Part 1b- Macrocosm

2-Mechanic of Macroscopic objects
2(1) - Motion of a rigid body
2(1)1- General aspect
2(1)1a-Preliminary step

In this section, we compare the result obtained on the basis of H particle-paths hypothesis regarding the special theory of relativity *(SRT)* from view point of a non preferred reference frame, *Sec. 2(6)2b*. Moreover, considering the experiments founded on one-way method, a new concept of time and space on the basis of relatively preferred reference frame is given, *Secs. 2(6) to 2(9).*

Supposing a rigid body *A, Remark 2(1)1a1,* at rest (*V=0)* , *Sec. 1(15),* respect to inertial reference frame R (x, y, z, t), *Remark 2(1)1a2*, with an observer o at rest, in all directions has a returnable or reversible motions of inner H particle-paths at constant light velocity C , *Fig. 2(1)*, as a result obtained from Michelson-Morley Experiment [72], *Sec. 2(6)5a, Remark 2(6)5a1.* Supposing another inertial reference frame R' (x', y', z', t') * [1]and an observer o' at rest. The origin o' moves relative to o at velocity $\vec{V}$ along the common coordinate of x, x' direction (other axes y, y' or z, z' is parallel at same directions respectively), *O* measures the coordinate x, y, z, t of an event, whereas o' measure the coordinate x', y', z', t' of the same event. Please refer also to *Sec. 2(1)1d.*

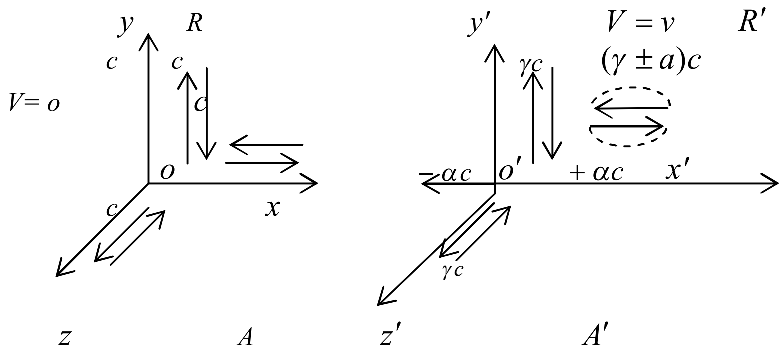

Fig. 2(1) - The H particle-paths velocities of two H systems A & A' at a relative motion related to a rigid body

Supposing m_0 the total mass of the rigid body *A* at rest and N_0 the total number of H-particle- paths constituting the rigid body *A*, thus:

$$N_0 \, H = E_0 \qquad 2(1)$$

$$N_0 \, Q = m_0 \qquad 2(2)$$

E_0 , is the inner energy at rest of *A* and *H* is the energy of each H particle-paths, $E_{q_\circ}$ *1(1)*, and Q is the mass per one H particle-path in *A*.

Now, select an H particle-path *Remark 2(1)1a1, part B*, of the system *A* in reversible motion at the position ***O*** and supposing α , the relative or proportional number of particle-paths entering inside the system *A* or interacting with it, *Fig. 2(1)*. Please refer also to *Comment 5(16)2c4*.

According to this entrance, the velocity of the system increase from *V*=0 to *V*=v and the new H system A' travel at o' position along the common xx' axes directions; thus:

I) The path portion of entered single direction H particle- paths, α, respect to an initial reversible H particle-path of system *A* at rest in order to transfer to the velocity of new moving system is:

$$\alpha \times c = \alpha c$$

II) The path portion of one initial reversible H particle-path before entrance and after that in the system are $c \times 1$ and *K,* respectively.

