M) \qquad \textit{Remark 8(6)1a} \qquad 8(8)$$

Symbol ⇔ means mutually H particle-paths exchange in a unique H system, *Sec. 8(5),* at equilibrium state; **. . . . . .** represent receding or approaching correlated H system to other one though flow of H particle-paths. Moreover, to each component of, *Eq. 8(8),* related a mixed quantum H hall quantized package related to pseudo unique H system, *Sec. 8(5),* as a quantum state from viewpoint of quantum theory, *Sec. 7(4)2b, Eq. 20*. As a result, the wave function of a unique H system, e.g., correlated (AB) is collapsed. It is accompanied by formation of an alternate wave function in the newly defined unique measuring H system, e.g., *BM* that preserve its correlation with escaping *A*, or, better to say we encountered with an simultaneous interchanging rather than wave function collapsing and formation independently, *Remark 8(6)1a*. During such a process such as, *Eq. 8(8),* the path-length is conserved, *Secs. 2(1)2*. Besides, according to *Sec. 5(16)9,* during any reaction or interaction *type R* or *type L* conserved, i.e. if the interacting components are right-handed dominant, the resulting components are right-handed dominant and vice versa. Moreover, the same thing is valid also for, *Eq. 8(8),* in *A* or *B* measurement (e.g., spin up or spin down) by *M*, i.e. measuring device. "Given the constraints on property ascription posed by Koshen-Specker theorem, one might argue that we do need to select a preferred basis in order to have any significant set of physical properties determinate"[155], *part 5*; therefore, the type conservation may acts as a physically preferred basis in this context.

As mentioned in, *Sec. 7(1),* last paragraph, ΔT, in *Eq. 7(10),* means the maximum time interval that an H system can stay in a position, e.g., an H hall quantized package; thus, it must transfer to the next position during this time tolerance interval, e.g., another H hall quantized package. Remarkably, by a far analogy the process, *Eq. 8(8),* can be compared to a substitution organic chemical reaction through valence electron of initial components, i.e. *A-B* and *M*; the H particle-paths according to *Sec. 9(2), Fig. 9(2),* interchanging between electrons of chemical bonding. In other words, compound *B-M* is formed simultaneous on the expense of compound *A-B* consumption through an intermediate compound $A\cdots B\cdots M$ state, *Sec. 8(7)2*; where **...** represent chemical and intermediate partial chemical bonds respectively. To shift a chemical reaction to the right side, i.e. reaction completeness, *BM* (or *A*) must be out of reach of *A*, (or *BM*) e.g., by precipitation of *BM,* or, exit of *BM* in the form of gas from the reaction mixture; please refer also to *Comment 5(16)6a,* and *Sec. 5(16)8,* in case of equilibrium.

Note 8(6)1a- According to *Sec. 8(9)*, the correlation of a pair of particle *AB* is through the emitter Source (*S*), i.e. *ASB*, due to the effect of inertia (or mass) of the source as a mass-body. Similarly, the effect of inertia of measuring device (*M*) must be considered. Therefore, in a system that acts as both emitter, and measuring device, e.g. the Earth's lab, the correlation of the pair of particle instead *ASB* can be simplified to *AB* due to same inertia of source and measuring device (detector). Please refer also to *Sec. 8(9)3* in this regards.

Remark 8(6)1a - Alternately, according to H particle-paths hypothesis, at all the time, there is a correlation between *A, B, M*. In other words, H system *B* is approaching to *M*; whereas, *B* is getting away from that. Therefore, there is an space contraction accompanied by time arrow reversal in the former case, i.e. path-length reduction and an space generation along with time arrow in the latter one, i.e. path-length generation. As a result, the H hall package *A* is correlated with that of *BM* through H particle-paths interchanging as escaping particle *A* from *B* (or *BM*). "According to Bohr each *quantum phenomenon* posses an element of wholeness, in the sense that experimental conditions determined by the measuring instrument constitute an indivisible whole" [364], *The Copenhagen (orthodox) interpretation*.

8(6)2 - H particle-paths interchanging

8(6)2a - General aspect

Considering a unique H system, *Sec. 8(5),* e.g., *BM*, through contribution of initially two individual H systems and mutual exchange of H particle-paths, *Note 8(6)2a1*, between *B* and *M*, *Sec. 8(6)2b*. The connectivity between *BM* is performed through e.g., emitted right-handed negapa from *B* to *M* and mutually reflection of its left-handed posipa conjugate, *Sec. 8(1)2,* according to *Secs. 5(16)9, 6(2)3,* and, vice versa. In fact, negapa and posipa are conjugate of each other, or, in other words, by inversing the axis of emission of negapa and its related time coordinate, *Sec. 5(16)9b,* its mirror image, i.e. posipa can be obtained or vice versa. Factually, negapa in our type *R* Universe, *Sec. 5(16)9a*, accompanied by time's arrow, *Sec. 5(16)7a*, and posipa along with reversed time's arrow; please refer also to *Sec. 8(1)2, Comment 8(1)2a*. In fact, it is better to say the preference of negapa over posipa, or, posipa over negapa in these cases.

