Part 3f- Time

5(16)7- Arrow of time

5(16)7a- General aspect

"One of the most obvious and compelling aspects of the physical world is that it has an *arrow of time*, certain process (such as breaking of glass or burning fuel) appear all the time in our everyday experience, but the time reverse of these processes are never seen "143] *part 1, introduction*. Considering *Sec. 5(16)3a,* discussion; the backward process, i.e. H particle-paths accumulation along with normal space contraction during time reversal is factually impossible in the phenomena such as based on thermodynamics' law; since entropy or disorder always increase with time. In other words, to reach the backward process the H hall quantized packages generated during an expansion somehow must be overlapped to a single H hall quantized package along with space contraction and time reversal to the past, *Remark 5(16)7a.* As an example, porcelain cup will fall to the flour and smash to smithereens; thus, the chemical and physical bonding of porcelain molecules break along with H hall quantized packages generation, i.e. space with time's arrow, *Eq. 5(70)3,* stretching [180]. Moreover, the reversible process, i.e. the pile of porcelain smithereens to form into a cup is impossible due to H hall quantized package contraction (overlapping) to a single one, *Note 5(16)7a1*. The time and space generation due to Universe expansion lead to arrow of time concept, *Sec. 5(16)7d*. According to [141] "one possible resolution of Lodschmidt's paradox is to hypothesize that there is a so-called arrow of time in the Universe, one possible mechanism for an arrow of time is to assume that time itself is defined by changes in cosmic entropy". Please refer to *Sec. 7(1), Eq. 7(11), Sec. 7(4),* and *Sec. 11(1), last paragraph.*

Factually, according to thermodynamic second law entropy, *Sec. 5(16)9d, part A*, increase during an irreversible process such as glass smash, the process of fixing information in a record. On the other hand, considering above statements space expands along with time increase during entropy increasing or vice versa in such a manner that "the entropy density of the Universe (i.e. entropy to volume ratio) remained reasonably constant, throughout most of its evolutions"[212], *Sec. 5(16)7b*. In article [251A], *abstract,* referred to relationship of cosmic inflation and the thermodynamic arrow of time. In other words, *by reversing the time's arrow, Remark 5(16)7c2, the space is contracted accordingly*, i.e. path-length contraction, or vice versa, i.e. path-length expansion (or generation), because of energy-mass conversion scenario, *Sec. 5(16)3a,* with reverse handedness behavior of H particle-paths, i.e. mirror effect, *Sec. 6(2)3.* According to this reason, the arrow of time is extended from past to future along with space expansion, *Sec. 5(16)7c*; thus, the reverse process in the whole Universe is thermodynamically impossible regarding its expansion. i.e. time's arrow is irreversible accordingly, *Note 5(16)7a*; please refer to , of a paradox arise by considering solely time's arrow reversal excluding reverse handedness. Remarkably, space spirally expands right-handedly (accompanied by time's arrow, *Consequence 5(16)7a1*). Therefore, through reversed handedness, it spirally contracts left-handedly (along with time reversing), *Sec. 5(16)5.*

Resuming arrow of time reversal, *Example 5(16)7a1*, is almost accompanied by handedness reversal related to antimatter Universe, *Sec. 5(16)9c*, *part A.* It must not be confused with a simply time rate (clock time) or velocity reversal during which no space and time contraction is taken place as in symmetric aspect of the dynamical law, or, in other words, no mass-energy (or mass-field) conversion is performed. "Therefore, from the viewpoint of mechanics, which obeys time-reversal symmetry, there is not preferred direction for the flow of time"[226]. Noteworthy, according to *Sec. 5(16)9d, part c,* at each instant there is a time symmetry, *Sec. 2(3)3*, at equilibrium stage besides intrinsic time's arrow or its reversal of the system. Note that, a system being driven by an external agent or field not be in equilibrium with its surroundings and can exhibit irreversible behavior as a result of the work being done on it"[226]. Moreover, the time's arrow in any of its aspects, *Sec. 5(16)7c,* is along with irreversible path-length, *Sec. 2(4)1*.

Consequence 5(16)7a1 – According to *Sec. 5(16)1b, part A, paragraph 15*, the time's arrow is due to the preference of spatial type *R* expansion at SN_r configuration in our type R matter Universe; thus, its reversal has type *L* contraction of SP_l configuration accordingly. Therefore, during space expansion the time's arrow is related to space (or vacuum space, *Sec. 5(16)3b*), and time's arrow reversal is due to the related mass-bodies at SP_l configuration, i.e. fermions. Please refer to *Sec. 5(16)2c, Comment 5(16)2c, A1*; *Sec. 5(16)9d, part B.* Factually, based on *Sec. 5(16)9d*, and *Sec. 5(16)11*, in one hand, the time's arrow is along with entropy increment in vacuum medium. In other hand, negentropy increment in mass medium, *Sec. 7(4)3*, up to full expansion of the Universe. Moreover, according to *Sec. 5(15)2, Note 5(15)2* at this stage, there is a possibility of Universe contraction up to big crunch accompanied by reverse handedness, *Note 5(16)7a1*. In the two above cases, the algebraic sum of entropy and negentropy remained constant.

Example 5(16)7a1 - During photons emission by an atom, mass is converted to energy, i.e. photons. According to *Sec. 8(5),* this system can be regarded as a unique H system; moreover, its H hall quantized package, *Sec. 5(16)3a,* expands along with time's arrow. Remarkably, the absorption of a photon by atoms along with energy conversion to mass can be regarded as reverse process, i.e. space contraction with time's arrow reversal (going backward in time at quantum world); please refer to *Secs. 8(4) to 8(7),* for additional information.

Note 5(16)7a1- The porcelain cup smash to smithereens, the burning of a fuel obeys an irreversible path-length, *Sec. 2(4)1*, of expanding type R_e through spatial medium, it is along with an irreversible path-length of contracting type L_c within mass medium, *Sec. 7(4)3*, at equal magnitude and opposite signs. Therefore, the reverse process in expanding spatial type R_e of our matter Universe is impossible. Therefore, according to *Sec. 5(16)6*, the reverse process must be down in a type L_c Universe based on CPT invariance.

5(16)7b – Time's arrow dependence to deviation degree from reversibility α

A) General aspect

The whole entropy increase linearly proportional to the Universe spatial volume, or, in other words, any H hall quantized package generation, *Sec. 5(16)3a*, imparts a quantized volume V_{HP}, *Eq. 5(70)2,* to the total spatial expansion of the Universe. It is along with a quantized time's arrow interval, ΔT_{Γ}, *Sec. 7(4), Eq. 7(15),* that is imparted to the total time elapsing in the Universe (or Universe age). Because of this discussion, considering, *Sec. 5(16)3a, Eqs. 5(19), 5(70)2* and referring to *Sec. 2(1)4, Note 2(1)4b, case II*, the following relationship is proposed:

$$H_0 = \frac{dM}{dt}\Big/_{M} \sim \frac{d\alpha}{d\tau}\Big/_{\alpha} \qquad 5(70)8a1$$

$$\frac{d\alpha}{\alpha} \sim H_o d\tau = \frac{N_G V_{HP}}{3}\left(\frac{u^3}{b}\right) \qquad 5(70)8a2$$

$$\int_{\tau_0}^{\tau} d\log_e \alpha \sim H_o \int_{\tau_0}^{\tau} d\tau$$

After integration, we have:

$\alpha = A\, e^{Ho\tau} - B$

At initial condition $\tau_0 = 0$, of rest object $\alpha_0 = 0$:

$$\alpha = A.(e^{Ho\tau} - 1) \qquad 5(70)8a3$$

Where:

- α, *Sec. 2(1)1a, Eq. 2(7),* the single direction H particle-paths to that of reversible one (deviation degree from reversibility) at time τ respects to an observer at rest at initial time τ

- $d\alpha$, the α variation during expansion related to time's arrow interval $d\tau$ at time τ (due to exit of related expanding spheres of dM mass equivalent) at accelerated rate proportional to α

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

In fact according to *Sec. 5(1)1, Note 5(1)2, M* is diminished as a function of time; please refer also to *Sec. 5(15)1, Remark 5(15)1.* In this case, the mass-body is viewed as isolated; therefore, other sorts of energy densities, except dark energy, are neglected.

Referring to *Sec. 5(1)2,* at the present the ratio of dark energy to mass equivalent energy, or, the ratio of returned single direction H particle-paths to the reversible ones (or total reversible H particle-paths at the era of Big Bang) is α = *0.74*. It is equivalent to v # *0.6c*, *Sec. 5(16)7b*, *part B*, and *Eq. 2(7), Sec. 2(1)1a.* Please refer also to *Note 7(4)3, J1*.

Referring to *Sec. 5(16)1a, Remark 5(16)1a2*, considering age of the Universe $\tau = H_0$, according to *Eq. 5(70)8a4*, we have *A= 0.43*

According to [272], *part 5*, the inflationary paradigm at the case of an accelerating Universe the curvature term $-k\,a^{-2}$ is neglected (flatness); thus, the *FLWR* equations led to:

$$a(t) \sim e^{Ht}, \quad H = \frac{8\pi}{3} G \rho_{\lambda} \qquad 5(70)8a4$$

Where, $a(t)$ is the scale factor, *H* Hubble constant, ρ_{λ} an energy density (dark energy) relating to cosmological constant λ. The scale factor $a(t)$ and α have a hard link with each other, *Sec. 5(16)2a, part B*, based on comparison of the *Eqs. 5(70)8a3,4*. Moreover, referring to [272] *part 5*, *B*, *Inflation* and *Sec. 2(1)4*, *Note 2(1)4b*, *case II*, related to acceleration equivalent, we have:

$$\frac{da(t)}{dt} = \overset{o}{a}(t) \sim \frac{d\alpha}{dt} > 0$$

Please refer also to *Sec. 5(15)1*, and *Sec. 5(16)2a, part B*.

Since ρ_{λ} is taken the dominate form of energy, the other contributions to the density in the *FLWR* equations are red-shifted away, since ρ_m (matter energy density), and ρ_R (radiation energy density) are proportional to a^{-3}, a^{-4} respectively.

Remark 5(16)7a- According to *Sec. 2(1)1b, Delta Effect, Fig. 2(3), & Sec. 2(5), Note 2(5)2,* through length contraction $dl \to dl'$, time interval also shorten, $dt \to dt'$ that means any one-dimensional H hall quantized package contraction is accompanied by related time interval diminution, or, vice versa. Referring to *Sec. 2(1)1b, 3c,* the above statements are applicable for three spaces and related time components. In other words, space and time are inseparable and are related to each other; thus, must be regarded as space-time, *Sec. 2(1)1*,or, path-length, *Sec. 2(1)2*, from view point of H particle-paths hypothesis; moreover, space-time texture is constituted of H hall quantized units, *Sec. 5(16)3a.* Remarkably, these units generated by conversion of matter from its contracted form, i.e. mass to field or energy, i.e. its expanded form, *Note 2(1)3b*; please refer to *Sec. 5(16)3b*. For example, during glass breaking, *Sec. 5(16)7a,* irreversible chemical reactions, nucleus splitting through β decay, *Comment 5(16)6a*, gravitational potential field generation of a mass, *Sec. 5(1),* H hall quantized unit generated, i.e. time and space

appearance through path-length generation. Factually, the time elapsing in an H system, e.g., the Earth, depends on these phenomena.

B) Superluminality scenario in a receding Universe

According to [280] "For the largest known redshift of z = *6.3,* the recession is not *6.3c =1,890,000 Km/Sec.* It is also not the *285,254 Km/Sec*. Given by special relativistic Doppler formula $1+z = sqr((1+\frac{v}{c})/(1-\frac{v}{c}))$. The actual recession velocity for this object depends on the cosmological parameters, but for a $Omega_M = 0.3$ vacuum-dominate flat model the velocity is *585,611Km/Sec*.This is faster than light". From viewpoint of H particle-paths hypothesis there is no superluminal velocity, *Sec. 5(16)3b, part F*. Moreover, by referring to *Sec. 2(1)1b, Consequence 2(1)1b1, part 3c* a correction factor $+\delta T$ (*Remark 5(16)3e3*) must be added to the traveling time of the light obtained according to *SRT* (scalar part) due to one-way trip of the light signal of a receding source. Noteworthy, we must add to the latter a second correction factor related to apparent background time, *Sec. 5(16)1c, part c*, as a result of universe expansion; please refer also to *Sec. 5(16)7c*, in this regards. Factually, the light speed depends on vacuum texture density, *Sec. 5(16)3b, part F1*. Therefore, in the domain of our solar system due to constancy of the texture density, it is equal to c . Noteworthy, in an expanding Universe, this density is decreasing proportional to the separating distance based on Hubble law respect to an observer on the Earth, i.e. Lab. In other words, through decreasing (or dilution) of the apparent vacuum quantized texture density, we are approaching to an abstract vacuum, *Sec. 5(16)3h*, and an apparent superluminality. Nevertheless, in each location of the Universe due to constancy of vacuum texture respect to its own observer, the light speed is the same as in our lab, i.e. *c, Example 5(16)7b, B1*. As a result, the clock rate also depends on the vacuum texture density. According to [44], "Astronomical measurements of the fine structure constant suggest that this particular constant is increasing was so slightly with the time". " found that *alpha* was smaller in the past than it is now";" the fine structure constant, alpha, is defined as $e^2/\hbar c$ where, e is the charge on the electron *h-bar* is the Planck constant divided by 2π and c is the speed of light and is about *1/137*. If alpha changes with time although no evidence has ever been detected for any of these constant changing". Referring to [43], the author said" we have measured the fine structure constant, *Sec. 9(4)6,* in *49* absorption systems covering look-back time from *0.2* to *0.9* time the age of the Universe.

According to [281] *Abstract*, "$\Delta\alpha/\alpha = 0.72 \pm 0.18 \times 10^{-5}$ over the red-shift range *0.5*< z <*3.5*, we find no systematic effects which can explain our results". Therefore *alpha* variation is very small that cannot be referred to the light speed increment as large as in this case at z = *6.3,* instead there is an apparent (or false) light speed as discussed in *Sec. 5(16)3b, part F*. Please refer also to *Sec. 9(3)1, Note 9(3)1c.* According to [282], "In case of an empty Universe such as Milne cosmology, where one can apply the concept of distance from special relativity, the value of the co-moving distance between two points does not reduces to the proper distance as defined by special relativity". In other words, the factor of expansion between two points must be considered in *SRT* as an improvement. Please refer also to [283], part 6, *Conclusion*, according to that, "These observations provides strong evidence that the general relativistic interpretation of the cosmological red-shifts is preferred over special relativity and tired light interpretation. The general relativistic description of expansion of the Universe agrees with observation, and does not need any modification for $v_{rec} > c$ ". In the latter article, the authors accepted the paradoxical Universe expansion faster than the speed of light in their interpretation

Example 5(16)7b, B1- Supposing a runner, is running in a checkered road in such a manner that he steps uniformly on successive transversal lines. Therefore, by elongation of the distance of two successive lines its jumps are increasing, i.e. its apparent speed is increasing. The motion of photon of a light on vacuum quantized texture is analogous to the runner. In other words, the photon is jumping (or jiggling, *Simulation 8(7)2, E5a, item23*) between successive H hall packages, *Sec. 5(16)3a*, of vacuum quantized texture of path-limit Γ_d through time intervals ΔT_Γ , *Sec. 7(4)3*, by decreasing the apparent vacuum quantized texture density (or dilution) Γ_d , and ΔT_Γ are increasing at a proportional rate, i.e. $\Gamma_d = c\ \Delta T_\Gamma$, please refer to *Sec. 7(4)2e*. As a result, photon has no smooth motion (as in case of a car) at quantum level, it Jumps between successive H hall quantized packages of path-limit Γ_d at equal time interval ΔT_Γ ; whereas, it keeps its correlation as in *Sec. 8(9),* with the emitting source. Resuming, the rate of sweeping of H hall package by photon defines the motion of photon at quantum level.