III) The combined momentum on y', z' plane is calculated according the law of velocity or linear momentum vector combination, *Fig 2(2)*.

$$c^2 + \alpha^2 c^2 = K^2 = c^2\,(1 + \alpha^2) \qquad \textit{Note 2(1)1a1} \qquad 2(3)$$

According to the constancy of the light speed, K must be equal to C and αc certainly to v,

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* [1] *Einstein's Special theory of relativity.*

$$(I)K^2 \xrightarrow{must\,be} c^2(II)$$ 2(4)

$$(III)\alpha^2 c^2 \xrightarrow{must\,be} v^2(IV)$$ 2(5)

Dividing the both side of two proportions, *2(4)* by *2(5)* respectively we have:

$$\frac{(I)}{(III)} = \frac{(II)}{(IV)} \quad \text{or} \quad \frac{K^2}{\alpha^2 c^2} = \frac{c^2}{v^2}$$ 2(6)

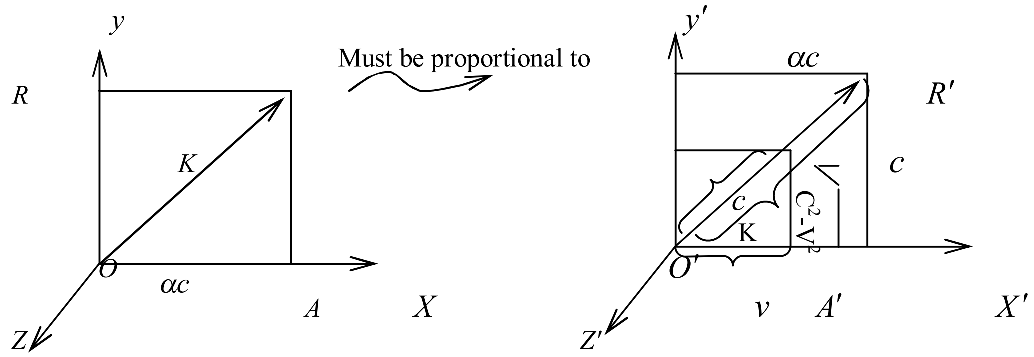
if $k = \gamma c$ or $\frac{K}{c} = \alpha \times \frac{c}{v} = \gamma$

By using $E_{qs.}$ *2(3), 2(6)* to relate α and γ :

$$\frac{c^2}{v^2} = \frac{c^2 + \alpha^2 c^2}{\alpha^2 c^2} = 1 + \frac{1}{\alpha^2}$$

$$\alpha = \pm \frac{v/c}{\sqrt{1 - v^2/c^2}}$$ *Remark 2(1)1a3*, *Sec. 2(7),* and *Note 2(1)4b,* 2(7)

$$\gamma = \frac{k}{c} = \frac{1}{\sqrt{1 - v^2/c^2}}$$ 2(8)



a) Normal mode of combination *b) contracted mode of combination*

Fig. 2(2) – method of evaluation the internal velocity of inner reversible motion

Where:

- α , the ratio of single direction or returned H particle-paths to the initial reversible ones; moreover, it can be nominated as "deviation degree from reversibility ".
- γ , the ratio of total H particle-paths of a moving H system to that of the initial number of reversible ones nominated as Lorentz factor"; moreover, its inverse γ^{-1} can be regarded as: *degree of contraction".*

By adding the square roots of the equations *2(4)* and *2(5):*

$$K \pm \alpha c \xleftarrow{must\,be} c \pm v$$ 2(9)

According to *Eqs. 2(7), 2(8):*

$$c\gamma \pm \alpha c \xleftarrow{must\,be} c \pm v$$ 2(10)

Therefore, in the direction of x coordinate instead of $c+v$ we must have $(\gamma + \alpha)c$ and certainly the opposite direction instead of $c - v$ must be $(\gamma - \alpha)c$.