On the basis of Wheeler-Feynman [159], Cramer, proposed the transactional interpretation of quantum mechanics (*TI*), which has analogy somehow to the above statements and *Secs. 8(4), 8(5),* as an alternate to Copenhagen interpretation. "The basic element of the transactional interpretation is an emitter-absorber transaction through the exchange of advance and retarded wave as first described by Wheeler-Feynman"[156], *part 3-1*. Remarkably, the H particle-paths hypothesis is the only one assumption that introduces handedness in these kinds of interpretation. "For example, solid entanglement with even a single atom will completely erase the photon's phase. In light of this result, it is a marvel that interference experiment is possible at all! Consider the photon in path $a1$ interacting with a mirror containing trillions upon trillions of light- responsive atoms. As it bounce of this mirror its phase will be completely destroyed if entangles (even in a non-destructive manner) with just one of the many myriads of mirror atoms Mirrors are truly marvelous (as are lenses) in that they are macroscopic objects that can strongly interact with and change a photon's state of motion without slightest hint of entanglement". [346] *Decoherence*. Factually, in this example, the type *R &L* Universes acts at equal probability without the disturbance of entanglement before reflection, merely through interchanges of their negapa and posipa with that of pair of photon.

Noteworthy, during reflection the H hall package of photon pair remains intact during these interchanging that is based on Mirror Image Effect, *Sec. 6(2)3.*
The H particle-paths exchanging process are performing through two main ways, one with no effect on entanglement, *Sec. 8(6)2b*, and other affecting entanglement, *Sec. 8(6)2c*.

Note 8(6)2a1-"We cannot measure anything in Nature without an energy exchange that tells us something has happened". "We cannot accept any statement about the measurement of a natural event unless we verify the energy exchange that allowed it."[501] *Understanding Energy Exchange.* Factually, The H particle-paths transfer is equivalent to its energy transfer.

8(6)2b – H hall package interchanging with no effect on entanglement

Based on discussion held on *Sec. 2(4)1, Sec. 2(4)2b, Sec. 5(16)3a,* and *Sec. 7(2).* The mutual exchanging of H particle-paths of two individual H systems are performed through H hall package, *Sec. 5(16)3a*. It is related to force applying, collision, impact, and light reflection by mirror and light passing through dense medium, glass, etc, in which H hall packages interchanging are occurring as a whole, thus, no effect on entangled particle; please refer to *Sec. 8(6)2a*.
In case of equilibrium number of H hall packages are exchanging between the two H systems in a correlated, *Sec. 8(7),* manner. In other words, the equilibrium is broken, whereas correlation is preserved, when:
I) The total number of exited H hall package is more than entered one; therefore, it is accompanied by space expansion and time arrow, *Sec. 5(16)7,* i.e. path-length increment.
II) The total number of exit of H hall package is less than entered one; thus, it is accompanied by space contraction and time arrow reversal, i.e. path-length diminution. Generally, speaking, in our matter Universe, the expansion, *case I,* is dominant respect to contraction, *Sec. 5(16)1b, part A,* Moreover, during an interaction the excess of H hall package in the *case I* respect to equilibrium state is linked to the vacuum texture, *Sec. 5(16)3b*, or, correlated with other mass-body (or vice versa). Please refer to *Sec. 5(2)1b, Fig. 5(2).* Noteworthy, any H hall package increment is equivalent to entropy increasing (or vice versa), *Secs. 5(16)9c, d*.