5(16)7c – Time's arrow categories

Factually, the time's arrow mainly depends on expanding gravitational closed surfaces (or spheres) generation, or, better to say expansion, *Sec. 5(15)2b*. Considering two reference frames, *R, R',* with three combined space-time coordinates (or 6-dimensional space, and time coordinate), *Sec. 2(1)1b, Consequence 12(1)1, 3c,* and supposing two equal masses *M,* and *M'*, located in the origins, *o, o',* of their respectively. Supposing, the reference frames, *R, R'*, are at straight and uniform motion at v speed respect to each other. Moreover, far enough of each of their; thus, having nil gravitational interactions according to *Sec., 5(16)1b, Fig. 5(8),* the geometrical shape of their gravitational expanding closed surfaces are symmetric in three spatial directions respect to their own observer, i.e. sphere. Therefore, the time's arrow flow (or components) in three spatial directions are the same respect to their own observer due to purely reversible H particle-paths motion, *Sec. 7(4)4,* and different respect to the other observer. In other words, the gravitational expanding surfaces of mass *M'* respect to observer *o* (or vice versa) is no longer geometrically symmetry; but can be visualized as ellipsoid due to combination of single direction motion in the x'-axis direction and reversible motion in

three spatial coordinates, x', y', z', axes (or vice versa). According to above statement, the time's arrow components must be analyzed according to *Sec. 2(1)1b, Consequence 2(1)1b1, case 3c*, in the reference frame R' as following, *Proposal 5(16)7c1*:

I) Local gravitational time's arrow, *Sec. 5(16)1b, part A, paragraphs 3, 15,* and *Sec. 5(16)1b, part E;* please refer to *Sec. 5(15)2c,* and *Sec. 7(4)2f, part D3.*

II) The background time's arrow due to whole Universe, *Note 5(16)1b, A6,* spatial expansion, *Sec. 5(16)1c, part c*. It must be considered in spatial location of the two mass-bodies, *M, M'*. Moreover, this time is irreversible, homogeneous and isotropic, *Sec. 5(15)2c;* please refer to *Note 5(16)7c1*.

III) Intrinsic time's arrow variation in a closed H system that is proportional to the entropy variation of the whole system and at the same sign; please refer to *Sec. 2(4)2.*

IV) Time's arrow at microscopic level (or quantum), *Sec. 5(16)7e*:

A) Time's arrow of weak nuclear force, *Sec. 5(16)8*.

B) Time's arrow reversal due to wave function collapsing in quantum scale, please refer to *Sec. 8(7)2, part D, Sec. 8(7)6, part B, Remark 8(7)6b*; *Sec. 8(9)1, paragraph 3.*

V) The radiative time's arrow, *Sec. 5(16)7f,* and *Sec. 5(16)3f, part B*.

VI) Time's arrow reversal*, Sec. 5(16)7e, Sec. 5(16)9, Sec. 5(16)11.*

VII) "The psychological arrow of time- we remember the past, we predict the future" [448] *Section I, Sec. 5(16)7g.*

VIII) The mono-directional time arrow, *Sec. 5(16)7j*.

Factually, the time's arrow in the cases *I, II, IV* depend on the density of the H particle-paths of the related textures; In other words, due to the presence of vacuum texture, *Sec. 5(16)3b*, in the lab medium during the measurement of a quantity, e.g., light speed, we must consider the local time's arrow of the lab. Note that, the lab may be the Earth, Mars, space station, etc., please refer to *Sec. 5(16)1b*, *paragraph 16*, in the two cases *I, II*, and *Sec. 8(9)1, paragraph 3* in the case *IV*; please refer also to *Remark 5(16)7c3*.

The sum of the above time's arrows, *Comment 5(16)7c1*, is the time in the reference frame according to the motion of mass-bodies under investigation that is composed of two parts as following:

A) Scalar time related to reversible motion of H particle-paths, i.e. t' in the, *Sec. 2(1)1b, Consequence 2(1)1b1, 3A*. In a spherical coordinate, the time's arrow varies radially, i.e. depends on r position.

B) Directional time due to single direction, or better to say, returned H particle-paths, or, in other words, the time's arrow in the direction of x-axis. The flow of this time's arrow depends on x position of the x-axis coordinate, i.e. clock rate.

The sum of the above time's arrows can be visualized as the total rate of time's arrow in the reference frame R'; moreover, each of the correlated directional time's arrow components along the x', y', z', axes follows the, *Sec. 2(10), Eqs. 2(116) to 2(119).* This can be related to space expansion and time's arrow, i.e. path-length, *Sec. 2(1)2,* generation. As a result, the transformation from reference frame R to R' must be done independently through the related combined space-time (path-length) coordinates.

Noteworthy, in the cases of M, M' at low masses, (e.g. particles), the rate related to the case *I* is negligible respect to that of the case *II*; therefore, the two reference frames R, R' are relatively equivalent according to *SRT.* By the way, in case of *M,* and, *M'* at different magnitudes, the preferred reference frame must be considered in the preference of higher one, i.e. *CMPRF*, *Secs. 2(6)2a,b.* By the way, in a closed system, or system under equilibrium state, the time's arrow variation (case *III*) is equal to zero.

Resuming according to above statement and *Sec. 5(16)1c, part A, Consequence 5(16)1c, A1*, time's arrow is somehow accompanied by its equal magnitude time's arrow reversal. In other words, path-length, *Sec. 2(1)2*, generation is accompanied by equal magnitude path-length contraction, *Sec. 5(16)11*; please refer also to *Sec. 2(4).* According to H particle-paths hypothesis except case I, *Remark 5(16)7c1*, the other cases of time's arrow can be specified to *SRT* as fourth time coordinate in a Minkowskian 4-space; the main of which is the background time's arrow (*case II*). There is also a zero time's arrow variation (*case III*) due to mirror image effect, *Sec. 6(2)3,* that is accompanied by mutual acceleration in a closed H system, e.g., collision, *Sec. 6(2)1a*, force application, *Sec. 6(2)1b*, regardless of effect of gravitation. In other words, there is an infinitesimal time-symmetry, *Sec. 2(3)3,* due to back to back matter and antimatter Universe, *Sec. 5(16)9b*, in this respect with zero time's arrow variation; on this basis, the quantum theory obeys the time's arrow variation as in the *case III*. Generally speaking, the time's arrow and its reversal are related in infinitesimal scales to wave function Ψ and its conjugate Ψ^* in such a manner that time's arrow variation is zero. Based on this assumption, the wave function of an entangled pair of particle collapse instantaneously even if they are separate, e.g., by a light year away, that resulting to so called *EPR* paradox, *Sec. 8(4).* In fact, according to *Sec. 8(7), Fig. 8(1),* considering two photons propagated at opposite directions of an emitting source at c speed, according to experimental test, the propagation time is vacuum background time, but wave function collapsing with zero time's arrow as stated above, i.e. superluminality measurements as in, *Sec. 5(16)7b*, *part B, please refer also to Secs. 8(7)2, 8(9)1*. Generally speaking, in the propagation case, we encountered with an expanding unique H system, *Sec. 8(5),* with specified background time's arrow, *Remark 5(16)7c2*. But, at the case of measurement, we have two separate H systems of reversed handedness, *Sec. 5(16)9b*, i.e. detected and not affected, along with time's arrow and its reversal, i.e. case *IVB*, at equal magnitude respectively, i.e. zero total time's arrow. In fact, time's arrow reversal can be attributed to detected photon (or absorbed), *Remark 5(16)7c2*, and time's arrow part can be referred to no detected one; please refer also to *Sec. 5(16)1c, part A*, *Consequence 5(16)1c, A1*. As an alternate interpretation, please refer to *paragraph IV* and *Sec. 5(16)3h.* Noteworthy, according to *Sec. 5(16)1b, part A, paragraph 15* spontaneity, *Sec. 7(4)2f, part c,* can be referred to an H system with zero (or infinitesimal) time's arrow as in quantum mechanic wave function collapsing.

The above result also is applicable also to a uniform transparent medium, e.g., glass; in order to obtain its background time's arrow; please refer also to *Sec. 5(16)2c, Eq. 5(68)4*.

Proposal 5(16)7c1 – Wave function collapsing time (proposed as a fictive time's arrow) is related to spontaneous wave function collapsing, *Secs. 8(4), 8(9).* "It appears that a measurement in one place have an instantaneous effect on something that may be light year away"[74]; please refer to *Sec. 5(16)3h*. Nevertheless, a wave function collapsing is accompanied by a time arrow reversal at microscopic level, *Sec. 5(16)7c, paragraph IV*; please refer also to *Sec. 8(6), Remark 8(6)1a; Sec. 8(7)2, part D.*

Note 5(16)7c1- According to *Sec. 2(6)2a, item c*, the time arrow depends on the rest mass (or fully reversible H particle-paths). Thus, the background time arrow also depends on the rest mass densities of e.g. dark matter, *Sec. 5(1)2*, in spatial medium, *Sec. 7(4)3, part A*.

Comment 5(16)7c1- "The more general idea, that these temporal asymmetries are due to the asymmetric behavior of physical processes in our world (whatever their origin, laws, past hypothesis) as opposed to more metaphysical sources seem very plausible" [421] *part 3*. Please refer also to *Sec. 2(1)1d, Remark 2(1)1d1*. From seven types of time's arrow the types *I, II* have dominance over the five ones, therefore they can be regarded as total time's arrow with a good approximation,

Remark 5(16)7c1 – According to [292], *part 2.1*, "Special relativity does not satisfy the equivalence principle of General Relativity, according to which inertial mass and of gravitational mass are identical. Special Relativity considers only inertial mass". Based on this argument, the local gravitational time's arrow (case *I*) cannot be considered as true time's arrow in *SRT*.

Remark 5(16)7c2 – Contrary to emission (or propagation), the photon absorption is accompanied by space contraction and time's arrow reversal in the related H system; please refer to *Sec. 5(16)9b; Sec. 6(2)3*. In fact, time's arrow in a part of an isolated H system is accompanied by time's arrow reversal in other parts of it simultaneously. Noteworthy, time's arrow with its reversal are a back-to-back entities. As an example when you have seen a movie, e.g., at 2 hours, after that time you reverse the direction of the movie film you see, e.g., a falling stone is levitate or a man died during movie scenario is lived again; this is not true in nature of two counter-current matter and antimatter Universes, *Sec. 5(16)9*. Nevertheless, at each instant you have both time's arrow and its reversal at a different part of the system at infinitesimal level with the slight preference of the former. Therefore, the summation of this preference constitute our ordinary time arrow; please refer to *Sec. 2(4)2*, in this regards. Therefore, quantum theory in this regards is in a right way. As a result, according to above statement and considering *Sec. 5(16)6b*, in case of a cyclic Universe hypothesis, it will be contracted in the form of antimatter one, i.e. in its handed reversal form.

Remark 5(16)7c3 – "There are unverified anecdotes of inventors or researcher detecting times anomalies (for example the dilation or slowing of time) because of experimental effects purported to come from the trapping of zero point energy" [350] *Fringes theories*. According to H particle-paths hypothesis this time anomalies depends on one hand to *Delta Effect, Sec. 2(1)1b*, and other hand densities of gravitational fields or vacuum texture.

5(16)7d – Cosmological time arrow

According to [224], "We are faced with the arrow of time. Although there is not a consensus view of the solution to this problem, most cosmologists would guess that it has something to do with inflation". According to [209], *the cosmological arrow of time*. "The cosmological arrow of time in the direction of the Universe expansion. It may be linked to the thermodynamic arrow, with the Universe heading towards a heat death (Big Chill) as the amount of usable energy becomes negligible". According to [225] "Why should the direction of the thermodynamic arrow agree with that of the cosmological arrow, the direction in which the Universe is expanding? Would the thermodynamic arrow reverses if the Universe reaches a maximum radius and began to contract? "Why is it that entropy increases in the direction that the Universe is expanding"? Why it was ever so low in the first place?" These questions can be answered, according to H particle-paths hypothesis.

"One explanation for the arrow of time is that it comes from thermodynamics. If we start with a Universe, which has very low entropy, the forward march of time can be marked by the upward increase of entropy. If we have started in a Universe with maximal entropy, presumably there should be no advance of time. However, if the increase in entropy corresponds to an increase in the forward direction of time, does it means that we can measure time in the same units of entropy? Can we measure time, then, in bits?" The concept of H hall quantized packages, *Sec. 5(16)3a,* and its generation during an expansion process can be fit in this proposition.

Resuming, H particle-paths hypothesis, reject the paradoxical (or sophisticated) time travel to the past, please refer to [350]. In other words, it is impossible to travel to the past as in science fiction stories. Please refer also to *Comment 5(16)7, g1* in this regards.

5(16)7e – Time arrow at quantum level

A) "Certain processes in quantum mechanics, relating to the weak nuclear force, are not time-reversible, keeping in mind that when dealing with quantum mechanics time-reversibility comprise a more complex definition. The time-symmetry phenomena in *QM* are too few" [431] *the laws solution*. Please refer also to *Sec. 5(16)8*, *Comment 7(4)2e2,* and *Sec. 5(16)1b, part F1*.

B) "Physical process at the microscopic level are either entirely or mostly time symmetric, meaning that the theoretical statement that describe them remain true if the direction of time is reversed; yet when we describe things at macroscopic level it often appears that this is not the case: there is an obvious direction (or flow) of time. An arrow of time is anything that exhibit such time-asymmetry"[209]. According to H particle-paths the arrow of time, *Sec. 5(16)7a* is extended to microscopic level as in wave function collapsing, *Sec. 8(7)2, part D*. Please refer also to *Sec. 2(3)3,* and *Sec. 8(9)1, paragraph 3*. According to *Sec. 8(6),* during a collision such as Compton Effect, *Sec. 3(1)1, Fig. 3(1),* the *(AB)* can be regarded as striking photon *B* of wavelength

λ (e.g., a pair of entangled particle *A, B*) and the stroked electron e as *(M)*. Therefore, the resulting H system is *(BM)* as scattered electron and *(A)* the conjugate of initial photon *B* in pair of entangled photon λ . In this system, a third member appeared because of Mirror Image Effect, *Sec. 6(2)3,* i.e. photon λ' as third member *(C);* please refer also to *Sec. 8(7)2, part A*. By the way, initially we have two H hall packages *(AB), (M)* and finally after wave function collapsing 3 H hall packages *(A), (BM)* and *(C),* therefore space expands along with time arrow *(type L)* due to the third H hall package of λ' reversed handedness, i.e. time's arrow reversal; please refer to *Sec. 5(16)10*. In all other phenomena in microscopic level of wave function collapsing there is at least one additional H hall package due to Mirror Image Effect. Therefore, during an interaction based on Mirror Image Effect, a reversed handedness, *Sec. 5(16)9b*, H hall package appeared during wave function collapsing. Please refer also to *Sec. 8(7)2, part D*. Noteworthy, each H hall package appearance is accompanied by a quantized time's arrow ΔT_{Γ} generation, *Sec. 7(4)1*. Please refer also to *Sec. 8(7)2, part G, item F, Note 5(16)1, A6*. "According to the theory of quantum decoherence, and assuming that the wave function collapsing is merely apparent, the quantum arrow of time is a consequence of the thermodynamic arrow of time"[209], *The quantum arrow of time*; please refer also to *Sec.8(7)1d*. According to H particle-paths hypothesis, the time arrow relating to expansion of gravitational spheres, e.g., in particles, atom & molecules, $d\tau$ *Sec. 5(16)1c, part A4,* has also a main role in microscopic level, *Sec. 5(16)1b, part F1*.

The formation of track texture of a particle along its expanding characteristic can be considered as a consequence of time's arrow ordering in quantum mechanics, *Sec. 5(16)3b, Consequence 5(16)3b1*. "The observed time asymmetries such as the thermodynamics arrow of time, the arrow of retarded radiation, the absence of white holes, etc. could be follow from a fundamental quantum mechanical distinction between the past and future" [448] *Section 2*. According to the latter, a probability formula for a particular history in the exhaustive of histories is given. "Whatever conventions are used for time ordering, there is thus an asymmetry between future and past exhibited in the formula for probabilities. That asymmetry is the arrow of time in quantum mechanics. The asymmetry between past and future exhibited by quantum mechanics implies the familiar notion of causality". "The common explanation for the origin of the arrow of time in quantum mechanics of measured subsystems is that measurement is an irreversible process and that quantum mechanics inherits its arrow of time from the arrow of time of thermodynamics. If that is the case, then the origin of the quantum mechanical arrow of time must be cosmological"[448] *Section 2*. Factually, the thermodynamics arrow of time depends on the overall expansion of the Universe, *Sec. 5(16)9d, part A*. In other words, the latter mainly determines the direction of time's arrow in each location. Note worthy, during a measurement, there is an infinitesimal interval of time arrow reversal respect to flow of actual time's arrow, *Sec. 5(16)7e*, that is negligible respect to the latter one.

5(16)7f- Radiative time's arrow

"This principle - that light will always take time, traveling forwards in time between two points - is called the radiative arrow of time (also known as the electromagnetic arrow of time)". "It makes no sense to talk about the entropy of a single photon (entropy is a statistical property of a large group of particles), so a single photon has no arrow of time"[558] *The radiative arrow of time*. However, according to *Simulation 7(4)2e1*, a single photon during its propagation emits expandons that are along with spatial expansion and time's arrow in spatial medium. "The radiative arrow of time must surely depend on the increasing sum total of entropy in the universe, not the total of electromagnetic field. Surely the radiative arrow of time must have the same cause as the thermodynamic arrow of time"[558] *The Radiative arrow of time.* Factually, the expandon emission by a particle, e.g. photon, is depended on mutual interaction of H particle-paths of photon main body with that of the H hall package of the medium, *Sec. 7(4)2f, part E*, that leading to time's arrow generation. Noteworthy, the H hall package generation is depending on spatial expansion of the Universe. Thus, it is related to thermodynamic arrow of time.