Supposing l_0 (proper length), the initial length or distance on x coordinate of reference frame *R* at rest (respect to observer *O*) according to $E_{q_\circ}$ *2(8)* , the l' length along the x' axis of reference frame R' at motion is obtained:

$$\frac{l'}{l_0} = \frac{c}{k} = \gamma^{-1}$$

$$\frac{v}{l'} = \frac{\alpha c}{l_0}$$ 2(11)

$$\frac{l'}{l_0} = \frac{v/c}{\alpha} = \sqrt{1 - v^2/c^2} = \gamma^{-1}$$

By regarding *Fig. 2(2),* after the entrance of the α , H particle-paths into the initial reversible H particle-paths system, the whole H system instead of traveling the distance $o'A = \alpha c = l_0$ in time interval Δt_0 , it travels the $o'A'$ in time interval $\Delta t'$ (proper time of *R'*) at the ratios [1] :

$$\frac{l'}{l_0} = \frac{\Delta t'}{\Delta t_0} = \frac{c}{k} = \frac{1}{\gamma} = \sqrt{1 - v^2/c^2} \qquad 2(12)$$

or, the distance or length diminished with the same ratio as the time interval variation; please refer to *Sec. 5(16)1c, part A4*, and *Sec. 7(4)* in respect to unit of time intervals.

Note 2(1)1a1- This quadratic relationship (Pythagoras theorem) is the direct result of path constancy as a law of nature. Indeed, mathematic is based on the physical concept and phenomena, e.g. a shortest distance between two points in space are a physical fact. "Vladimir Arnold, one of the greatest contemporary mathematician, said "Mathematics is a part of physics; physics is an experimental science, a part of natural science" [45]."Mathematics tools were originally developed for analyzing the physical world. Geometry, for example, was developed as a tool for measuring plots of land and constructing buildings, while counting and arithmetic were developed for commerce and trading of goods. So mathematics was developed as an abstraction from physical reality. We would do well to remember that at the start it was physical reality that provided the motive for developments in mathematics, as the axiomatic principles behind mathematics were established in those early days"[570] *Why does Physics follow Mathematics?* "I have suggested (Tegmark 1998) that complete mathematical democracy holds: that mathematical existence and physical existence are equivalent, so that all mathematical structures exist physically as well. This is the *Level IV* multiverse."[580] *Part IVB.* "Nothing in the physical world (outside mathematics) corresponds to the notion of infinity"[570] *Why there is no such thing as infinity.*" Infinity can exist in mathematics, but I do not see it in physical reality. You cannot have objects, which are infinitely large, you can't travel at infinite speed, etc. Maybe the universe is infinite in extent, and who knows what goes on in black holes, but we don't seem to have infinity in physical reality"[570] *Comments, Andrew Thomas, 10th January 2007.* According to *Sec. 4(3)1, part B, item XXII*, the charged particle cannot considered as point-like. Therefore, the distance r cannot be zero in case of mutual interaction of charged particles. Moreover, in *Sec. 5(16)1c, part A*, instead of infinity scale of the Universe, its scale based on observation is taken into account. "Mathematics is now appearing as nothing more than an abstracted language for describing (and building upon) the physical axioms (for example, the presence or absence of physical objects) "[570] *Why does Physics follow Mathematics?*

Remark 2(1)1a1

A) In this article, the word of rigid body is applied to a bulk of atoms or molecules of a mass body in a macroscopic scale that follows the Lorentz contraction concept [1], *part 5*, respect to the word of particle in a microscopic scale, *Sec. 3*.
In the above discussion, the term of rigid body means an agglomeration or arrangement of atoms and molecules with the ability of internal relative motion. Thus, the information would have to travel through the entire body regarding the constancy speed of the light; moreover, this must not be confused with rigid body in which the distance between every atom are fixed and do not change.
B) Through this part everywhere dealing with an H particle-path, it means an H particle-path or a group of their according to *Sec. 7(4).*

Remark 2(1)1a2- "Minkowski 4-vectors are merely a mathematical tool to help making correct calculations in special relativity. The physical meaning of their components becomes clear only when written as a Euclidean 4-vector" [230].