8(6)2c – Interaction affecting entanglement due to measurement

This section is related to separation (or elimination) one of the conjugate in the equilibrium stage related to indistinguishability, e.g., left- or right-handed configuration, *Example 8(9)1a*, of H hall package that is engaged with measuring device as following:
I) Measurement or detection of one of the pair of entangled particle, *Secs. 8(4), 8(7),* by measuring device
II) Electromagnetic interaction of charged particles, *Sec. 4(3).*
III) Photon absorption by atoms and molecules, *Sec. 9(3)1.*

8(7) - Entangled pair of particles

8(7)1 – General aspect

8(7)1a- Between pair of particle

A system of correlated pair of particles, *Comment 8(7)1a1,* extent as long as their unique H hall quantized package, *Sec. 5(16)3a*, and *Sec. 8(7)2*. In other words, at each part of H hall quantized package during its extension before measurement we encountered with counter current H particle-paths of entangled pair of particles, e.g., photons, *Notes 8(7)1a1*, *a2* within path-limit, Γ, *Sec. 1(12).* Therefore after the measurement process, *Sec. 8(4),* the counter-currency is interrupted and the second particle continues motion in a single direction mode at opposite direction, *Figs. 3(4)c, a*. As a result, no separation between H particle-paths of the pair is allowed before any measurement, i.e. a unique H system. Considering [182], *part11, conclusion* "A pair of entangled photons must be considered a single global object, that we can not consider as made of individual objects separated in space-time with well defined properties". Moreover, according to [177], "The experimental violation of Bell's inequalities ([178]) confirms that a pair of entangled photons separated by hundreds of meters be considered a single non-separable object-it is impossible to assign local physical reality to each photon". "It is worth emphasizing that non-separability, which is at the roots of quantum teleportation does not imply the possibility of practical faster-than-light communication"[177]. According to the above discussion there is no causality violation on the basis of H particle-paths hypothesis in this regard, *Sec. 8(9)*; please refer also to *Example 8(7)1a1, a2.* Noteworthy, entangled pair production is based on Mirror Image Effect, *Sec. 6(2)3a*.

Example 8(7)1a1
A) When an entangled pair of photon is emitted by a source on a massif mass-body (e.g., Lab in the Earth) and the latter acts as a detector, a measurement is taken place. By the way, the wave function of the correlated pair is collapsed according to quantum theory; whereas, H particle-paths has an alternate viewpoint, *Sec. 8(6), Remark 8(6)1a*, the detected photon and the lab constitute a Unique H system, i.e. a unique wave function. In other words, the initial wave function of the lab because of its massif mass is already unaffected by this measurement, i.e. the effect is negligible. Moreover, the correlation between lab H system and the second photon is established due to decoherence, *Sec. 8(7)1d*. In this example, the system is the pair of photon and the environment or measuring device is the lab.
B) Now considering the emitter source (*S*) is a satellite that rotates around the Earth (lab) and the latter acts as detector. A similar case as in the case *A* is occurred, by the difference that the correlation of second (unaffected one) is established between the center of mass of Earth-satellite instead of the Earth. The center of mass because of low mass of satellite respect to the Earth is coincides with the center of gravity of the Earth. This effect is equivalent to time dilation as in satellite respect to the Earth. Noteworthy, the converse is not true, i.e. the clock rate of the Earth respect to satellite. Please refer to *Sec. 2(6)2b*, according to which the true time evolution must be performed respect to inertial *CMPRF*, i.e. the center of mass reference frame of a system constituted of mass-bodies and particles.

Example 8(7)1a2 - As an example according to *Sec. 4, Example 4(7)1,* and referring to *Fig. 4(14)a*, a spin down electron is entangled with up positron or vice versa, i.e. *Fig. 4(14)b*, e.g., neutron pion decay, that are reversed handedness of each other. Please refer also to *Sec. 3(1)1, Note 3(1)1c, Eq. 3(17)1, Note 3(1)2b, Eq. 3(27),* free discussing on electron spin. According to [235]," The electron actually, exists in both states until you measure it to see which state it is in. The interactions of your measuring device causes one of the probability functions to collapse leaving just a spin either up or spin down electron. In fact posipa is the time's arrow reversal of negapa and vice versa, or, in other words, there is an equilibrium between left and right-handedness of H particle-paths at each instant related either to one of the types up or down spin, that is broken randomly through measurement (or detection*, Sec. 8(7)2*); please refer to *Secs. 5(16)7, 9b*; *Sec. 8(9), and Sec. 8(7)2, part E4.* According to above statements, we concluded that in a unique H system of entangled pair, the posipas (or negapas) are in the same direction and vice versa. In other words, the right-handed (negapa) and left-handed (posipa) H particle-paths are in counter-current mode of motion as in case of a single particle, i.e. a single quantum state for two particles, *Sec. 8(9)1,* and *Note 8(7)1a2.* Factually, at this case before measurement, *Sec. 8(6),* the concept of propagating entangled pair of photons at opposite directions must be replaced by pair of photon H hall quantized package expansion regarding uncertainty principle, *Sec. 7(1), Eq. 7(10),* i.e. space expansion along with time's arrow, *Sec. 5(16)7a*, (or, path-length expansion). According to [219]," Dr. Polzik, E., team of Aarhus University in Denmark have entangled two large clusters of cesium atoms in a pair of glass containers a few millimeters apart by using a single laser beam. From view point of H particle-path hypothesis this two clusters of atoms can be considered as a unique H system, *Sec. 8(5).*