5(16)7g- Psychological time's arrow

A single example in this kind is the probable selection of a trajectory on an expanding track texture (or its sub-tracks) by a particle. In other words, a particle during passing from point A to B , *Consequence 2(4)1a*, in spatial medium, *Sec. 7(4)3, part A*, chooses a track texture at a probable manner, *Sec. 5(16)3b, part B*, i.e. future, *Note 5(16)7, g1.* While, an interaction (or information) in this probable selected track is transferred by contractons exactly through an H hall package tunnel *Sec. 5(9)3d, part c*, to the particle source mass medium, *Sec. 7(4)3, part D*, and ultimately it is absorbed irreversibly by the super-massif black hole of the host galaxies and clusters spontaneously, *Sec. 7(4)2f, part c*, i.e. past. "In 1976, he showed that when a black hole is formed, it radiates energy and starts loosing mass. This radiation gives no information about the matter inside the black hole, and once the hole disappears – all the information are lost with it. This brings in a serious paradox known as 'black hole information paradox'. If information is totally lost it arises important practical and philosophical consequences. If this really happens, then 'we could never be certain of the past or predict the future precisely"[535]; please refer also to *Sec. 5(7)3*, and *Sec. 5(15)3c*. As a result, by a far analogy during the expansion phenomenon in spatial medium that is linked to time's arrow, *Sec. 5(16)7*, the mind predicts at a probable manner the future events, and remember the past exactly, *Comment 5(16)7, g1,* through its link to black hole due to contractons transfer within mass medium, and H hall package tunnels,. Similarly to the stated above particle at finite speed, the transmitted signals by the man brain searches probable ways of thinking (or guess) between the present, i.e. point A and future, i.e. point B of an event. Each way is separated through stay time ΔT , *Sec. 7(4)2f, part c*, from other ones. Therefore, it chooses the most probable one, *Sec. 8(7)2, part G*. At the point B , the contractons of the interacted event signal is transferred through an H hall package tunnel to the source of thinking, i.e. the brain saving, and ultimately to the related black hole spontaneously, *Note 5(16)7, g2*. In other words, the signals emitted by brain cells are correlated through mass-bodies via successive P_R, P_L contractons transfer to the black hole at present time. "The process of decoherence is bound to affect the states of the brain". "Decoherence, or more to the point, environment-induced super-selection, applies to our own state of mind". "Why the preferred basis of neurons becomes correlated with the classical observables in the familiar universe. It would be, after all, so

much easier to believe in quantum physics if we could train our senses to perceive non-classical superpositions"[552] *Quantum theory of classical reality*; please refer also to *Sec. 8(7)1d*.

Note 5(16)7, g1- "This logical inconsistency prohibiting you from remembering the future (based on MacKay's reasoning) arises because the following two statements cannot both be true:

1. You can receive - or "remember" - information about events in the future.
2. It is possible to change future events.

However, it might be possible to remember the future (the first of those two statements being true) if the second statement is, in fact, false. Indeed, if all of spacetime is laid-out as an unchanging four-dimensional block universe then the future is just as "set in stone as the past"[558] *Could it be possible to remember the future?* Please refer to *Sec. 5(15)3d*, *part A*. According to *HPPH*, the future (time's arrow) is along with expanding (or diverging) characteristic in spatial medium at finite speed less than light speed; while, the past (time's arrow reversal) is accompanied by contracting (or converging) characteristic in spatial medium towards mass medium spontaneously; please refer also to *Sec. 5(16)3f*, *part B*, and *Sec.7(4)2f, part c*. According to *Consequence 2(4)1a,* based on different paths between two points *A, B,* by some analogies we can guess the future at a probable manner, *Sec. 8(7)2, part E4*. While, according to *Note 5(16)7, g2*, there is a single path between screen and the source trough slit via common H hall package tunnel, *Sec. 5(9)3d, part c*, in double slit experiment. In other words, the contractons at the moment of photon measurement on the screen are transferred backward towards the source within a single H hall package tunnel at the same path that previously photon traveled, *Simulation 8(7)2, E5*. By this similarity, spontaneously we remember the past exactly. These analogies also implies an arrow (of time) toward the future.

Note 5(16)7, g2- At double slit experiment, *Sec. 8(3)4*, the H hall package tunnel, *Sec. 5(9)3d, part c*, is taken form during photon travel up to its striking on the screen, i.e. measurement. Thus, photon makes a link between its source, the slit (that photon has passed before) and the striking point on the screen. According to *Sec. 2(4)4a*, the released contractons just during the measurement are transferred backward via this tunnel (a single path) to the source*, Simulation 8(7)2, E5*. "In quantum mechanics we find that once an observation is made (i.e., once the particle hits the screen) then it appears clear that the particle only passed through one slit. It is though the act of defining an observation position (placing the screen) forced the past history of the particle to take only a single route through a single slit. It is as if the history of the particle is then defined backwards in time along its path once the observation position is defined. We can now see the similarity between this process and the efficient ray tracing method by which rays are traced backwards from the eye to the light source. It will always be more efficient to generate reality by waiting until an observer position is defined, rather than modeling all possible eventualities"[571] *The CGI Universe*. "A number of experiments will be reviewed underlining these views. This will include an entangled photon delayed choice experiment where the decision whether a photon that has passed a double slit did this as a particle or a wave is delayed not only until a time after its passage through the double slit assembly but even after it has already been registered"[573]. "The histories of the universe depend on what is being measured, contrary to the usual idea that the universe has an objective, observer-independent history" [571] *The CGI Universe*, *Sec. 5(15)3d*, *part A*. According to *Sec. 8(9)2, Fig. 8(1), paragraph III*, just during the interaction (or measurement, *Sec. 8(7)2*), the released contractons at the point *T* of stroked photon on the target are transferred back. This transfer is through H hall package tunnel, *Sec. 5(9)3d, part c,* that is perforated by photon during its travel, i.e. before measurement, towards the source spontaneously, *Sec. 7(4)2f, part c*, up to suppermassive black hole of the host galaxies, *Sec. 5(7)8*. Resuming, the photon chooses at an appearance of randomness, *Remark 8(7)2, E5b,* the slit and its path through the combined track texture, *Sec. 8(3)4b*. Photon at each stage of its transfer to an H hall package perforates an H hall package tunnel up to the target. The tunnel, *Remark 8(3)4, b1,* thus perforated is the contractons transfer route from target to the source via the slit that photon passed trough before, i.e. a single path, *Fig. 5(10).*

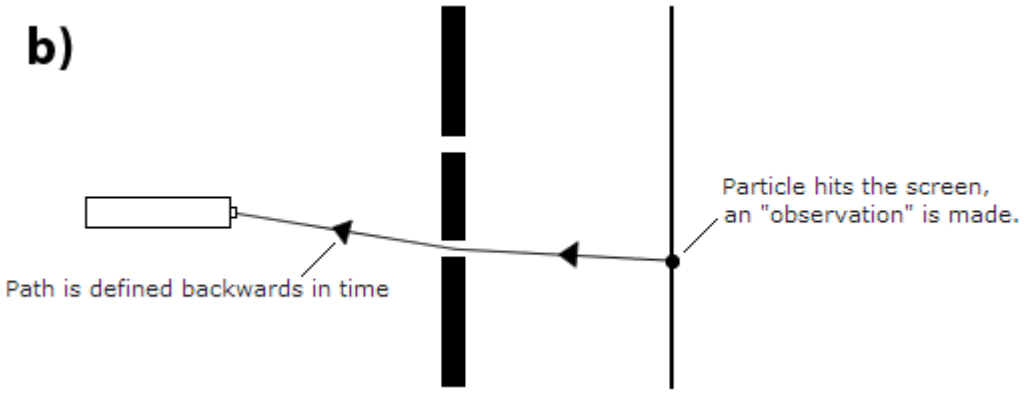


Fig. 5(10) - The backward path of released contractons during an observation in a double slit experiment

Comment 5(16)7, g1- According to *HPPH*, the probable manner to future depends on expanding characteristic of spatial medium, *Sec. 7(4)3, part A*, in our matter Universe along with entropy increment related to future. While, the exact manner of the past remembering depends on contracting characteristic towards the past respect to present and future along with entropy decrement. Noteworthy, the time travel to the past and future are restricted by entropy decrement and increment respectively in spatial

medium, despite of equality of path-lengths in both future & past in case of twin paradox, *Consequence 2(6)1a*. As a result, the travelling in time respect to the medium of the Earth (or lab) system clock implies that the entropy in the medium of moving (or traveling) system is increasing faster respect to the lab. In other words, at any instant of time travel, the entropy magnitude of moving system medium is the same as the entropy of the lab system medium that will be reaching in the related future.

5(16)7h – Time perception

During the continuous process of expansion phenomenon, we have the time perception from past to present. According to *Sec. 5(16)1c, part A1*, our time depends on the continuity of expansion process both radially & tangentially, *Sec. 5(16)5*. In other words, if expansion is stopped suddenly, the matter will be crashed. Thus, its duration (or time flow) secures our life. Similarly, the gravitational expansion during its H hall packages generation affects on time duration through superposition of its H hall package with that of vacuum texture, *Sec. 5(16)1b, part A*. Note that, expansion is performed spirally right-handedly in our right-handed matter Universe, *Sec. 5(16)9a*. Therefore, the H hall packages are also have right-handed spin. Resulting, left-handed expansion is not allowed. In other words, there is a preferential right-handedness over left-handedness based on bi-Universe hypothesis, *Sec. 5(16)9*, that is equivalent to *T*-symmetry along with slight time's arrow, *Sec. 5(16)8d,* and *Sec. 5(16)9c*. As a result, the expansion that is based on steadily H hall package generation defines the time's arrow *Sec. 5(16)7a*, (i.e. time-asymmetry). Therefore, time elapse (or flow direction) is spirally right-handed (i.e. non-linear) and along with emergence of space during right-handedly expansion of the Universe, or, better to say right-handed path-length generation that is more fundamental than time and space alone. "Gödel drew the conclusion that if matter is distributed so that there is Gödelian space-time (that is, what a preponderance of galaxies rotating in one direction rather than other), then the Universe has no linear time" [434] *part 4a, relativity and quantum mechanics*. "The assumption is that time does not exist independently of the space-time relations exhibited by physical events" [434] *part 4c, Infinite time.*

5(16)7i- Time's arrow direction

The time's arrow at a location of a medium is depended on two factors as following:

I) The population density of H particle-paths

II) The rate of generation of H hall quantized packages in a direction as carrier of H particle-paths.

The two cases *I, II* defines the time's arrow magnitude, and direction respectively, *Sec. 7(4)2f, part A*, and *Sec. 5(16)7j*. Therefore, homogeneity, and isotropy of space implies homogeneous population density of quantized vacuum texture, *Sec. 5(16)3b, part A*, of constant magnitude all over the free space. In other words, at any location of space, there is a constant H hall packages generation along with time's arrow in all spatial directions. This time's arrow according to *Sec. 5(16)7c, item II,* is nominated background time's arrow. Moreover, the gravitational time's arrow, *Sec. 5(16)7c, item I*, at small spatial location can be regarded analogous to background one, but at a large scale it depends on the radial direction of gravitational closed surfaces (or expandons, *Sec. 5(16)1c, part A3*) expansion, and the density of H particle paths at the location. Noteworthy, the time's arrow at microscopic level, *Sec. 5(16)7c, item IV*, related to weak nuclear force is depended on the direction of related H hall packages generation.

As a result, the time's arrow obeys the reversible and single direction aspects, *Sec. 1(3)*, of motion of H particle-paths. As an example, the time t' in reference frame *R', Sec. 2(1)1a,* depends on the reversible aspect; whereas, the *Delta Effect, Sec. 2(1)1b*, the time is related to single direction aspect.

5(16)7j –Mono-directional time arrow

Factually, there is no three independent time coordinates as in case of spatial coordinates. The classification based on individual (not independent) time coordinate is related to inseparable space and time, path-length direction, S*ec. 2(1)2,* as an independent combined space, and time coordinates in three spatial directions. Noteworthy, a path-length as a single entity is confined in a mono-dimensional H hall package. The gravitational expanding spheres, *Sec. 5(16)1b, part B,* imposes only a single time's arrow in three spatial directions that are linked together according to *Sec. 2(10)1, Eqs. 2(116)-118,* i.e. path-length coordinate. "If the number of dimension differed from I, Tegmark argued, the behavior of physical systems could not be predicted reliably from knowledge of the relevant partial differential equations" [430] *privileged character of 3+1 space-time.* "Space by itself, and time by itself, are doomed to fade away into mere shadows and only a kind of union of the two will preserve an independent reality" [434] *part 4a, Relativity and Quantum Mechanics*. Factually, according to *Consequence 2(1)1b1, case II*, the time has also a single direction time in case of a moving mass-body that cannot be detected through time measurement by a clock in an orbiting satellite. Noteworthy, the direction of mono-dimensional time also altering according to the motion direction of the satellite about the Earth. Thus, merely the dilated time interval *Sec. 2(6)2a*, *item c* related to purely reversible H particle-paths can be detected in each of its turn. In case of twin paradox, *Sec. 2(6)1*, the receding and approaching twins cannot acquired mono-dimensional time in its go and back travels in motion direction analogous to satellite. In fact, the inertia, *Sec. 2(1)4*, of the Earth has a determining effect on time interval. The background time arrow, besides the gravitational and inertial time arrows, *Sec. 5(16)7c, case II*, affect twin travels. It is better to use the path-length in case of twin paradox and mono-direction time arrow dimension in related reference frame. As a result, the ordinary clocks cannot detect the mono-direction time intervals $\Delta t' \pm \delta T$. Resuming, according to above discussion, one factor decreases the mono-dimensional time, or, in other words, the time variation δt , *Consequence 2(1)1b1, case II*, is of *T*-symmetry, *Sec. 2(3)3*, characteristics and are independent from time arrow, *Sec. 5(16)7*; please refer also to *Sec. 2(6)2a, item c.* Moreover, the time arrow related to expandon emission and contracton releasing, *Simulation 7(4)2e1*, of mono-directional motion that affects the mono-dimensional time arrow is negligible at low relative speed; please refer to *Consequence 5(15)1b*, in this case. According to *Sec. 7(4)2f, part A, Eq. 7(9)3*, the time unit (or stay time interval) depends inversely to the frequency equivalent of particle (here expandon) of N_0 H particle-paths in an H hall package of path-length limit Γ . In other words, two successive beats, *Sec. 7(5)3d, part D*, frequency (or inverse stay time interval) increase by

increment of H particle-paths population density in a location of reference frame R'. Thus, there is anisotropy of time interval based on this population. Noteworthy, this anisotropy exists in the co-direction and counter-direction of motion of reference frame that increases by increment of relative velocity of reference frame R' respect to R observed by an observer at the *CMPRF*, *Sec. 2(6)2,* of the latter.

5(16)8- CP violation

5(16)8a- General aspect

CP violation occurs if the decays rate for a particle differs from decay rate at its *CP* conjugate particle. To date, this phenomenon observed in neutral kaon meson and B^0 meson systems. According to [144], "describing the neutral Kaons is much more complex; the, K^o and its antiparticle $\overline{K^o}$ are identical except for strangeness content. What is actually observed, then, are quantum mixtures of the two, with the same mass but different decay lifetime. One is called K_S, the other K_L. These particles decay into pions by exchange of two *W* bosons". The neutral kaons are symmetric and antisymmetric mixture of the quark combination down-antistrange and antidown-strange. The long life kaon, K_L, decays respect to short life kaon, K_S, at the rate about 1 part in 500, [222]. Referring to [243]: *a)* the neutral *K*-mesons (K^o) and its antimatter counterpart ($\overline{K^o}$) can both be thought as a combination of a short-lived particle (K_S) which mostly decays into two pions and a long-lived particle (K_L) which decays mostly into three pions; *b)* In some cases, however, the K_L (*CP=-1*) turns into a K_S (*CP=1*) which then decays into two pions. This is evidence for indirect *CP* violation; *c*) the recent observed case in which K_L's seen to decaying directly into two pions. This is evidence of direct *CP* violation. Based on H particle-paths hypothesis, and according to *Sec. 5(16)3a, 5(16)5, Comments 5(16)4, 5,* the decay process can be attributed to the generation of left-handedly H hall quantized units (*type L*) dominant as in our spatially, *Note 5(16)8a1*, *type R* Universe, *Sec. 5(16)9,* related to kaon K^o. On the other hand to the generation of right-handedly dominant H hall quantized packages (*type L*) related to kaon, $\overline{K^o}$ antiparticle. Therefore, the latter case will be diminished the abundance of, $\overline{K^o}$ in the type *R* Universe, or, in other words, favored the existence of K^0 respect to $\overline{K^o}$; please refer to *Sec. 5(16)8b*, and *Remarks 5(16)9b,c,* in this respect.

$$K^o \rightarrow \pi^- + e^+ + \upsilon_e \quad 5(70)8b \qquad \overline{K^o} \rightarrow \pi^+ + e^- + \overline{\upsilon_e} \quad 5(70)8c$$

Please refer to [180] and *Sec. 5(16)9, Example 5(16)9a1*, *Sec. 5(16)11* in this regards.