Remark 2(1)1a3 – In case of a bi-dimensional motion of H particle-paths on a closed surface, e.g., electron shell in hydrogen atom, α is replaced by its square α^2, (or $2\pi\alpha^2$); please refer to *Sec. 9(4)6.*

2(1)1b- Delta Effect

Delta effect is a new model of interpretation of constancy of light speed according to H particle-paths hypothesis.
Assuming, δl the diminution of the length or distance

$$\delta l = l_0 - l' = l_0\left(1 - \sqrt{1 - v^2/c^2}\right) \qquad 2(13)$$

and δT the time interval diminution:

$$\delta T = \Delta t_0 - \Delta t' = \Delta t_0\left(1 - \sqrt{1 - v^2/c^2}\right) \qquad 2(14)$$

, *Example 2(1)1b1; Remark 2(1)1b1*

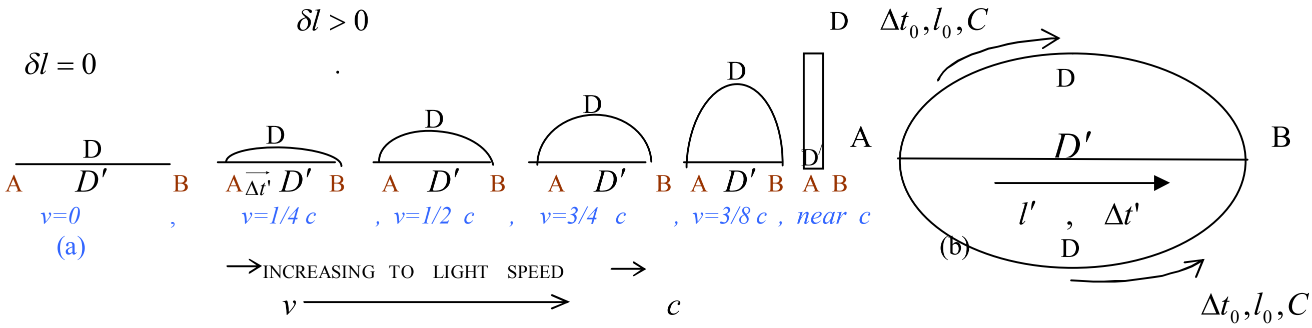
In case of light or signal propagation:

$$\frac{\delta l}{\delta T} = \frac{l_0}{\Delta t_0} = \frac{l'}{\Delta t'} = c \qquad 2(15)$$

$$\delta l = \overset{\frown}{ADB} - \overline{AD'B} = l_0 - l'$$

$$\frac{\overline{AD'B}}{\overset{\frown}{ADB}} = \frac{l'}{l_0} = \frac{\Delta t'}{\Delta t_0} = \gamma^{-1}$$ *Comment 2(1)1b1,* 2(16)

Please refer also to *Note 7(5)3d, B4.*



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a) -manner of contraction with respect to γ^{-1}, *b)- H particle–path bending in the moving H system, Comment 2(1)1b2*
Fig. 2(3) - Delta effect as a result of bending characteristic of H particle-paths within a constant path-limit Γ

Please refer also to *Sec. 2(6)5a, Remark 2(6)5a1, Fig. 2(7).*

Considering *Fig. 2(3),* in case of $v = 0$, $\delta l = 0$, $ADB = AD'B$ (rest state) and in other cases *2* to *6* $\delta l \rangle 0$; moreover, to have a general aspect of *Fig. 2(3*), it must be rotated 360^o about v-axis. In other words, ABD arc occupies the distance AB, in the form of one complete 2π cycle left or right–handed spiral (spin, *Sec. 2(1)1d*), i.e. analogous to a wavelength, at the direction of motion, *Sec. 3(1)2.* Thus, we encountered with a helix in the direction of motion, the path-length of which is independent of relative motion of observers in all inertial reference frame according to path constancy, *Sec. 2(1)2.* Please refer also to *Consequence 2(1)1b1,* and *Note 2(1)1b2.*

Assuming α represent the ratio number of H particle-paths entered into the initial H-system respect to initial H particle–paths, the total number of combined H particle-paths represented as $\gamma = \sqrt{1+\alpha^2}$, instead of $1+\alpha$, that depends on constancy of light speed. Moreover it is improved by consideration the conservation law of energy, momentum, definition of initial mass (rest mass), *Example 2(1)1b2*, respect to this problem.