Note 8(7)1a1- A unique H system, *Sec. 8(5)*, of a pair of entangled photons or particles of rest mass due to the counter-currency of its internal H particle-paths can be viewed analogous to an H system at rest respect to the lab reference frame, i.e. zero total momentums of center of mass of external motion, *Sec. 1(3).* According to [181], *part 1* "the sum of the particles' momenta (with eigenvalue 0) is well defined, as is the difference of their positions" (with eigenvalue of k as a constant). Moreover, according to [181], *part 3,* " Due to entanglement, the sum of the two photons' energies is extremely well-determined; thus, the sum of their energies and the difference of their arrival times can be simultaneously known from high precision, though the absolute time of emission is unknown. This is to be contrasted with the case of the single particle, whose time and energy may not be known to arbitrary accuracy due to the uncertainty principle". Therefore, according to H particle-paths hypothesis, the difference of two entangled particles lies within, Γ, *Sec. 1(12),* path-limit, i.e. $k \leq \Gamma$ According to [183], *EPR* correlation have been observed with photons propagating in ten kilometers of commercial telecommunication fiber; thus, k is more than *10Km*".

Note 8(7)1a2- Considering, *Sec. 8(9)*, the center of mass of entangled particles are at rest respect to the lab; at the case of a moving source at v speed respect to the lab reference frame, i.e. preferred reference frame *CMPRF, Sec. 2(6)2b*. The source can be considered as locally fixed reference frame, *LFRF*, *Secs. 2(6)2c, e*; therefore, the law of motion of the entangled pair obeys based on the above statement as one of the results that can be obtained considering H particle-paths hypothesis.

Comment 8(7)1a1- According to *Proposal 5(2)1a1*, any particle of the pair has a reverson, *Sec. 7(5),* through its mass medium, *Sec. 7(4)3, part D*, of *T*-symmetry, *Sec. 8(3)3,* related to inertial characteristic of the particle mass. Noteworthy, according to *Sec. 7(4)2e*, each pair of particle has a matter wave, *Sec. 5(6),* counterpart, i.e. expandon in spatial medium, *Sec. 7(4)3, part A*, that is along with its contracton conjugate through particle's mass medium. It is related to gravitational characteristic of the particle mass that is linked to spatial expansion and time's arrow, *Sec. 5(16)7*, in spatial medium.

8(7)1b- In subsystems of a single particle

According to [497], there is entanglement in a single particle, e.g. neutron. "We report an experiment of single-neutron interferometry to show the violation of a Bell-like inequality. There contrary to the conventional experiments with entangled particle pairs, the entanglement is accomplished between different degree of freedom in single part, i.e. the entanglement between the spinor part and the spatial part of the wave function" [497 *Introduction*. "In the manipulation, the important parameters are the relative phase χ between the two beams and the spinor rotation angle α . To show the capability of our manipulation, we measure interference oscillations for two-level systems in the (neutron) interferometer; one for a spatial, i.e. path and the other for spinor"[497] *Experiment*. :It is worth noting the entanglement is not limited to different particles but generally applicable to different subsystems, thus a correlation between variables in single particles being also expected" . "The measurement results for the spin and path polarization are correlated due to the fact that subsystems in single neutron are entangled" [497] *Discussion*. Referring to *Sec. 3(1)2a*, according to path-constancy, *Sec. 2(1)2*, the total path of electron at rest, and total path of moving electron have a constant value and depends on electron spin that can be revealed during an interaction (or detection). Any spin orientation α has an equivalent path variation χ through spatial medium. In other words, supposing the total number H particle-paths of neutron particle is N . Therefore, according to path-constancy, the total path variation χ related to spin orientation α as following:

$$N\alpha \int_0^R dr = N\alpha R = N\Delta x = \chi \qquad 8(8)1$$

Where:

- R , can be regarded as an average value proportional to effective radius of the particle
- r, The distance from the center of mass of the particle
- Δx, The path variation per an H particle-path of total N ones. According to *Sec. 5(9)3d, part A*, the path-length in spatial medium at two opposite direction has two opposite signs that eliminate each other. Therefore, the path-length related to angle from