As a result, analogous to the phenomena that depend on second thermodynamic law such as glass breaking and fuel burning, during a β decay an irreversible process on the basis of space expansion along with time's arrow take place; thus, according to *Eqs. 5(70)8b, c*, an overlapped H hall quantized package of neutral kaon expands to three H hall quantized packages, i.e. charged pion, electron or positron and related neutrino or antineutrino, *Sec. 5(16)8b*.

Example 5(16)8a - During π^- decay, *Eq. 10(11),* three H hall quantized units, i.e. related to muon, μ^-, muon antineutrino and photon appeared per one pion H hall; thus, we encountered with space expansion related to two additional H halls , i.e. $2V_{HP}$, *Eq. 5(70)2,* that is related to mass-energy conversion. In other words, pion H hall can be considered as superposition of at least 3 H halls; in return, during muon subsequent decay process, *Eq. 10(8)*, 3 individual H Halls related to electron, electron antineutrino and muon neutrino appears accordingly. To take into account that π^- is also created during another decay process accompanied by additional H hall appearance, the step-like expansions, i.e. $\overline{\pi}$ to $\overline{e}$, during the mentioned decay process can be deduced. Similar cases will be occurred during beta decay, alpha decay process during which the mass convert to energy. As another example mass to energy conversions, according to [143], *part 3.3*"what are really doing when we burn gasoline or metabolize food is producing entropy, the critical resource is not the energy (which after all is conserved), but the reliability of the arrow of time". Please refer also to *Sec. 5(16)7a; Sec. 5(16)8, Remark 5(16)8; Sec. 11(1), last paragraph.*

Note 5(16)8a1- Based on *Sec. 5(16)9a*, through slight preference of type R universe over L one in spatial medium, and slight preference of mass medium of type L universe over type R one as two countercurrent Universes, one can configure matter Universe (first variety). Factually, the matter Universe is expanding spatially right-handedly (*type* R_e*)* due to expandons generation of SN_r configuration, *Sec. 5(16)1c, part A3.* Therefore, its mass part is contracting left-handedly (*type* L_c) due to contracton generation of SP_l *Sec. 5(2)1c, part c,* it is nominated simply type *R*. Thus, the reverse process, i.e. a hypothetical spatially contracting Universe of SP_l configuration, and mass medium of right-handed SN_r configuration of expanding characteristic nominated simply type *L* one. From viewpoint of H particle-paths hypothesis, this kind of configuration can be regarded as preference of right handedly H particle-paths over its left-handed countercurrent counterpart in expanding spatial medium that is compensate by preference of left-handed H particle-paths over its right-handed countercurrent counterpart ones in contracting mass medium at the same magnitude of paths-lengths, but at opposite sign. It is nominating bi-Universe Hypothesis, *Sec. 5(16)9*. Please refer also to *Sec. 3(1)2* in case of counter-currency mode of motion of H particle-paths. By analogy according to above statement, a counter-current universe of expanding spatially left-handedly L_e (or contracting spatially right-handedly R_c), and mass medium contracting right-handedly R_c (or expanding left-handedly L_e) can be visualized as second variety that is not in the domain of this article.

5(16)8b – Discussion

According to *Sec. 10(6), Eq. 10(11), Note 10(6)1*, π^-, *Eq. 5(70)8b,* decays ultimately [through μ^- decay, *Eq. 10(8)*] to left-handed electron and right-handed electron antineutrino, *Eq. 10(8)*, and left-handed muon neutrino and right-handed muon antineutrino. Therefore, K^o decay's end-product, *Eq. 5(70)8b*, consist ultimately of *3* right-handed *(type R)* quantized H hall quantized packages, *Sec. 5(16)3a,* related to e^+, *Eq. 5(70)8b,* $\overline{\upsilon_e}$ and $\overline{\upsilon_\mu}$, *Eq. 10(8),* due to π^- decay and *4* left-handed *(type L)* H hall quantized packages related to υ_e, *Eq. 5(70)8b*, e^-, υ_μ, *Eq. 10(8),* and photon, *Eq. 10(11).* Please refer to *Sec. 5(16)3b, part G,* and *Sec. 5(16)11*. Resuming, based on handedness conservation, *Note 5(16)8b1*, i.e. K^o overlapped H hall quantized package expands ultimately to 3 *type R*, H hall quantized packages (related to type *R* Universe), and 4 *type L* ones (related to type *L* Universe), along its related time's arrow, *Sec. 5(16)7a*. Noteworthy, the decay products of neutral kaon K^o constitute an H system of slight preference of type L_c path-length over R_e one, *Sec. 5(16)11*, before a measurement, *Sec. 8(7)2*, i.e. the same as the K^o before decaying. Factually, by the same argument, similar result will be obtained for $\overline{K^o}$ decay and its end-products According to these statements and *Sec. 5(15)2b, the Eq. 5(70)8c* is favored, whereas *Eq. 5(70)8b* is not. Please refer to [239, 240, and 242] for search of right-handed currents in μ^+ decay. According to [239], *abstract division,* "Limits are reported on right-handed currents, based on precise measurement of the e^+ spectrum end point in μ^+ decay". Please refer also to *Sec. 5(16)9c, part B,* dealing with the dominance of matter Universe respect to antimatter one. Moreover, according to [242], part related to *muon decay in the standard model*, "The standard model parity violation is introduced in an ad hoc manner, by arranging (following experiment) that *W*-boson couples only to current involving the left-handed component of the fermions' fields. The questions of why nature appears to select fermions of only one handedness to participate in the weak interaction, is the context of the *SM* unanswered". Considering the above discussion, on the basis of H particle-paths hypothesis the concept of two types *R&L* Universes, *Sec. 5(16)9*, is an obvious fact. Factually in the type *R* Universe, the gravitational closed surfaces, *Secs. 5(4), 5(16)5,* of left-handed negatively charged fermions, e.g., electron's electromagnetical field expands in a right-handed manner, i.e. right-handed negapa. Moreover, in type *L* one, the closed surface of left-handed positively charged fermions, e.g., hadrons electromagnetical fields, expands in a left-handed manner, i.e. left-handed posipa, with the preference of right-handedly expanding type *R* Universe that can be considered as our matter Universe (or vice versa related to antimatter Universe). In other words, the left-handed fermions belong to type *L* Universe; but the field of negatively charged category expands in type *R* Universe and positively charged one expands in type *L* Universe conjugate in a one-way manner with the dominance of right-handedness combined expansion in matter Universe, *Consequence 5(16)8b1*.

According to *Consequence 5(16)8b1*, during a measurement, *Sec. 8(7)2, part c* (or decay process) one of the left- or right-handed feature of a particle (e.g. K^o or $\bar{K}^o$) is revealed randomly, *Sec. 8(7)2, part E4,* along with slight preference of the former in our matter Universe. Factually, a particle in each of its left- or right-handed feature has two path-lengths, *Sec. 2(1)2*, of opposite signs. The magnitude of left-handed one (or entropy, *Sec. 5(16)9d*) has a slight excess respect to its right-handed aspect. As a result, the total path-length of the spatially right-handily expanding matter Universe is increased steadily this manner. Noteworthy, there is an excess of path-length (or negentropy, *Sec. 5(16)9d*) through the contracted form of matter, i.e. mass, *Note 2(1)3b,* in type *R* matter Universe that has not taken account in the above statement). It has the same magnitude as the stated above excess through the expanded form of matter (or spatial vacuum texture, *Sec. 5(16)b*) in the matter Universe. In other words, the total algebraic sum of path-length of the two type *R & L* countercurrent universes has the same magnitude, and opposite sign. Please refer also to *Sec. 5(2)1c, part c1* in this regards. As a result, the total algebraic sum of path-length of the Universe is remained unchanged from viewpoint of bi-Universe hypothesis. If we suppose mass of matter accept left-handed (type *L*) path-length in type *R* matter Universe. Similarly, the antimatter accept right-handed (type *R*) path-length. The conservation of types *R* (or *L*) path-length leading separately to conservation of lepton and baryon numbers respectively. Noteworthy, the particle with left-handed (or right-handed) H hall quantized package, *Sec. 5(16)3a*. Resuming in matter Universe, any matter particle is contracting due to spatial expansion. Thus, any particle of positive electric charge is contracting. The first category of matter particle has left-handed path-length. Similarly, in case of second category, the reverse argument is valid. As a result in matter Universe, all of the particles have contracting left-handed path-length; whereas, the quantized texture of vacuum space has an equal magnitude of expanding right-handed path-length, i.e. type *R* Universe, or, vice versa in case of type *L* one.

According to above discussion, in case of decay process K^o in the left hand side of *Eq. 5(70)8b* it has type *L* path-length; whereas, in left hand side of equation π^-, υ_e have type *L* path-length, and e^+ has type *R* path-length character. Noteworthy, the total path-length of K^o, and its decay products before measurement is remained constant. Similarly, by the same argument $\bar{K}^o$ has type *R* path-length aspect.

Consequence 5(16)8b1- There is a competition of spatially right-handed expanding (type R), and left-handed contracting (type L) of counter-current Universes, *Sec. 5(16)9a*, (indistinguishability in case of particles in microcosm before measurement, *Sec. 8(7)2)*) along with slight preference of type R one in our matter Universe over its type L counter-current counterpart. It is nominating simply type R_e, i.e. first category, *Note 5(16)8a1*; please refer to *Sec. 5(16)11*. For reason of simplicity, in some parts of this article the two types R_e & L_c are shown as *R & L* respectively.

Note 5(16)8b1- Factually, the path-length of matter particle is at equal magnitude and opposite sign of its antimatter one in spatial medium, i.e. $+h,-h$ respectively that is leading to handedness conservation.

5(16)8c – Sub-unique H system

The path-length, *Sec. 2(1)2*, of K^o is equal to algebraic sum of type *L&R* path-lengths of end products in *Eq. 5(70)8b*. Noteworthy, the end products are correlated, *Secs. 8(7), 8(9),* with each other's in the framework of an H hall package of the same handedness as in K^o, i.e. a Unique H system, *Sec. 8(5).* Therefore, during measurement, *Sec. 8(7)2,* (or interactions), the H hall package of each of the end products are taken forms. Please refer also to *Sec. 5(9)3d* in the case of path-length at opposite sign, and their algebraic sum, in case of an isolated system. According to that e^+,υ_e in the right side of *Eq. 5(70)8b* (nominating L_c choice), there are two path-lengths of equal magnitudes and at opposite signs. In other words, according to *Sec. 5(16)11* e^+ has expanding type R_e path-length of SN_r configuration, υ_e has contracting type L_c path-length of SP_l configuration. Therefore, the algebraic sum of path-length of this system constituting of lepton-antilepton remained unchanged (or zero), *Note 5(16)8c1*, and is increased by five units.

According to above discussion, the leptons, *Sec. 10(6),* and antileptons have two path-lengths of equal magnitude and opposite signs, the same argument is also valid for baryons. This phenomenon is considered in computation of lepton and baryon numbers as positive and negative sign. As a result, according to *Sec. 10(6),* in our type *R* matter Universe a lepton, e.g. electron, of left-handed axeon is mantled with electron shell. This shell is constituted of negapas of right-handed characteristic. Therefore, a system of electron and its antineutrino as a naked axeon's conjugate also of right-handed characteristic (or spin) constructs a sub-unique H system as a part of a unique H system, *Sec. 8(5),* i.e. the right side of *Eq. 5(70)8c* (nominating R_e choice) related to type *R* Universe. In other words, this unique H system is constituted of two sub-unique H systems. The first one is constituted of a lepton family, i.e. e^-,υ_e coupling of left- and right-handed characteristic of SP_l, SN_r configurations respectively, and other one of a sub-unique H system, i.e. π^+ meson of SN_r configuration, *Sec. 5(16)8d*. Therefore, in an isolated many particles system, *Sec. 8(7)6*, that is constituted of heterogeneous particles, any set of particles of the same family or category, constitutes a sub-unique system of coupled SP_l, SN_r configurations. Thus, an isolated many particles system that is regarded as a unique H system can be constituted of a set of sub-unique H systems, *Example 5(16)8c1.*

Example 5(16)8c1- One can compare by a far analogy the solar system with the right side of *Eq. 5(70)8b, or c*. In this example, the solar system can be supposed as a unique H system, whereas each of its planet and its related moons can be supposed as sub-unique H system. In this comparison, the electron and its antineutrino can be visualized as the Earth and its moon; whereas, the sun can be viewed as another sub-unique H system along with its planet-moon (e.g. Earth-moon) subsystems. In case of right-hand side of *Eq. 5(70)8c*, electron and its antineutrino has a preferred entanglement, *Secs. 8(7), 8(9),* respect to electron (or its antineutrino) with pi meson plus.

Note 5(16)8c1- In case of atoms, electrons' field constituting of negapas (i.e. negaton) of SN_r configuration has a type R_e path-length; whereas, the nuclei's field constituting of posipas (i.e. positon) of SP_l configuration, *Sec. 4(6)4*, has a type L_c path-length regardless of the path-length of electron's, and nuclei's' main bodies.

5(16)8d – Time's arrow dependence on interaction

After decay process, R_e choice, and L_c choice are revealed in the framework of a single entity (indistinguishability), the former of expanding characteristic along with time's arrow, the latter of contracting one accompanied by time's arrow reversal. Noteworthy, in our expanding matter universe there is a slight preference of R_e choice over L_c one based on bi-Universe hypothesis, *Sec. 5(16)9*, i.e. a slight preference of type *R* Universe over type *L* one as two countercurrent universes through spatial medium, nominating simply type R_e one, or vice versa that is nominating type L_e Universe. Therefore, during a measurement, *Sec. 8(7)2*, (or interaction), R_e choice along with L_c choice takes form with slight preference of R_e choice, or excess of right-handedness, *Consequence 5(16)8b1*. Note that, the R_e choice is expanding through vacuum space medium of SN_r configuration, and L_c one of SP_l configuration is contracting through the mass medium, *Note 5(16)8a1,* at a rate based on stated above excess. Please refer also to *Sec. 5(16)1c, part A1*, and *Sec. 5(16)9d, part B*. Noteworthy, the whole R_e-L_c single entity system before measurement can be regarded as a mass-body of spatial SN_r configuration due to gravitational field, and SP_l one through the mass medium, *Sec. 5(16)1b, part A, paragraph 15*.

Resulting, during an interaction, if the R_e-L_c single entity system chooses two ways of equal probability through passage of at least a singularity stage, the R_e choice leads to expansion along time's arrow generation. Similarly, the L_c one leads to contraction along with time's arrow reversal. Noteworthy, the slight preference of right-handedness over left-handedness one in type R_e matter Universe is leading to slightly none zero variation on behalf of time's arrow, i.e. time's arrow increment. As a result, the time's arrow generation is depending on magnitude and rate of interaction. Note that, in a system of particle (or particles) and measuring device, the R_e choice is along with L_c one, and slight preference of the former magnitude. It is equivalent to *T*-symmetry along with slight time's arrow at the ratio of K_Γ respect to the *T*-symmetry, *Comment 7(4)2e2*.

5(16)9- bi-Universes hypothesis

5(16)9a- Right and left-handed Universe

According to *Comment 5(16)6a,* by inversing:

I) Right-handed H particle-paths (negapa) to left-handed ones (posipa), *Sec. 1(5),* or vice versa, the positively charged Co^{60} and negatively charged electron convert to negatively charge Co^{60} , i.e. its anti-matter and positron (electron antimatter) respectively; please refer to *Sec. 4(3)2, case 3.*

II) Coordinate via mirror manner, or, in other words, the observer of antimatter Universe use a left-handed coordinate system, *Sec. 5(16)5,* respect to right-handed coordinate of matter Universe.

Please refer *to Remark 5(16)9a1, and Sec. 5(16)5, Remark 5(16)5a, Comment 5(16)5b*, and *Sec. 5(16)8c*.