According to the above statement, and *Eqs. 2(1), 2(7), 2(8):*

$$N_t = N_0 \gamma$$ 2(21)

$$N_\alpha = N_0 \alpha$$ 2(22)

N_0, N_α, N_t, are the initial number, entered in, and total number of H particle-paths in a H-system moving with velocity $V = v$.

Finally, according to *Delta Effect*, *Fig. 2(3),* any transformation from a coordinate of a reference frame to the other one that are moving at uniform motion respect to each other, is accompanied by H particle-paths geometrical shape deformation that is interpreted as four dimensional time-space configuration in *SRT*, i.e. length. In other words, a group of right-handed single direction H particle-paths moving at counter-currency mode of motion*, Sec. 3(1)2*, in a reference frame system is viewed as left-handed ones by observer of the other inertial system moving at a uniform motion and vice versa; moreover, the degree of H particle-paths bending depends on their relative velocity.

The stated above characteristic is a direct result of H particle-paths hypothesis respect to the other theories; moreover, this leads to the foundation for the subsequent twin controversy, *Sec. 2(6)1.*

Consequence 2(1)1b1- To transfer from reference frame R to R', a contraction ratio $\frac{c}{k} = \gamma^{-1}$ apply to the moving H system; therefore, we encounter with the changing of the following cases:

1) Internal velocity of the H-system (e.g. $\sqrt{c^2 - v^2}$ instead of c)

2) x-coordinate and its time e.g.: Instead of $x = x' + vt_0$ *2(17)* in Galilean reference frame, we have:

$$x = x'\gamma + vt'\gamma = \gamma(x' + vt')$$ 2(18)

3) y and z coordinate and it's time and choosing one of the following items:

A) $y = y', z = z'$ and $t' = \gamma^{-1} t_0$, (or $t' = t_{x'} = t_{y'} = t_{z'} = \gamma^{-1} t_0$), alternately 2(19)

B) $y = \gamma y', z = \gamma z'$ and $t_{x'} = \gamma^{-1} t_0$, $t_{y'} = t_{z'} = t_0$, alternately 2(20)

C) Each of the coordinates x, y, z; (or x', y', z') has its own individual time coordinates, i.e. t_{0x}, t_{0y}, t_{0z} (or $t_{x'}, t_{y'}, t_{z'}$), *Comment 2(1)1b3,* respectively, or, better to say path-length, *Sec. 2(1)2*. In other words, there is no definite boundary between space and time in the related reference frame contrary to two above items (cases *A, B*), *Sec. 5(16)7j*. Thus, we encountered with a reference frame with three combined space-time coordinates, or, in other words, a six dimensional character space-time ones*, Sec. 2(6)2a, Note 2(6)2a1, Comment 8(8)2a*; please refer also to *Comment 2(1)1d2.* As a result, the relation *Eq. 2(15)*, or its components are applicable at each of these separately*, Sec. 5(16)1c, part B*. As a result, the ten Einstein's gravitational field equations in the general theory of relativity by appropriate transformations, or, coordinates selection can be reduced to six ones; consequently, only six metric tensor components, g_{ik}, are independent. In fact, each of these three combined space-time coordinates can be visualized as path-length components of an individual H particle-path, *Fig. 2(3).*
Remarkably, the time in an inertial reference frame depends on two parts as following, *Sec. 2(3)2a*:

Case I –Scalar part related to reversible motion, *Sec. 1(3), paragraph II*, in each direction that can be represented by identical component, e.g. t_0, as common time in the three spatial directions; moreover it can be considered as a background time. The latter according to *Sec. 2(6)2a*, depends on the inertia, *Sec. 2(1)4,* of the related H system, *Sec. 1(3),* [or, in other words to rest energy, E_0 *Eq. 2(35)1*], respect to a preferred reference frame, *Sec. 2(6)2b;* moreover, this time is affected by γ^{-1}, factor, *Sec. 2(6)5b.*