0 to π is at opposite sign of π to 2π, and so on. Therefore, path χ has similar co-direction periodicity as angle α as in *Eq. 8(8)1*. Supposing the latter takes random values during diction (or measurement, *Sec. 8(7)2*), the total path χ during an appropriate time interval has zero value. "The expectation value $E'(\alpha,\chi)$ in terms of beam polarization as frequently used in neutron optics: The condition polarization together with the path and the spin polarizations. These polarizations vary from -1 to +1". "The value E' can not be factorized as:

$$E'(\alpha,\chi)=\cos(\alpha+\chi)\neq\cos(\alpha).\cos\chi=P^{S}(\alpha).P^{P}(\chi) \qquad 8(8)2$$

Although $\hat{P}^{S}_{\alpha;;\pm1}$ and $\hat{P}^{P}_{\chi;\pm1}$ commute with each other"[497] *Discussion*.

8(7)1c- Correlation from view point of H particle-paths hypothesis

Referring to *Sec. 8(7)1b,* according to *Sec. 5(16)11*, any contracting path-length variation of type L_c within mass medium of SP_l configuration related to spin orientation angle α is along with expanding type R_e path-length variation of SN_r configuration in spatial medium due to path shift χ of equal magnitude and opposite signs. The expandons (or an expanding group of H particle-paths) in spatial medium is correlated via common H hall packages, *Sec. 5(9)3d, parts C, D*, to the reverson, *Sec. 7(5),* of the related mass medium trough spontaneous, *Sec. 7(4)2f, part c*, contracton transfer to the reverson. The similar scenario is also valid in case of entangled pair of particle through contractons transfer by the both particle to the source regarded as mass medium. In other words, according to *Simulation 7(4)2e1*, the $WR\,\&\,WL$ expandons emission in spatial medium, *Sec. 7(4)3, part A,* by particles are along with $PL\,\&\,PL$ contractons transfer to the mass medium, *Sec. 7(4)3, part D,* of the source.

8(7)1d- Decoherence

"Decoherence is the mechanism by which the classical limit emerges out of a quantum starting point and it determines the location of the quantum-classical boundary". "Decoherence can be viewed as the loss of information from a system into the environment (often modeled as a heat bath)"[326] *Introduction*. Please refer also to *Remark 5(16)3b, B2,* in case of irreversibility. "Any elements that decohere from each other via environmental interactions are said to be quantum entangled with the environment. The converse is not true: not all entangled states are decohered from each other. Any measuring device or apparatus acts as an environment since, at some stage along the measuring chain, it has to be large enough to be read by humans. It must possess a very large number of hidden degrees of freedom. In effect, the interactions may be considered to be quantum measurements. As a result of an interaction, the wave functions of the system and the measuring device become entangled with each other"[326] *Mechanism (phase space picture).* "Today, the decoherence program studies quantum correlations between the states of a quantum system and its environment. But the original sense remains, decoherence refers to the untangling of quantum states to produce a single macroscopic reality"[326] *Introduction*. "However, decoherence by itself may not give a complete solution of the measurement problem, since all components of the wave function still exist in a global superposition. To present a solution to the measurement problem in most interpretations of quantum mechanics, decoherence must be supplied with some nontrivial interpretational considerations"[326] *Measurement*. Please refer also to [343], *Example 8(7)1a1,* and *Sec. 8(7)2.* Noteworthy, "Decoherence does not provide a mechanism for the actual wave function collapse; rather it provides a mechanism for the appearance of wave function collapse. The quantum nature of the system is simply "leaked" into the environment so that a total superposition of the wave function still exists, but exists — at least for all practical purposes— beyond the realm of measurement"[326] *Interpretation of quantum mechanism.* "The role of a measurement is to convert quantum states and quantum correlations (with their characteristic indefiniteness and malleability) into classical, definite outcomes. Decoherence leads to the environment-induced superselection (einselection) that justifies the existence of the preferred pointer states. It enables one to draw an effective border between the quantum and the classical in straightforward terms, which do not appeal to the “collapse of the wave packet” or any other such deus ex machine"[552] *Decoherence in quantum information processing.* "Decoherence is a consequence of inevitable coupling of any quantum system to its environment (or bath), causing information loss from the system to this environment."[584] *Introduction*. According to *Proposal 5(7)3a*, the contractons information transfer to the supermassif black hole. Noteworthy, any expandon emission by a particle in spatial medium (environment) during stay time interval ΔT_P is leading to contracton release by particle to the black hole, *Sec. 5(7)8*. "Decoherence destroys superpositions. The environment induces, in effect, a superselection rule that prevents certain superpositions from being observed. Only states that survive this process can become classical"[552] *Quantum theory of classical reality*.