The magnetic moment of anti-Cobalt 60, nucleus also point up because of negatively charged nucleus. This observer would conclude that the charged leptons (positrons) are preferentially emitted in the direction opposite of the magnetic moment of nucleus. Hence, his observation is the same as that of the right-handed observer in the matter Universe; please refer to *Example 5(16)9a1*. From these results, we concluded that the weak force responsible for β decay is symmetric under the combined transformation of reflection [*parity, P, Sec. 5(16)6*], i.e. case *II*, and charge conjugation (c), i.e. *case I*, or, we say the β decay is *CP invariant*[149] during Co^{60} , β decay. Moreover, the two cases, *I & II* can be generally visualized as conversion of left-handed to right-handed one, or vice versa, conversion from view point of H particle-paths hypothesis. According to *Sec. 2(1)1b, Consequence 2(1)1b1, case 3c* supposing three components for time; the time also can be regarded type *R* related to right-handed path-length as in type *R* Universe and type *L* related to type *L* universe, *Note 5(16)9, a1*. As a result, it is better to say both space and time combination (or path-length) can be regarded as right-or left-handed, *Consequence 5(16)9a1*. The type *R* time respect to type *L* one, *Sec. 5(16)1b, part A, paragraph 15*, means that advance in one dimensional time component (e.g., x-coordinate) *Sec. 2(1)1b, Consequence 2(1)1b1, part 3c*, in *type R* Universe, $t_{0x}>0$ is equivalent to the related time component (e.g. x'-coordinate), $t_{x'}<0$ (i.e. into the past) of type *L* Universe or vice versa. By the way, the negapa and posipa are right- and left-handed H particle-paths respectively; thus, according to *Sec. 6(2)3,* negapa reflect backward as posipa, i.e. its dimension in the direction of motion along with related time component reversed during macro-bodies collision, light reflection by a macro-body and vice versa. Noteworthy, in the world of religions, e.g., ancient Persian Avestic, and Mazdakite dualistic religions, there are two rival spirits or original Principles, *Comment 5(16)9a1*.

As a result, the time type *R* of negapa (e.g. spatially right-handed in vacuum medium from the mass medium) is compensate by type *L* time (or time reversal) of posipa (e.g. spatially left-handed in vacuum medium towards the mass medium, *Sec. 7(4)2e*), *Sec. 5(16)9b*. Therefore, the returned internal time δT , *Note 2(6)2,* of a mass body at rest is equal to zero, or, in other words, the rest (external) time, ΔT_0 , has its maximum value, *Remark 5(16)9a2*. Now, in case of a moving object the returned time, δT has non-zero value due to single direction motion of negapa and posipa respect to the counter-current one at rest state.

Generally, through one of the space and time coordinates inversion, e.g., $x \to -x'$, *Comment 5(16)9a2*, and $t_{0x} \to -t_{x'}$, *Comment 5(16)9a3,* we can transfer from right-to left-handed configuration or vice versa. In other words, if two axes of a couple of three-dimensional right-and left-handed reference frames coincide, the third ones are at opposite directions of each other. Therefore, this statement is valid for three-space and time coordinates, *Sec. 2(1)1b, Consequence 2(1)1b1, case 3c*. Remarkably, the handedness of spatial dimensions, *Comment 5(16)9a2,* and time *Comment 5(16)9a3,* and charge, *Secs. 4(3), 4(5),* that are the results of right and left-handedness behavior of H particle-paths construct, *CPT* invariance, *Sec. 5(16)6*.

Consequence 5(16)9a1- In fact, inseparable space and time must be regarded as right- or left-handed entity instead of merely time alone that revealed in the form of right-or left-handed path-length, *Sec. 5(16)11,* from view point of H particle-paths hypothesis. The path-length in this hypothesis can be compared with space-time in *SRT & GRT*; therefore, the curved space-time is comparable with curved path-length related to path-limit Γ , *Sec. 1(12).*

Example 5(16)9a1- "Neutron can decay in free space inside nuclei into proton and electron and right-handed antineutrino, proton inside a nucleus can decays into a neutron, a positron and left-handed neutrino, we note that left-handed anti neutrino and right-handed neutrino never been seen"; please refer to [149], and *Remark 5(16)9a1*. Based on H particle-paths hypothesis, according to *Sec. 5(16)5*, and right-handedness of negapa related to electron field, *Sec. 1(5),* and left-handedness of posipa related to positron field, we concludes that during neutron decay space expands preferably right-handedly, *Note 5(16)8b1*. Moreover, proton stability to decay can be interpreted as during its decay space must be expand preferably left-handedly related to antimatter mode of expansion; please refer to *Sec. 5(16)8b.*

$$n \to p + \bar{e} + \overline{\upsilon_e} \qquad 5(70)8b1 \quad ; \qquad p \to n + e^{+} + \upsilon_e \qquad 5(70)8c1$$

By the way, comparing, *Eqs. 5(70)8b, c, & 5(70)8b1, c1,* respectively; the $\overline{K_o}$ half-life is shorter than K_o by the same reason. Moreover, neutrinos and antineutrinos for their naked axeons, *Sec. 10(8)* characteristics (negligible rest mass) have no apparent role in spatial expansion; please refer also to *Sec. 10(6).* In other words, spatial expansion is performed through engaged axeons of particles, atoms, and molecules of normal matter; please refer to *Sec. 5(15)2b*. According to above statements, the *Eq. 5(70)8b1* is favored and *Eq. 5(70)8c1* is forbidden. According to [309] "Theoretical motivation despites of lack of observational evidence for proton decay, some grand unification theories required it. According to some of these theories, the proton would

have a half-life of 10^{36} years, and would decay into a positron and neutral pion that itself immediately decays into photons in the range of gamma radiation:

$$p \rightarrow e^{+} + \pi^{0} \rightarrow e^{+} + 2\gamma \text{ "} \qquad 5(70)8c2$$

The *Eq. 5(70)8c2* for the above statements is also not favored.

Note 5(16)9, a1- "The idea that the universe can split into two branches is a potential solution to the father dead or alive? problem. It is considered in detail in David Deutsch's book, The Fabric of Reality"[571] *Comments, Andrew Thomas, 3rd January 2007.* According to *HPPH*, it is based on types R & L Universe according to bi-Universe Hypothesis, *Sec. 5(16)9*.

Comment 5(16)9a1 – According to Avestic religion, Ahura Mazda is the creator of goodness, and Ahriman is the creator of darkness. "The result of the dualistic conception of the Universe is that of a continuous warfare that has been going on even from the beginning between two hostile worlds or Camps" [442] *part II Dualism*. According to Mazdakism, there exist two original principles. Good (or light) and Evil (or Darkness), light acts by free will and design; Darkness, blindly and by chance. By accident the two became mixed, producing the world" [443]. "And of everything we have created pairs that you may be mindful" [110]*A Al-Dhariyat, Surah 51, verse 49*. " The absolute pure is God who created in pairs all things that the Earth produces as well as people themselves and ***other things which is not known to mankind yet***" [110]*A Ya-Sin, Surah 36, verse 36*. According to Quran, any thing is existing along with its conjugate, e.g. electron & positron that is not known at that time.

Comment 5(16)9a2- The same result is obtained by simultaneous inversion of three spatial coordinates, i.e. $x \rightarrow -x', y \rightarrow -y', z \rightarrow -z'$; thus, the transformation is termed inversion, it transformed a right-handed coordinate to a left-handed one. No rotation in space can make these systems coincide (like left-hand and right-hand gloves). The wave function is linear; therefore, if it is not changed its forms during this transformation. The function is termed even if its signs do not change or odd if its sign changes during this transformation [36], *part 31, page 334*; please refer to *Sec. 8(1)3*. An H particle-paths and its counter-current partner (conjugate), *Sec. 3(1)2,* can be attributed to the even and odd natures of a wave function respect to inversion transformation respectively from view point of H particle-paths hypothesis.

Comment 5(16)9a3- The same result is obtained by simultaneous inversion of three time coordinates, *Sec. 2(1)1b, Consequence 2(1)1b1, case 3c,* i.e. $t_{0x} \rightarrow -t_{x'}, t_{0y} \rightarrow -t_{y'}, t_{0z} \rightarrow -t_{z'}$; this transformation is termed time coordinate inversion, it transformed a type *R* time coordinate to type *L* one [similar to *Comment 5(16)9a2*]. Through this time transformation, alternate result may be obtained from wave functions and equations. Please refer also to *Consequence 5(16)9a1*.

Remark 5(16)9a1– According to *Sec. 5(16)8, Eqs. 5(70)8b,c,* considering K^0, related to our matter Universe, and $\overline{K^0}$ to antimatter one. Based on neutrino handedness, i.e. left-handed neutrino υ_e, is related to K^0 decay products and right-handed $\overline{\upsilon_e}$ related to $\overline{K^0}$ decay products. In fact, according to *Sec. 10(6),* the positron right-handedness as in, *Eq. 5(70)8b,* and electron left-handedness, as in *Eq. 5(70)8c,* can be referred to their internal axeons, *Sec. 10(8),* as positron antineutrino and electron neutrino, *Eq. 10(10),* respectively. Generally, the handedness behavior in fundamental particles is specified by the related neutrino or antineutrino handedness; *Sec. 1, Remark 1(5)1.* As a result, the neutrino, and antineutrino conserve the handedness in the decay process end-products before a destructive interaction (or measurement, *Sec. 8(7)2*).

Remark 5(16)9a2- Remarkably, the proper time Δt_0, in any reference frame, e.g., The Earth, respect to its own observer at rest is the manifestation of total sum of space expansion (accompanied by time's arrow) such as gravitational spheres expansion*, Sec. 5(4),* expansion due to thermodynamically irreversible process such as β decay, *Secs. 5(16)6, 8*, glass smash, fuel burning, etc., through it in our matter Universe; moreover, the spatial expansion related to particle generation, e.g., electron, proton, located in an H hall quantized package, *Sec.5(16)3*, obeys the *Eqs.7(5),7(10);* please refer also to *Remark 5(16)7a.*

5(16)9b- Handedness reversal

"The basic probability equation developed by Max Born back in 1926, itself contains an explicit reference to the nature of time and to the possibility of two kinds of Schrödinger equations, one describing waves that move forward in time and the other representing waves that move backward in time"[173], part related to *solving the quantum mysteries*. According to H particle-paths viewpoint in a right-handed Universe (type *R* of SN_r configuration), the waves that move forward in time can be represented by right-handed H particle-paths, i.e. negapa that is in counter-current motion, *Sec. 3(1)2,* by its conjugate, i.e. left-handed H particle-path (posipa). The latter can be considered as waves that move backward in time, *Sec. 8(1)2,* i.e. reversed time's arrow, *Sec. 5(16)3f, part B*. It is obvious that this order is reversed at the case of type *L* Universe of SP_l configuration; please refer to *Sec. 5(16)2a, Consequence 5(16)2a*. As a result, there is a steady conversion to left-handedness in mass medium along with right-handedness in spatial part of type *R* Universe, *Sec. 5(16)11*. E.g., weak interaction of the short range weak force only affect left-handed fermions that make up matter, *Sec. 6(2)5*, the reverse process, i.e. handedness reversal must be performed on the basis of *CPT* symmetry. According to [223]" The implication of *CPT* symmetry is that a mirror image of our Universe - will all object having momenta and positions reflected by an imaginary plane (corresponding to a parity inversion), with all matter replaced by antimatter (corresponding to a charge inversion) and reversed in time – would evolved exactly like our Universe. At any moment, the two Universes would be identical and the *CPT* transformation would simply turn one into other", contrary to the

idea as in [252] over time most of the antimatter has annihilated with matter. Leaving the very small initial excess of matter to dominate the Universe"; please refer to *Sec. 5(16)6.* Factually, considering two opposite electrical charges are reverse handedness of each other, *Secs. 1(5), 2(1)1d, 4(5),* related to H particle-paths behavior as singlet that are correlated with parity and time (as H particle-paths behavior in its single direction and reversible motions, *Sec. 1(3)*), we conclude that *CPT* symmetry is related to handedness (or handedness reversal) behavior of H particle-paths. In other words, a *type R expansion dominant* Universe (matter) is transformed to its *type L contraction dominant* conjugate (antimatter) and vice versa, *Sec. 5(16)9c, part B*. At the normal condition, for the reason of irreversibility of space expansion along with its time's arrow generation, this kind of transformation is almost inaccessible. Except in the special case and region, i.e. right handedness to left handedness conversion (i.e. time's arrow reversal along with space contraction) during interaction in a limited energy-space-time location, *Sec. 5(16)9c*, *part A, Secs. 5(16)10, 7(5).*

Resuming:

A) Time's arrow along with space expansion (translational & spirally, *Sec. 5(16)5)* related to matter Universe [related to left-handed fermions, and leptons,..]

B) Time's arrow reversal along with space contraction (translational & spirally) related to antimatter Universe [related to right-handed antifermions, and antileptons,..]

$$\text{Antimatter} \quad \overset{\text{Time-arrow Space-Expansion Right-handedly manner}}{\longrightarrow} \quad \text{Matter} \quad \overset{\text{Time-arrow-reversal Space-Contraction Left-handedly manner}}{\longleftarrow}$$

Comments 5(16)9b1, b3 5(70)8d

In other words, a matter Universe during its time's arrow reversal and space contraction as stated above will be transformed to antimatter one and vice versa; therefore, left-handed fermions, and leptons in our matter Universe are reversed to right-handed antifermions, and antileptons during this transformation respectively and vice versa; please refer to *Sec. 5(16)8b.* Therefore, at each instant there is an equilibrium between two back to back coherent matter and antimatter in the favor of matter, *Eq. 5(70)8d*, that depends on the total rate of expansion. It can be related to the internal counter-current mode of motion, *Secs. 1(3), 3(1)2,* of right-handed negapas and left-handed posipas of mass-bodies respectively, *Comment 5(16)9b2*; please refer to *Sec. 5(16)2a, Consequence 5(16)2a.* As a loose comparative example as if a left-handed rolled of paper sheet (or tissue) is opened and rolls right handedly, *Remark 5(16)9b1*. If the matter Universe after an expansion period will be contracted as its antimatter form down to the Big-Crunch a period before Big Bang, *Sec. 5(15)3b*. In other words, if the Universe is evolved as expanding it has matter characteristic (as it is at present time). Therefore, the same Universe in its probable contracting evolution will be antimatter, (*bi-Universes hypothesis*), *Note 5(16)9b1*, i.e. H particle-paths handedness reversal, in contrary to the idea that matter Universe is the remnant of matter and antimatter annihilation with the preference of matter respect to antimatter, *Sec. 5(16)9c, part B.*

Note 5(16)9b1 – The bi-Universe hypothesis is an intrinsic characteristic of rest mass, it cannot be attributed to the field, *Sec. 8(7)2, part B.* Factually, there's a countercurrent motion of type $R \,\&\, L$ H particle-paths, *Comment 3(1)2b*. In case of matter Universe, there is a slight preference of negapa over posipa in expanding spatial medium, i.e. SN_r configuration, and type R_e path-length, and an equivalent preference of posipa over negapa within mass medium, i.e. SP_l configuration of type L_c path-length, *Sec. 5(16)11*. In other words, according to bi-Universe hypothesis, there is a slight preference of type R Universe in expanding spatial medium along with slight preference of type L Universe over type R in contracting mass-medium, i.e. type $R_e - L_c$ matter Universe nominating simply group *R* Universe (or vice versa in case of antimatter Universe, i.e. type $L_e - R_c$, nominating simply group *L* Universe). Please refer also to *Sec. 7(4)3*.

Comment 5(16)9b1- Factually, the expansion of the universe is performed through H hall package, *Sec. 5(16)3a* generation. To an H hall package as a spatial quantized entity associated with a path-length of h value. In a right-handed Universe, the spatial expansion is performed right-handedly through right-handed H hall package (or path-length of h value). "The law of conservation of angular momentum controls Planck's constant. This constant is a vector value. The direction of this vector coincides with the direction of the vectors of the magnetic moments of the electron and the proton. The electron availability of the rotation process of the electrons allows for the possibility for us to suppose that this process form right-handed Planck's field near electron. As the electron and hydrogen atom are the main connecting links between the atoms in the molecule, their right-handed Planck's field should influence this process. It is that the *DNA* molecule's helix is twisted to the right" [383]. According to H particle-paths hypothesis, any particle in micro world, e.g., photon, electron, hydrogen atom, are confined in a H hall package of path-length value h that is expanded in a path-limit Γ. As a result in our matter Universe these H hall packages have right-handed path-length.

Comment 5(16)9b2- "None has ever produced antimatter without obtaining the corresponding matter particles also. The scenario must have been the same during the birth of the Universe, when equal amounts of matter and antimatter must have been produced in the Big Bang. Just one more thing…"So if matter and antimatter annihilate, and we and everything are made of matter, why do we still exist? This mystery arises because we find ourselves living in a Universe made exclusively of matter. Didn't matter and antimatter completely annihilate at the time of the Big Bang? Perhaps this antimatter still exists somewhere else? Otherwise where did it go and what happened to it in the first place? The mystery demands teams of scientific Sherlock Holmeses to conduct thorough detective works to uncover a logic that is ultimately elementary"[525] *Antimatter detective*. "Why do we observe matter and almost no antimatter if we believe there is a symmetry between the two in the Universe?"[532]. The stated above mystery is solved by heuristically assumption of countercurrent bi-Universe hypothesis based on H particle-paths hypothesis. Therefore, there is no need to scientific detective as mentioned above.