Case II -Mono-directional (vector) part related to single direction (or returned) motion, *Sec. 1(3), paragraph I*, that can be represented according to *Sec. 2(9); Sec. 2(6)1; Notes 2(6)2; Sec. 2(6)4b,* by its $\pm\delta T$, (related to $\Delta T_F, \Delta T_B$ times) components in a forwarding or backwarding manner along with slight preference of $+\delta T$ over $-\delta T$ in our matter Universe, *Secs. 5(16)7, 9*, i.e. time's arrow, *Sec. 5(16)7j*; refer please also to *Secs. 2(9), 2(10).* These components according to the direction of motion in each spatial direction is related to single direction (or returned) of motion represented by momentum, *Eq. 2(30);* moreover, this time is not affected by γ^{-1} factor, *Sec. 2(6)5b.* Please refer to *Remark 2(1)1b1.*

The algebraic sum of two kind of stated above time parts as in *Eqs. 2(109), 2(114),* can be regarded as the total time component, *Comment 2(1)1b3*, in each spatial coordinate of an inertial reference frame. Resuming, each spatial direction has its own individual time component considering the direction of motion respect to a preferred reference frame, or, in other words, time depends on motion direction in this respect; please refer also to *Sec. 2(10); Sec. 5(16)7a, Sec. 5(16)7c*.

Factually, according to general acceptance; as internal energy is depended on the time, *Note 2(3)1a, III; Eq. 2(60),* and external linear momentum on the related coordinates; the *case 3(A)*, is applied firstly on this article for the reason of simplicity, *Note 2(1)1b1,* on the basis of special theory of relativity. Whereas, the *case c* from right- and left-handedness view point of H particle-paths behavior, *Secs. 4(5), 5(16)7;* singularity at event zone from view point of time, *Sec. 5(16)2a*; Sagnac Effect, *Sec. 2(6)4, Sec. 2(6)1, Sec. 2(6)2a, Note 2(6)2a1, and Sec. 2(6)5b,* is the preferred one of the three above cases considering H particle-paths hypothesis that will be discussed later.

Experiment 2(1)1b1- According to [205], an experiment showing that a *33 GHz* microwave signal received by rotating antennas is not exhibiting the frequency shift (i.e. transverse Doppler Effect) predicted by the relativity Doppler formula. The sensitivity of the apparatus used has been tested to be sufficient for detecting frequency shifts as small as $10^{-3}\,Hz$ which corresponds to the value of $\left(\frac{v}{c}\right)^2 = 5\times10^{-14}$ used in the transverse Doppler shift experiment reported here. This experiment can be regarded as confirmation of independency of orthogonal axes, y, z, from the axis in the direction of motion, x, from view point of both space and time coordinates. For an alternative interpretation of this experiment; please refer to *Note 2(10)3a*. Similar results are obtainable through Stern-Gerlach experiment respect to the axis along which is performed electron spin measurement; please refer to [241].

Example 2(1)1b1 - According to time dilation experiment with four atomic clocks performed by J. Hafel and R. Keating in 1971 [54], despite criticism on the accuracies of the results [123] for the reasons of drift-rates of the clocks:
1) First they flied the clock to the East, i.e. the same direction of Earth rotation, the four clocks on the East ward back with an average of 59 nanoseconds slower than the stationary clocks, *Comment 2(1)1b3.*
2) The same experiment on the westward trip, i.e. the opposite direction of Earth rotation, were averagely 273 nanoseconds faster, *Comment 2(1)1b3*.

Considering the Sagnac Effect in this test; according to internal motion of H particle-paths we can imagine their related motion calibrated in a straight (non bended) direction respect to a non-rotating reference frame that its origin coincide with that of the Earth center of gravity, i.e. Earth-centered non-rotating frame; moreover, its x-axis direction in the East; please refer to *Sec. 2(6)2b*, and *Sec. 2(8).*
According to above statements we have:
A) The H particle-paths of aircraft body at rest on the Earth surface has the same shape of H particle-paths of the rotating Earthward surface as in *Fig. 2(3).*
B) During take off to the East by propulsion effect of burned fuel gas, the air craft began to accelerate. During its acceleration the single direction H particle-paths of aircraft body bend more and more respect to that of the Earth surface till an equilibrium or constant speed respect to the Earth surface; thus, time dilation delayed respect the clock at rest on the Earth surface; please refer also to *Sec. 2(10).*

C) In the course of take off to the west as above, during acceleration the single direction H particle-paths of aircraft body enlarged and straightened more and more respect to the fixed reference frame ; thus, the time contract respect to the clock at rest on the Earth surface; please refer also to *Sec. 2(10)*.
D) The time contraction stopped when aircraft speed reach the Earth rotation speed in opposite direction respect to the observer at rest on the Earth surface. In other words, the measured time Δt , *Note 2(3)3b, Eq. 2(97)2*, has its maximum value, Δt_0 , at this stage, i.e. $\delta T = 0$, regardless of the altitude effect on the time. Moreover, by increasing the aircraft speed from that of the Earth surface speed limit, the time begins to dilate as H particle-paths began to bend respect to that of fixed reference frame. However, with the following differences that according to *Secs. 1(11),3(1)2, 6(2)3,* and *Note 4(3)3a,* all the single direction negapas and posipas moving through the counter-currency, *Sec. 3(1)2,* mode of motion in *(type L-R of SP configuration) or (type R-L of SN configuration)* manner, *Sec. 3(1)2, Fig. 3(5),* of the case *B* interchanged on the basis of mirror image effect, *Sec. 6(2)3,* respect to case c, i.e. in *SN or SP* configuration. In other words, the overall spinning of single direction H particle-paths reversed; But, as there are *SN* and *SP* manner exist at equal probability; thus, the H particle-paths configurations in its purely reversible internal motions have no revealing directional effect on the aircraft body; i.e. space isotropy.

Example 2(1)1b2- Supposing a photon with frequency, υ , and energy $E_p = h\upsilon$, of total number of H particle-path N_p is propagated along the x-coordinate. Supposing it is absorbed by an atom of rest mass m_0 , or, total number of H particle-paths N_0 , *Eqs. 2(1), 2(2),* at rest, located at *O*. Thus:

$$E_p = N_p H = N_p a_1 h = \upsilon h$$

Therefore:

$$N_p a_1 = \upsilon \text{ , or } a_1 = \frac{\upsilon}{N_p}$$

According to *Note 3(1)1c, Eq. 3(10)*:

$$\alpha = \frac{N_p}{N_0} = \frac{\upsilon}{a_1 N_0} = \frac{\upsilon}{n_0}$$

Where:

a_1 - The media coefficient a for an H particle-path, *Note 1(2)1*

n_0 - The frequency equivalent number, *Comment 2(1)1b4,* of H particle-paths through mass m_0 internal motion *Note 2(1)3, Eq. 2(35)*

According to above discussion, we have:

$$\underset{\text{before absorption}}{(1+\alpha)_i} \quad == \quad \underset{\text{after absorption}}{(1+\alpha)_f}$$

Multiply the both side by $n_0 h$;

Assuming E_t , E_0 , the total and rest energy of the atom respectively, *Eqs. 2(33), 2(35):*

$$(n_0 h + \alpha n_0 h)_i = E_0 + E_p$$

$$(n_0 h + \alpha n_0 h)_f = E_t = E_0 \gamma = m_0 c^2 \gamma$$

$$E_0 + E_p = E_t \qquad \text{, Law of conservation of energy}$$

$$m_0 c^2 + h\upsilon = \frac{m_0 c^2}{\sqrt{1 - v^2/c^2}} = n_0 h(1+\alpha) \qquad \text{or}$$

$$n_0 h(1+\alpha) = \frac{n_0 h}{\sqrt{1 - v^2/c^2}} = n_0 h\gamma$$

Thus:

$$1 + \alpha = \gamma$$

Moreover, according to the law of conservation of linear momentum:

$$P_i = P_f \qquad \text{or}$$

$$\frac{h}{\lambda} = \frac{m_0 v}{\sqrt{1 - v^2/c^2}}$$

$$\frac{hc}{\lambda} = h\upsilon = m_0 c^2 \frac{v/c}{\sqrt{1 - v^2/c^2}} = m_0 c^2 \alpha \qquad \textit{Eq. 2(7)}$$