Comment 5(16)9b3- Based on bi-Universe hypothesis, *Note 5(16)1b, A1*, there is a competition between two right- and left-handed Universes, *Sec. 5(16)9*, i.e. a competition between group *R* gravitational spheres with related group *L* ones along with slight preference of the former in a $R_e - L_c$ Universe, *Note 5(16)9b1*. In other words, the $R_e - L_c$ Universe overcomes the $L_e - R_c$ one in spatial medium, *Sec. 7(4)3, part A*, and their handed reversal within mass medium, *Sec. 7(4)3, part D*.

Remark 5(16)9b1– At the present, we are in the flat middle of this paper sheet. According to [261], The density of the Universe is very close to the critical density, and that the geometry of the Universe is flat, like a sheet of paper, that is the result confirmed by the *WMAP* science; please refer also to *Sec. 5(5)2*, and article [259] in this regards. Please refer to *Sec. 5(16)4, Remark 5(16)4b*. As a result, according to *Sec. 5(16)2a, Consequence 5(16)2a*, after the consumption of dark matter to dark energy in an accelerating expanding matter Universe, finally, the handedness reversal will be occurred based on negapa conservation to posipa and vice versa. In other words, at this stage we encountered with an accelerating spatial contraction along with time arrow reversal at SP_l configuration. Therefore, the fermions are converted to related right-handed conjugate antifermions of SN_r configuration based on Mirror Image Effect, *Sec. 6(2)3*. Noteworthy, the negative charges are converted to related positive ones, and vice versa. In case of charge reversal during handedness reversal of their H particle-paths, please refer to *Secs. 4(3)2, 4(5)*. Resuming, the three stated phenomena can be referred as *CPT* symmetry. Moreover, entropy, *Sec. 5(16)9d, part A,* is decreased in such a contracting left-handed antimatter Universe. "If the Universe is homogeneously matter-dominated now, then *CPT*-symmetry would imply that it will be homogeneously antimatter-dominated at the time inverted epoch in the future" [448] part related to *T-violation in the weak interaction*.

5(16)9c – Preference of matter respect to antimatter

A) (proposal)- According to *Sec. 5(16)9b,* and kaon-antikaon oscillation mechanism [222].

$$\underset{s}{\overset{d}{-}}\left(\overline{K^o}\right) \xrightarrow[\text{Time arrow}]{} \underset{d}{\overset{s}{-}}\left(K^o\right) \qquad 5(70)8e$$

$$\xleftarrow[\text{Time arrow reversal}]{}$$

Antimatter (Type L Universe) *Matter (Type R Universe)*

Two different neutral *K*-mesons carrying different strangeness can turn from one into another through weak interactions, since these interactions do not conserve strangeness. The strange quarks in K^o turn into a down quark by successively emitting two *W*-bosons of opposite charge. The down antiquark in $\overline{K^o}$ turns into a strange antiquark by absorbing them and vice versa. There is a steady time's arrow and time's arrow reversal (*CPT* symmetry) between K^o and $\overline{K^o}$ system. As there is a time's arrow dominates in our matter Universe, the above equation is shifted to the right side analogous to a chemical reaction at an equilibrium state in the favor of K^o due to external and background time's arrow, *Sec. 5(16)1c, case B*, or better to say to the related H particle-paths effect. Noteworthy, the preference of matter respect to antimatter is very low and in order of gravitational field strength due to exit of expanding spheres, e.g., 1part per 100 millions; please refer to *Sec. 5(16)10, Example 5(16)10*. Factually, the preference of matter Universe respect to antimatter one due to gravitational expanding spheres is negligible in case of emission, absorption, collision (i.e. an equal probability at the ratio of strong interaction e.g., collision respect to weak gravitational effects.

B) As a result of *part A*, in case of a mass-body there is a competition between internal right-handed negapas (related to matter Universe) along with forwarding time's arrow, ΔT_F, and left-handed posipas (related to type *L* Universe) accompanied by backwarding time's arrow reversal, ΔT_B, *Sec. 2(10), Eqs. 2(116) to (119),* in a counter-current, *Sec. 3(1)2,* (or reversible) mode of motion of H particle-paths on the favor of negapas on the basis of preference of right-handed expansion in matter Universe respect to left-handed contraction in antimatter one. This preference is depended on the rate of expansion of gravitational spheres, *Sec. 5(4),* both radially & spirally of the related mass-body in matter one (or vice versa) ; please refer to *Sec. 5(16)1c, parts A1, A4*. In other words, if the expansion rate stopped suddenly, the H particle-paths of matter will be contracted or collapsed, *Sec. 5(16)1c*, *A1*, please refer also to *Comment 5(16)5b*, and *Sec. 5(16)7h*. As a result, the time's arrow in matter Universe is in equilibrium with the time's arrow reversal in antimatter one with the preference of the former during the expansion phenomenon. In fact time's arrow is inseparable from space expansion, *Consequence 5(16)9a1* (i.e. H hall quantized packages, *Sec. 5(16)3a*, generation) and vice versa; please refer to *Sec. 6(2)3, Consequence 6(2)3a*. Generally speaking, disorder in one Universe is accompanied by ordered in its conjugate contrary to the case set forth through, *Fig. 5(11)b, Sec. 5(16)9d, part A,* on the basis of dynamical symmetry in time.

5(16)9d – Entropy and arrow of time dependence

A) General aspect

According to [164], "for every set of motions that raises the entropy, there is an opposite set (perfectly consistent with the law of dynamics) that lowers it in violation of the second law of thermodynamics". In fact by simply reversing the sign of the time parameter in Boltzman's proof, one may conclude that, just as the entropy will rise from a specified low-entropy state as a result of inter-molecular collisions, so too must it have fallen from a higher entropy state, prior to the specified state", *Fig. 5(11).* Please refer also to [141] *Lodschmidt's paradox*. "It turns out that the entropy of either a black hole of the Universe is proportional to its size squared. But, the Universe is expanding, so its size is increasing. Thus, the total entropy of the Universe is also increasing. This leads us to the idea that the second law of thermodynamics, *Note 5(16)9d, A1,* may be a consequence of the expanding Universe. Thus, cosmology explains this nineteenth century principle. Even more wild is the idea that if the expansion of the

Universe determines the direction of time's arrow, then if the Universe starts to contract the direction of time will also reverse" [399] *Thermodynamics of the Universe*. Please refer also to *Sec. 5(7)1, Sec. 5(7)6.*

According to H particle-paths hypothesis, by introducing handedness reversal, *Sec. 5(16)9*, along with time's arrow reversal (instead of simply time reversing according dynamical law symmetry in time) at $t<0$, the entropy may be decreased in a reverse handedness manner related to conjugate (antimatter) Universe, *Sec. 5(16)9*, respect to the case $t=0$ observer. It is nominating negentropy, *Sec. 5(16)9d, part B*. It evaluates entropy increasing during $t>0$. In other words, there is a reversed handedness entropy state, i.e. complex conjugate entropy state. Thus, at any equilibrated state of gas we can refer an state in the favor of space expansion and time's arrow and an equally conjugate state in the favor of space contraction and time's arrow reversal that can be compared with H particle-paths and its counter-current partner conjugate, *Sec. 3(1)2.*

As a result, at any given instant related to $t=0$ of time origin by infinitesimal increasing, $dt>0$ of time's arrow we have negapa and posipa, *Sec. 1(5),* as in mass-body; thus, by reversing to $dt<0$ (time's arrow reversing) we encountered with their related counter-current, *Sec. 3(1)2*, i.e. posipa and negapa respectively. In other words, the reversed handedness confogurations, *Secs. 5(16)9, 6(2)3; please* refer to *part c.*

Therefore, there is an handedness equilibrium at each instant of time's arrow, i.e. an equilibrium state, *Sec. 2(4)1, Remark 2(4)1b*, of *disorder/order* competition of *matter Universe/antimatter conjugate Universe* at a low rate entropy increasing in the preference of expanding matter Universe. In other means, according to *Sec. 5(9)d, part B* during time's arrow there is a steady right-, and left-handedness separation based on this disorder/order competition respectively. It must be added to the entropy of expanded gas in its equilibrium state inside the box, *Fig. 5(11)a*, (bottom picture). This equilibrium is continuously broken due to exit of gravitational spheres, *Sec. 5(4),* in the preference of time's arrow, i.e. space expansion due to H hall package increment, *Sec. 5(16)3a*; please refer to *Sec. 5(16)1b, part A, Remark 5(16)1b, A2*. According to [249]" Our Universe expanded at the expense of a twin Universe that collapsed down to microscopic size, *Remark 5(16)9d, A1*. In our matter Universe, the low contraction (or relatively more expansion) related to electron with right-handed negapa, *Secs. 1(5), 4(3), 4(5).* Similarly, the high contraction along with the reversed time's arrow (or, relatively less expansion) related to positively charged nucleon, i.e. left-handed fermions, due to left-handed posipa that is reversed handedness (conjugate) of right-handed negapa. Moreover, the local time's arrow rate in the above case is defined by local gravitational expansion rate, *Sec. 5(16)1b, part A*; please refer to *Sec. 5(16)9c*, *part A*.

According to [180] "a block diagram of the relationships of the various arrows of time postulated by two models *A* and *B* are illustrated that is based on thermodynamic and electromagnetic concepts".

As a result, according to the above statements we have two time's arrows as following:

1- A universal time's arrow due to expansion of gravitational closed surfaces (or spheres) that cannot be stopped and depend on the mass characteristic, *Sec. 5(16)1b, part A*, i.e. the gravitational time's arrow.

2- A local time's arrow that is revealed only during expansion of a gas in a box. In other words, H hall quantized package generation (or space expansion) along with time's arrow up to reach equilibrium. Therefore, through expansion of a contracted gas from a low volume in the box to higher one, during gas expansion the related time's arrow appears until to reach equilibrium in the latter stage, i.e. thermodynamically time's arrow.

3- According to [251B], *section 3*, "If one watched a random box of gas it would be in equilibrium almost all the time, a state with no arrow of time".

Factually by increasing the box volume the thermodynamic time's arrow also can be extended accordingly up to an infinite box volume (or vacuum space) during H hall quantized packages generation of gas H system, i.e. entropy increasing; please refer also to *Sec. 7(2).* "It seemed to many physicists that there was some sort of connection between time's arrow and entropy increase" [434] *part 8b*. By the way the equilibrium state of the gas molecules inside an isolated box considering collision of gas molecule with each other and with that of box wall it can be interpreted as following:

During each collision (or impact) contact at first step a time's arrow reversal along space contraction, i.e. H hall quantized packages diminution (or overlapping), take place that is compensated equally with space expansion and time's arrow through a reversed handedness; thus, an equilibrium will be obtained; please refer to *Sec. 2(1)1c*, in this regards.

Note 5(16)9d, A1- "The rule that entropy increases with time is called the second law of thermodynamics" [558] *Entropy*.

Comment 5(16)9d, A1- Boltzman proved that random molecular agitation would (with overwhelming probability) drive the gas to a higher entropy state at $t>0$. However, because the underlying dynamical laws are symmetric in time, the same reasoning leads to the conclusion that the gas must also have been at a higher state at $t<0$. This suggests that the arrow does not reside with the molecular dynamics, but concerns the question of how the low-entropy state at $t=0$ was achieved in practice" [164]. According to *Note 5(16)9d, B1*, during $t>0$ the entropy increment in a system through spatial medium is along with negentropy increment at opposite sign in mass medium through a time arrow reversal at equal magnitude to intrinsic time's arrow of gas molecules at spatial medium, *Sec. 7(4)3*, from viewpoint of H particle-path-hypothesis. Please refer to *Fig. 5(11)b*.

Remark 5(16)9d, A1– "A critique of cosmic inflation who emphasized the point that initial conditions which made it possible that a thermodynamic arrow of time in a Big Bang type of theory must necessarily a low entropy initial state of the Universe and therefore to be extremely improbable"[319], *Antropic principle in cosmic inflation*. According to H particle-paths hypothesis the twin universe of our matter Universe is its counter-current conjugate, i.e. antimatter universe, that is based on bi-Universe hypothesis, *Sec. 5(16)9b*. Thus, the disordering in one is accompanied by equivalent ordering of the other. At the present, the disordering (or entropy) is related to our matter Universe due to spatial expansion, and ordering (negentropy) related to the mass contraction, Sec. 5(16)11. After the full expansion, *Sec. 5(15)2b*, the Universe will be begun to contract in its antimatter form, *Sec. 5(16)9, Remark 5(16)9b1*, down to Big Crunch, along with entropy decrement.

B) Discussion

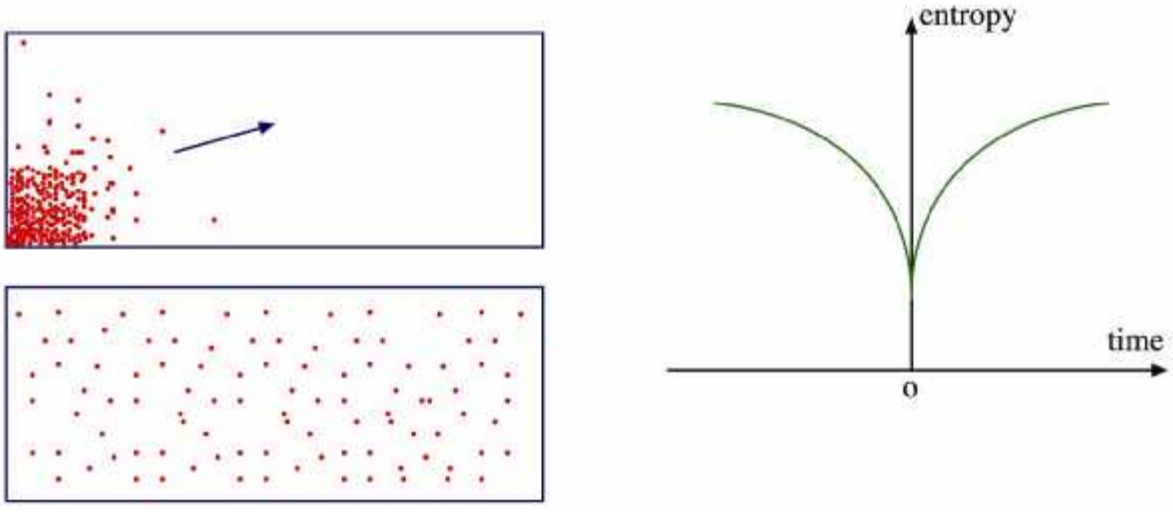
According to discuss held in *Sec. 5(16)9d, part A, and Sec. 5(2)1c part c, Remark 5(2)1c4.* The spatial expansion of our type *R* matter Universe, *Sec. 5(16)9a*, is along with right-handed H hall packages, *Sec. 5(16)3a*, increment (or entropy increasing) due to expandons, *Sec. 5(16)1c, part A3*, generation. Thus, according to Mirror Image Effect, *Sec. 6(2)3.* It is associated with a left-handed H hall package contraction (or overlapping), *Consequence 5(16)2a1*, along with entropy decrement, *Note 5(16)9d, B1*, (nominated negentropy in mass medium) that is related to contractons respect to the initial H hall package.

Resuming, the rate of production of physical entropy by expandons (of spatial expansion) is equal to the rate of production of negentropy by contractons (contracted inside the mass) of H systems in our Universe. According to *Sec. 3(1)2*, a bosonic type mass-body (e.g., dark matter) of *SM* configuration, *Fig. 3(4)c*, confined in an H hall package (type *M*) is split to expandons of SN_r configuration, *Fig. 3(5)b*, confined in right-handed (type *R*) H hall package in vacuum space. It is associated with contractons of SP_l configuration, *Fig. 3(5)a*, confined in a left-handed (type *L*) H hall packages in fermionic matter, *Sec. 5(15)2b*.

As an example, an H hall package type *M* has path-length value h, *Sec. 5(16)3g*, is split to e.g., *4* expanded type *R* H hall packages each of path-length value h, and e.g. *4* contracting type *L* H hall packages each of path-length value h of opposite sign, *Sec. 5(16)3b, part D2*, *item V*. Therefore, type *M* H hall package is split to *4* expanding type *R* and one type *L* contracted H hall package from overlapness of *4* H hall packages, *Note 5(16)9d, B2*. In other words, the path-length increment (i.e. right-handed spatial expansion along with time's arrow, *Sec. 5(16)7a, Sec. 5(16)9a*) is equal to $4h$ in this example, that is equivalent to *3* folds entropy increment, i.e. *4* entropies, and *4* negentropy. Please refer also to *Sec. 5(15)2,* and *Note 5(16)8a1* and *Secs. 5(16)9, 5(16)11.* Resuming, an H hall package of *SM* configuration split to equal amount of right-handed SN_r configuration, and left-handed SP_l configuration, *Sec. 5(15)2d*, but the former is evaluated as total entropy, i.e. spatial disordering, and the latter contracted to one ordered pack of negentropy that is attributed to the mass (or better to say contracton, *Sec. 5(2)1c, part c*), *Fig. 5(11)b*. In other words, the right-handed H particle-paths (i.e. negapa) are revealed in the expense of left-handed one (i.e. posipa). Please refer also to *Example 5(16)9d, B1*.

According to above discussion, and referring to *Sec. 5(2)1*, the reversed contracting of expandons leads to antigravity instead of gravity in the contracting antimatter Universe of type L_c. Therefore, the mass-bodies, and black holes are converted to antiparticles of antigravity character, i.e. this universe is transferred to smoothness; whereas, the particles, and related spatial patches preserve their correlations down to Big-Crunch at microscopic level. Noteworthy, the gravity is the result of expansion in an expanding Universe. Please refer to *Sec. 5(16)1b, part A* in this regards.

Example 5(16)9d, B1– Considering, a mass-body and related spatial patches correlated system (matter ingredients H system, *Sec. 5(16)3b, part H*), its mass-body, and related contractons of SP_l configuration entropy are ordering, whereas SN_r configuration of spatial patches entropy disordered during expansion in type R_e matter Universe. Therefore, the reverse process is occurred during contraction of spatial patches of SP_l configuration ordering along with anti mass-body (regarded as antimatter) of SN_r configuration disordering in type L_c Universe, *Sec. 5(16)11.* In other words, the algebraic sum of the entropies of both SP_l, and SN_r configurations of the whole system is remained constant during the period of expansion, and contraction, i.e. time's arrow, and its reversal. It is based on path-length of spatial patches and its equivalent path-length of opposite sign, and equal magnitude in related mass-body according to bi-Universe hypothesis, *Sec. 5(16)3b, part D2, item V.* The same agreement is also valid for other mass-bodies' spatial patches correlating system that constituting the whole Universe in a cycling Universe from Big-Bang to Big Crunch (or vice versa). Please refer also to *Sec. 5(16)9b*.



a) *- A gas is isolated in a rigid box. Initially the molecules are confined of the top picture, but as a result of the intermolecular collisions, the gas rapidly expands into the available space, eventually filling it uniformly (bottom picture). The reverse of this process (bottom picture followed by top picture) would be considered preposterous.*

b) *- At time t=0 gas is in a low entropy state, Comment 5(16)9d, A1.*

Fig. 5(11)- Entropy via time and time reversing

Note 5(16)9d, B1– "Entropy decreases towards all singularities"[450] *Hawking and the Big Crunch*. "Our Universe might have low entropy at both ends, or more generally in the region of any singularities"[450] *the case against the cold Universe*. According to H particle-paths hypothesis a matter Universe at its maximum entropy of spatial SN_r configuration is reversed back through spatial SP_l configuration at its lowest entropy related to antimatter Universe, please refer to *Remark 5(16)6d, A1,* and *Note 5(16)8a1*. In other words, the normal matter of SP_l configuration is converted to antimatter of SN_r configuration, whereas the space is contracted in SP_l configuration manner down to Big Crunch. As a result, the algebraic sum of entropy and negentropy, *Sec. 5(16)11*, related to the sum of SN_r, and SP_l configurations respectively is remained unchanged. In other means, by increasing a configuration, the other one is decreased (or vice versa). At the end of Big Crunch, the reverse process, i.e. expansion, due to matter Universe is started in the form of Big Bang at SN_r spatial configuration. Factually, we estimate the entropy variation related to spatial medium, and not to the mass medium. Evidently, based on *Note 5(16)9d*, *B2,* the correlations between the expandons, contractons, and related mass in the reversed process, and in the form of their antimatter configuration are holding. Noteworthy, this kind of correlation is established all over the expansion and contraction of the Universe, *Example 5(16)9d, B1*, between the mass-bodies and related spatial patches, *Sec. 5(16)3b, part H*, regardless of Big Bang, and Big Bang eras, *Sec. 5(15)3b,* and the size of the Universe. "Although the vast majority of microscopic motions in the Big Bang give rise to purely entropy-increasing worlds, a very, very special set of motions could indeed in an initial entropy increase, followed by a subsequent decrease. For this to come about the microscopic constituents of the Universe would not be started off moving randomly after all. But each little particle, each electromagnetic wave, set off along a carefully chosen path to lead to this very special future evolution… such changeover requires… an extraordinary degree of cooperation between countless number of atoms" [450] *the case against the cold Universe*.

Note 5(16)9d, B2 – Factually, expandons, and contractons are correlated through their related masses up to a measurement, *Sec. 8(7)2,* (interaction, or detection)). In the example of *4* expandons their H hall package take form just during a measurement. In other words, before measurement all of the expandons along with its related mass-body and generated contractons can be regarded as a unique H system, *Sec. 8(5).*

C) Entropy increment in backward time

According to bi-universe hypothesis, *Sec. 5(16)9*, in our matter Universe there is an slight preference of type R over type L one that leading to time's arrow along with entropy, *Sec. 5(16)9d*, increment in spatial medium, *Sec. 7(4)3, part A*. Therefore, at each instant there is an equilibrium between type R and L one with the slight preference of the former one. In other words, at each instant there is *T*-symmetry, *Sec. 2(3)3*, at an equilibrium stage along with slight time's arrow respect to *T*-symmetry at K_Γ factor ratio, *Remark 2(3)1b*. Similar scenario is also valid in case of reversed aspect, i.e. slight preference of type L over R one, i.e. time's arrow reversal; please refer to *Example 5(16)9d, C1* in this regards.

"In the general case, entropy increases in the backward time direction in just the same way as it increases in the forward time direction: change of entropy is symmetrical with time"[558] *But change of entropy is fundamentally time-symmetrical!!*; please refer also to *Sec. 5(16)9d, Fig. 5(11)b*. As a result, there is time symmetry at equilibrium stage besides the intrinsic time's arrow (or its reversal). "Hence, change of entropy is fundamentally symmetrical"[558] *But change of entropy is fundamentally time-symmetrical!!*

Example 5(16)9d, C1- Considering N balls in a lottery drum are circulating at a constant speed. Suddenly a small hole is opened on the wall of the drum. At a random manner, a ball of N balls is escaped out of the drum at a ratio factor $1/N$. It is similar by a far analogy to a (gravitational) time's arrow at a ratio factor K_Γ, *Remark 2(3)1b*, respect to total time symmetry in an isolated mass-body.

5(16)10- Photon traveling through a barrier

A photon traveling in vacuum according to *Eq. 7(10),* has spatial expanding characteristic along with partial arrow of time dispersion, ΔT_v, *Sec. 5(16)7a,* energy dispersion ΔE_v, in its related H hall quantized package, *Sec. 5(16)3a.* However, the same photon has contracting characteristic during passing through mass medium, *Sec. 7(4)3*, of a barrier from view of H particle-paths. It has an energy equivalent to mass dispersion ΔE_b = (mass of the barrier media + photon)$\times c^2$, and partial arrow of time dispersion, ΔT_b in its related H hall quantized package. Thus, we have $\Delta T_b << \Delta T_v$, *Sec. 5(16)11*. In other words, photon travels in mass medium of barrier at very low partial time's arrow, or, alternately time's arrow reversal, *Remark 5(16)10b* respect to vacuum medium; please refer to *Sec. 2(10),* and *Sec. 7(4),* in this regards. Referring to [173], part related to *photon faster than light*, "in the experiment performed by Chiao, R., the photon traveling barrier is detected first respect to simultaneous emitted counterpart that traveled via vacuum the same distance"; please refer also to *Sec. 5(16)6, Experiment 5(16)6a*, and *Remark*

5(16)10b. According to [176], "the purpose is to investigate general feature of wave packets in the purpose of tunneling through potential barriers. It is assumed that the initial momentum uncertainty is small and we look at the large-time asymptotic". In fact, on the basis of H particle-paths hypothesis, traveling of the two stated above photons between two equidistance positions depends on equal path-length of their, *Remark 5(16)1a,* not solely on time or length distance, *Secs. 2(1)1b, 2(1)2, 7(1)* separately, that is consistent with relativity regarding inertia, *Sec. 2(6)2a*, and concept of causality, *Consequence 5(16)10a1*. Remarkably, the equality of time or distance of traveler photon is valid in case of identical traveling media, i.e. same energy-space-time correlation, *Sec. 7(6).* According to [346], *mind over matter*, "Ebehard's proof shows that at the Earth and Pluto may be instantly connected in reality (through entanglement of photon pair), it is impossible in the world of appearance using current physical process to send faster than light messages via the quantum entanglement channel"; please refer to *Sec. 8(7)2, Example 8(7)2, B1.* The above discussion is related to the incident photon normal to the barrier. By increasing the angle of incident photon from normal to the barrier plates, we encounter with successive reflections of the photon inside the barrier; the delay time increases by increasing the incident angle respect to normal; please refer to *Sec. 5(16)2a, Sec. 5(16)2c*. The stated above case can be regarded as an example of transformation from matter Universe to antimatter one in a limited location of energy-space-time, i.e. path-length density, *Sec. 7(6).* In our matter Universe, a particle, e.g. photon, electromagnetical wave expandon, *Sec. 4(3)1, part c*, propagating through vacuum medium has expanding type path-length characteristic; while, during passing a mass medium, it has contracting type path-length characteristic, *Sec. 5(16)11*, at a reversal handedness of the former one in case discussed in the *Sec. 5(15)3b*. In other words, a photon that the H particle-paths of its field are expanding right-handedly at SN_r configuration through vacuum medium. In mass medium, the related field's H particle-paths are contracting left-handedly at SP_l configuration towards the photon main body. Therefore, the latter similarly to contracton, *Sec. 5(9)3d,* is tunneled through the mass medium spontaneously, *Sec. 7(4)2f, part c*. Please refer to *Example 5(16)10a*, and *Sec. 6(2)3, Consequence 6(2)3a.*

Example 5(16)10a – By analogy with polarized light, i.e. passing a vertically polarized light through a filter oriented *45* degree to vertical, and according to [243] " Something like this is at work in converting K_S and K_L into each other just as vertically polarized light is turned into horizontal. Instead of polarizer, however, the *K's* (neutral kaon) are made to pass through thin slabs of matter, in which beams of short-lived (K_S) are regenerated from beam of pure long-lived (K_L). In this example analogous to photon traveling through a barrier, we encountered with time's arrow reversal along with handedness reversal based on bi-Universe hypothesis, *Sec. 5(16)9b*; please refer also to *Sec. 5(16)9c*, *part A*, in this regards.

Consequence 5(16)10a1- Respect to an observer, at vacuum medium, and at each instant, the path-lengths of two entangled photons (or particles), one through vacuum texture, and other through vacuum texture plus a medium other than vacuum are equal algebraically regardless of the kind of non-vacuum medium; please refer also to *Sec. 7(4)3*.

Note 5(16)10a - According to [182], *part 10*, "for the polarization entangled state of photons pair, υ_1, υ_2 propagating at opposite directions can be written as the superposition of a state $|L,L\rangle$, where both photons have a left-handed helicity and a state $|R,R\rangle$ with two right-handed helicity.

$$\Psi(\upsilon_1,\upsilon_2)=\frac{1}{\sqrt{2}}\left[|R,R\rangle+|L,L\rangle\right]$$ "

Please refer to *Sec. 5(16)1b, part A, Fig. 5(8),* and *Sec. 8(9).*

Remark 5(16)10b- Referring to [175], a set of references is presented relating to the tunneling time or tunneling speed of photon through a barrier untitled "faster-than-light speeds in tunneling experiments. According to H particle-paths hypothesis, this can be related to the time's arrow reversal along with space contraction, *Sec. 5(16)9b,* (i.e. H hall quantized package overlapping), through the barrier media. In fact, the tunneling speed is seemed to differ from signal speed through vacuum in this regards.

5(16)11- Path-length in different media

In case of entangled pair of particle emitted by a source in vacuum medium. The path-lengths of two photons are equal. Noteworthy, according to *Note 5(16)8a1* in matter Universe, the path-length of photon through vacuum texture of SN_r configuration is type R_e of spatially expanding characteristic along with time's arrow. Similarly, the path-length of photon through its travel in mass medium of SP_l configuration is type L_c of contracting characteristic along with time's arrow reversal, Sec. 5(16)10; please refer also to *Sec. 7(4)3, parts A, D*. Now, supposing the photon *1* is traversed through a tiny barrier, and the photon *2* is not. Based on path-length constancy, *Sec. 2(1)2,* of the two photons, and stated above discussion we have:

Photon 1 path-length (type R_e) + *Photon 1 path-length (type L_c)* = *Photon 2 path-length (type R_e)* 5(71)
(Through vacuum texture medium) *(Through barrier's mass medium)* *(Through vacuum texture medium)*

Note that according to *Sec. 5(16)8b*, the magnitude of path-length of type L_c has opposite sign respect to type R_e one. In addition, according to *Eq. 5(71),* the magnitude of path-length (or Path) of photon *1* is larger than that (or Path) of photon *2* in vacuum medium; whereas, their algebraic sum of pair of entangled photons *1, 2,* path-lengths are equal. Thus:

Path of Photon 1 in vacuum - *Path Photon 1* = *Path of Photon 2* 5(71)1

(before and after passing barrier) *(in Barrier medium)* *(in vacuum)*

$$N_{\upsilon 1}.c.\Delta T_{\upsilon 1} - N_b.c\Delta T_b = N_{\upsilon 2}.c\Delta T_{\upsilon 2}, \qquad \Delta T_b << \Delta T_{\upsilon 2}, \Delta T_{\upsilon 1} \qquad 5(71)2$$

Therefore:

$$N_{\upsilon 1}.\Delta T_{\upsilon 1} > N_{\upsilon 2}.\Delta T_{\upsilon 2}, \quad \textit{or Path Photon 1>Path Photon2} \qquad 5(71)3$$

Considering $N_{\upsilon 1} = N_{\upsilon 2}$ in case of entangled pair of photon, $c.\Delta T_{\upsilon 1} > c.\Delta T_{\upsilon 2}$. In other words, through an identical medium, i.e. vacuum medium, and respect to a stationary observer respect to the photon source at this medium, the trajectory of photon *1*, is longer than photon *2*, i.e. the photon *1* reach sooner respect to photon *2* at an equal distance in vacuum medium. According to *Eq. 5(71)*, any path-length of type L_c in mass medium is accompanied by same magnitude of path-length of type R_e in vacuum medium. It is consistent with Mirror Image Effect, *Sec. 6(2)3*. Therefore, the algebraic sum of the two types of path-lengths remained unchanged. In other means, the algebraic sum of entropy related to type R_e, and negentropy related to type L_c path-length of the whole Universe remained unchanged from Big-Bang era, *Sec. 5(5).* Please refer also to *Sec. 5(16)9d* in this regards. Factually, there is a contraction, and at the same amount dilation on the common H hall package, *Sec. 5(16)3a*, of photons *1, 2* at c speed in the both media that will be revealed during a measurement (or detection), *Sec. 8(7)2.*

As an example according to *Sec. 5(16)8, Eqs. 5(70)8b, c,* K^o has type L_c path-length of $-h$ value of left-handed H hall packages; whereas, its antimatter conjugate $\overline{K^o}$ must have type R_e path-length of $+h$ value of right-handed H hall quantized package individually, *Note 5(16)11a*. Thus, the total algebraic sum of both path-lengths remained unchanged. Noteworthy, in the case of decay products of K^o, and $\overline{K^o}$ equal number of H hall packages of left-, and right-handed are generated. In other words, entropy, and negentropy are increased in magnitude, but at opposite signs, i.e. the algebraic sum remained constant (or zero). Moreover, there is a slight preference of left-handed K^o over right-handed $\overline{K^o}$ due to the right-handed expansion of our matter Universe through expanding spatial medium that is along with the same magnitude of contraction within mass medium. It is discussed in detail in *Sec. 5(16)1b, part A*, due to expandons, *Sec. 5(16)1c, part A3*, generation along with at the same amount of contractons, *Sec. 5(16)1c, part c,* (or axeon's, *Sec. 10(8),* of excess K^o). Therefore, in this case there is an equal magnitude of two types R_e, L_c paths at opposite signs. Please refer also to *Sec. 7(4)2e*.

Resuming, in our matter Universe the spatial expansion (entropy) is along with type R_e path-length. On the other hand, the mass (or better to say contracton) contraction is accompanied by type L_c path-length (i.e. negentropy), *Note 5(16)11b*. Therefore, at the full expansion of the Universe entropy, and negentropy have their maximum values, and at equal magnitude; whereas, in the period of Big Bang both entropy, and negentropy have their minimum values at equal magnitude. In other words, their algebraic sum is remained unchanged during Universe evolution after Big Bang era.

The path-length in mass medium, *Sec. 7(4)3, part D*, grace of its left-handed SP_l configuration is also of SP_l configuration, and contracting type L_c one; whereas, the path-length in vacuum texture medium, *Sec. 7(4)3, part A*, or, vacuum plus gravitational texture, *Sec. 7(4)3, part B*, that has expanding right-handed of SN_r configuration of type R_e. Moreover, the path-limit Γ, *Sec. 1(12),* of a particle as minimum amount (or unit) of path-length in a medium depends on the population density of H particle-paths of that medium (or media coefficient a, *Sec. 7(4)3*). As an example, if one of the pair of entangled photons is shot toward the center of gravity of a mass-body, e.g. The Earth, and its other counterpart at the opposite side, the path-limit Γ of the former is contracted respect to the latter one; whereas, their path-lengths are equal at each instant. Please refer also to *Sec. 5(11), Fig. 5(7).* The path-length of a particle, e.g. photon, electron, during its propagation through vacuum texture at c speed is remained constant, i.e. h; whereas, its path-limit Γ is increased at c speed up to a measuring device, i.e. measurement, *Sec. 8(7)2*. Alternately, a particle propagating in a medium (e.g. vacuum, and gravitational field, *Sec. 5(16)3b, part D2*) just during a measurement with a measuring device, i.e. mass, has a constant value for its path-limit Γ, and path-length value h, *Sec. 5(16)3g.*

Note 5(16)11a- The attribution of sign plus, and minus to the path-length are conventional. Factually, for the reason of determination of type R_e path-length in vacuum medium, and its increment with time's arrow, we apply this kind of sign convention. Therefore, the type L_c path-length for its contracting characteristic and for its distinction respect to type R_e path-length has minus sign. In other words, the both types of path-lengths are increasing, or, decreasing with each other at two reversed configurations.

Note 5(16)11b- Based on *Note 5(16)3a3*, in case of emitted photon by a source, an expanding H particle-paths flow of type R_e path-length generated on the Schwarzschild surface of the mass-body, e.g. source, that propagating towards spatial medium. Simultaneously, its equivalent (or conjugate) contracting H particle-paths' flow of type L_c path-length is leading towards the mass-body, i.e. source Schwarzschild surface, and ultimately tunneled to super massif black hole of related host galaxies, or, clusters, *Sec. 5(9)3d*, through a reversible counter-current motion, *Sec. 3(1)2*, up to photon detection (or measurement, *Sec. 8(7)2*).

5(17)-Two successive gravitational spheres radii difference of proton, in case of an isolated hydrogen atom

According to *Eqs. 5(7), 5(35), 5(52), 5 (53):*

$$\frac{dr}{r} = H_o d\tau = R_n^{-1} = \frac{8\pi^2 G}{c^3}\left(\frac{a_s}{b}\right) = 0.51\times 10^{-33} \qquad 5(72)$$

Where, *dr* is two successive gravitational spheres radii difference, please refer to *Sec. 5(16)1c, part A1.*
Please refer also to *Sec. 5(16)1c,* in this respect.

At the case of the principal state *n*, $r = a_o n^2$. Moreover, according to *Sec. 2(1)3, Eqs. 2(35), Sec. 5(72),* and *Sec. 9(1),* we have:

$$dr = \frac{8\pi^2 G n^2 a_o}{c^3}\left(\frac{a_s}{b}\right) = \frac{8\pi h n^2 \varepsilon_0}{e^2 n_{0e} c} \qquad 5(73)$$

Where, N_{0e}, a_o ,are the total number of H particle – paths of electron at rest and radius of Bohr orbit corresponding to ground state , i . e., *n = 1*, respectively.
According to *Eqs. 5(35), 5 (52), 9(26), 9 (31)*; we have:

$$dr = \frac{4\pi G n^2}{c V_o N_{0e}} = \frac{1}{2\pi R_n \alpha}\times\frac{n^2}{N_{oe}}.(u^{-1}) \qquad 5(74)$$

Where, α , is the fine structure constant.

According to *Eqs. 5 (72) , 5 (74) , 9(6),* the potential sphere expansion rate , $\overset{o}{r}$, in the case of hydrogen atom on the basis of Bohr model is obtained as following :

$$\overset{o}{r} = \frac{d r_n}{d\tau} = \frac{n^2 H_o}{2\pi\alpha N_{oe}} = \frac{e^2 H_o E_n^{-1}}{8\pi\varepsilon_o c} = \frac{H_o \alpha h E_n^{-1}}{2}\left(\frac{a_s}{u}\right) \text{ , or, } \overset{o}{r} = \frac{dn}{d\tau}u^{-1} = \frac{n H_o}{4\pi\alpha N_{0e}}(u^{-1}) \qquad 5(75)$$

Where:
- *En* , is the energy level of the quantum state , n.
- $a_s = 1 s^{-1}$, *Note 1(2)1,* $b = 1 kg^{-1}, u = 1 m^{-1}$ of inverse dimensions based on units of dimensions in *SI* units.

As a result at each time interval , $d\tau$, some appropriate number of gravitational spheres, dn , *Eq. 5(75),* exit as a mass reduction from proton passing through principal states of hydrogen atom . Moreover , the expanding spheres are the same as concentric sphere of proton electrical field , *Sec. 4 (6);* please refer to *Example 5(17)1.*

Example 5(17)1- According to H particle-paths hypothesis, mass is the contracted form of the field and energy; moreover, the latter is expanded form of the mass*, Note 2(1)3b*.
Now, supposing:
a) The center of gravity of an isolated mass *M* is located in the center of a sphere at r radius, that is larger than Schwarzschild radius, *Eq. 5(31)* of mass *M*,
b) At time $\tau = \tau_0$, exist, R_n , *Eq. 5(35),* number of gravitational spheres, equivalent to mass *M*, *Sec. 5(1), Eq. 5(1).*
c) According to *Sec. 5 (16),* during, $d\tau$, time's arrow interval, *Eq. 5(51);* a sphere at radius r expands and its radius increases according to *Eq. 5(72),* to $r+dr$.
d) Assuming $d\eta$ gravitational spheres with n_G , H particle-paths passes through an imaginary constant radius sphere R, surface at constant volume V_R , the center of which located on the center of gravitational sphere *R*; since, $d\eta$ is the generated gravitational spheres inside the volume V_R that is passing through surface of sphere *R* during time's arrow interval $d\tau$.
Thus, based on above assumptions supposing:
1) ρ_s - average density of H particle-paths mass equivalent inner the Schwarzschild sphere at radius l_s, *Eq. 5(31)*, and volume V_s ; thus, according to *Eqs. 2(35), 5(67):*

$$\rho_s = \eta\frac{\delta m_0}{V_s} = \eta\frac{n_G a_1 h}{V_s c^2} = \eta\frac{a_G h}{V_s c^2} \qquad 5(77)$$

Where:
- a_1 , Constant of media coefficient, *Note 1(2)1.*
- a_G , Media coefficient in a gravitational medium, *Note 1(2)1.*
δm_0 - Mass equivalent, *Eqs. 2(33) to 2(35),* related to $d\eta$ gravitational spheres
n_G - The total number of interacting H particle-paths on a gravitational sphere *Eq. 5(1).*
η - The total number of gravitational sphere equivalent, supposing the related mass is constituted of η times of constant n_G, i.e. R_n , *Eq. 5(49),* for reason of simplicity at low time's arrow interval $d\tau$.
V_s -Schwarzschild volume related to l_s .
ρ_s - Average density inside the volume V_s .
2) P- Radiation pressure of H particle-paths through sphere *R* surface during time interval, $d\tau$:

According to *Eqs. 6(2), 6(6),* we have:

$$P = \frac{1}{A}\sum F = \frac{1}{A}\sum \frac{dp}{d\tau}\left(\frac{u}{a_s^2}\right) = \frac{1}{A}\times\frac{\alpha c\delta\, m_0}{d\tau}\left(\frac{u}{a_s^2}\right) = \frac{1}{A}\frac{n_G a_1 h}{c^2 d\tau}\times d\eta\left(\frac{1}{a_s}\right) \quad 5(78)$$

Where, A is the sphere R area and p momentum related to force F.

3) dV_n - Volume increment of nth expanding sphere r at $r = R$, during time's arrow interval $d\tau$:

$$dV_n = Adr \quad 5(79)$$

According to *Eq. 5(67),* at the case of Schwarzschild sphere of V_s volume:

$$d\left(V_s\rho_s\right) = d\left(V_s\frac{\eta\, n_G a_1 h}{V_s c^2}\right) = a_G\frac{h}{c^2}d\eta \quad 5(80)$$

At the case of exit of a gravitational sphere from the sphere R surface, according to *Eqs. 5(78), 5(79),* we have:

$$P\,dV_n = \frac{1}{A}\frac{n_G a_1 h}{c^2 d\tau}Adr\left(\frac{1}{a_s}\right) = \frac{a_G h dr}{c^2 d\tau}d\eta\left(\frac{1}{a_s}\right) \quad 5(81)$$

According to *Eqs. 5(80), 5(81),* we have:

$$\overset{o}{r}\,d\left(V_s\rho_s\right)\times\left(\frac{a_s}{u}\right) = P\,dV_n \quad 5(82)$$

Where, $\overset{o}{r}$, *Eq. 5(75),* is the expansion rate.

Supposing:

$$V_s\rho_s = V_n\rho_n$$

According to *Eq. 5(82)*, we have:

$$\overset{o}{r}\,d\left(V_n\rho_n\right)\times\left(\frac{a_s}{u}\right) = Pd\,V_n \quad 5(82)1$$

At the case of proton, *Sec. 5(17),* and considering, *Eq. 5(82)1*, we have:

$$\overset{o}{r}\,d\left(V_N\rho_N\right)\left(\frac{a_s}{u}\right) = \frac{H_o\alpha h E_n^{-1}}{2}d\left(V_N\rho_N\right)\times\left(\frac{a_s}{u}\right)^2 = Pd\,V_N \quad 5(82)2$$

Where:

- V_N, ρ_N are volume and, average density related to N^{th} gravitational sphere of proton respectively.
- E_n, is the energy of n^{th} principal state of hydrogen atom that coincides with N^{th} gravitational sphere of its proton.
- a_1, constant of media coefficient, *Note 1(2)1*.
- $a_s = 1s^{-1}$, *Note 1(2)1,* $b = 1kg^{-1}, u = 1m^{-1}$ of inverse dimensions based on units of dimensions in *SI* units.

According to *Eq. 5(7):*

$$\frac{d\eta}{d\tau} \approx \overset{o}{r} = H_o r \quad 5(83)$$

Thus, η varies proportional to the rate of expansion because of Friedman and Lemaitre equations and analogous to that at the cosmological scale through exit of H particle-paths in the form of expanding gravitational spheres (or expandons, *Sec. 5(16)1c*, *A3*). Therefore, according to this scale the whole Universe expands accordingly. Moreover, the same result as discussed above is also valid for any H system (e.g. particles, atoms, Earth, Sun, stars), or, in other words, the H systems, e.g., the Universe, galaxies, Sun, particle expand at the same rate universally.

As a result:

A) Eq. 5(82), shows that the variation of total energy of H particle-paths inner a sphere volume by a factor of the rate of expansion is proportional to the work done by H particle-paths pressure in the dilatation of that volume. Moreover, sphere radius, R, may be extended from the Bohr orbit, a_0, of hydrogen atom, *Sec. 9(3)1,* up to the scale of the star.

B) Considering an isolated H system in a finite volume of space, because of exit of gravitational spheres (Expandons) from the boundary of that volume, no longer it can be considered as isolated (*case I*). If the potential on finite volume boundaries is as in case of ideal gas in a box, the ideal gas's expandons, *Sec. 5(16)1c, part A3*, strike with the box's walls. Thus, according to Mirror Image Effect, *Sec. 6(2)3*, there will be a reversed handedness of H particle-paths of the box's walls along time arrow reversal. In other words, in the above example, the total gravitational time arrow, *Sec. 5(16)1c, part A4*, is zero, i.e. there is no time scale. Therefore, entropy also remained unchanged (*case II*).

In the *case I*, the whole system is isolated if and if, the total volume increasing according to spatial expansion, therefore contradicts the Poincare' recurrence theorem. In the *case II*, the recurrence time of the whole system is zero. According to [318] "In mathematics, the Poincare' recurrence theorem states that a system having a finite amount of energy and confined to a finite volume will, after a sufficiently long time, return to an arbitrary small neighborhood of its initial state; please refer also to *Sec. 5(9)3d, part D, item c* .

5(18) - Pendulum and the Wall

Considering, a metal ball *B* is hanging by a string from a stand, the inner H particle-paths of ball *B* are in an equilibrium state in the gravitational field of the Earth. According to *Fig. 5 (2) of Sec. 5(2)1b,* there is entrance of the Earth *CF-lines* and exit of ball *CI-lines* at the same curved path but at opposite direction. Now, let moving the pendulum ball to oscillate, the equilibrium state is broken. In the other words, according to *Fig. 5(1)* of *Sec. 5(2)1a*, the entered Hs particle-paths of the Earth *CF-lines* are accompanied by the H particle-paths of ball*'s B, CI-lines*. By repeating this test at the vicinity of a rock wall, *Note 5(18)a,* the exited H particle-paths of the ball *B'*s *CI-lines* are entered in the wall as force-lines *CF-lines* and reflect as wall's repulsive-lines *CI* . Subsequently, the latter are entered into the ball *B* as *CF* force-lines at a different path direction to that of the Earth in the first case. Thus, a weak secondary force is appeared, i.e. gravitational anomalies.

"Australian researchers, attempting to measure the gravitational constant in a mine shaft, found a discrepancy between the predicted and measured value, with the measured value being two percent too small. They concluded that the results may be explained by a repulsive fifth force with a range from a few centimeters to a kilometer. Similar experiments have been carried out onboard a submarine (*USS* Dolphin (*AG SS-555*) while deeply submerged. The above experiments search for that is, like gravity, independent of the composition of an object, so all objects experience the force in proportion to their masses. Forces that depend on the composition of an object can be very sensitively tested by torsion balance experiments of a type invented by Lorand Eotvos." [462]. the stated above anomalies are related to fifth force. It is "Proposed in *1986* to account for gravitational discrepancies observed during some experiments. It was said to result in a repulsive effect about *1000* times less powerful than gravity, and its strength was said to fall off quickly with distance, during range about *700 ft* (*200m*)." [462]. Conversely, "Results of a three-year study in Pacific Ocean found no variation of *G* from the value predicted by Newton's inverse square law for gravitational force. The study suggests that the fifth force does not act over distances from few feet to a few miles. "Their results, (of Australian researchers) were questioned one year later at a physics collonium on New and Exotic Phenomena held in French Alps. The collonium found that Australian group not fully taken into account the local density distribution of the rocks in the mineshaft. This oversight resulted in an overestimate of the size of the gravitation anomaly present in the rock layer"[466}. Factually, any increment of local density in a direction respect to the average density can be viewed as a case of rock wall, *Note 5(18)a*, in that direction.

The three alternate interpretation discussed in *Note 5(2)1b2, Example 5(9)3c1* that are accounting for gravitational discrepancies nominating as a new force, e.g. fifth force; please refer also to references [467 to 470].

The stated above discrepancies cannot be related to extra-dimensions, Yukawa power-law forces, and isotopic spin as following, *Note 5(18)b*:

"Motivated by higher-dimensional theories that predicts new effects, we tested the gravitational $1/r^2$ law at separations ranging down to 218 μm using a 10-fold symmetric torsion pendulum and a rotating 10-fold symmetric attractor, and find no deviation from Newtonian physics"[464] *Abstract*. "New physics could produce ultra-feeble long-ranged Yukawa interactions that would violate the Equivalence Principle (i.e. the universality of gravitational free fall) or the gravitational Gauss Law.". "No evidence for new forces has been found, but the null results provide significant constraints on particle and gravitational physics and on cosmological speculations."[465] *Abstract*. "They (Adelberger, and Stubbs) found no significant variation from Newton's gravitational constant attributed to isotopic spin."[466].

Note 5(18)a – According to [37], "The period of a pendulum, firstly well verified as a constant, changed when it got closer to a rock wall, depending on which of the two materials was closer to the wall".

Note 5(18)b- New theories like string theory, quantum gravity, etc; most of which violate the equivalence principle at small level. Tests like this can be used to find new interactions (fifth force)."[467].