$$h\alpha n_0 = m_0 c^2 \alpha$$

$$n_0 = \frac{m_0 c^2}{h}$$

Example 2(1)1b3-According to the experiment down on the basis of *GPS* satellites' clock rate and the receiver's clock rate are not adjusted as a function of their velocity relative to one another. Instead they are adjusted of their velocity with respect to a chosen frame of references as in the, *Example 2 (1)2,* i.e. the Earth-centered non-rotating (quasi) inertial frame [62], contrary to special theory of relativity. According to [230], "One more contradiction, this time in static, may be mentioned: This is the lever with two equal arms at right angle and pivoted at the corner. It is kept in equilibrium by two equal forces producing equal and opposite couples. According to the Lorentz transformations referred to a system moving with respect to the lever system, the couples are no longer equal so the lever should be seen to rotate, which is, of course, absurd". In other words, the reference frame transformation on the basis of *Consequence 2(1)1b1*, *case 3A* failed in this regards. Therefore, the space and time coordinates in the *case 3c* must be arranged in such manners that during any inertial reference frame transformation, the static of the lever conserved.
According to *Examples 2(1)2, 2(1)3,* and referring to *Sec. 2(6)2,* one should consider the deviation degree from reversibility, α *Eq. 2(7),* links with its inertia or related mass. In fact, Sagnac Effect is a simulation of daily Earth rotational motion around its axis; please refer also to *Sec. 2(8).*

Note 2(1)1b1- At the event zone, *Sec. 5(16)2*, a singularity arises in space-time metric of general theory of relativity due to infinite time dilation at the case *3A*, *Sec. 5(16)1b, part A, paragraph 9*; but, according to case *c*, we can interpret this anomaly. In micro-scale there will be no distinct separation between time and space regarded as independent coordinates according to uncertainty principle, *Sec. 7.*

Note 2(1)1b2 - According to *Fig. 2(3)b*, considering the H particle-paths bending along *AB* in the direction of the velocity , "a disk, in vacuum can be accelerated more easily in the direction of its axis , rather than in the direction of its diameter" [37] at high speeds.

Comment 2(1)1b1- $\Delta t_0, \Delta t'$ are only valid for the reversible motion of H particle-paths, *Note 2(3)2b1,* as in case of matter of rest mass and respect to an observer at rest in a reference frame fixed on the former, i.e. as an average time interval in a back and forth motion. Thus, for the single direction case refer to *Sec. 2(6)2a, Note 2(6)2a1,* and *Eq. 2(109)a, b.* Moreover, in case of photon emitted at past time and observed at present time in a *FLRW* type expanding Universe, please refer to *Sec. 5(16)3, Sec. 5(16)2c.*

Comment 2(1)1b2:
A) The H particle-paths of a moving body (moving reference frame) bend respect to the rest one observer; whereas, it is supposed calibrated as straight respect to its own observer. Therefore to remove this paradoxical effect the need to an inertial preferred reference frame as center of mass preferred reference frame, *CMPRF*, *Sec. 2(6)2b*. In addition, it is obvious in which, the H particle-paths of moving bodies bend according to their relative velocities respect to *CMPRF* observer; by the way, the H particle-paths of the latter is calibrated as being straightened. Please refer to [107]; moreover, according to [229] "All basic relativistic effects (time-dilation and length contraction) can, if observed, only be of relative (subjective) nature, due to observational circumstance, as in the observation of a natural process from within another inertial frame than the one in which said process to replace". From H particle-paths viewpoint the need to the preferred reference frame, *Sec. 2(6)2b,* is a real fact. At the case of microscopic scale, *Doppler Effect* of electromagnetic wave is a direct result of *Delta Effect*, *Sec. 2(1)1b*, i.e. wavelength contraction or dilation, *Secs. 3(4).*
B) According to [283] *part 4.1* " General relativistic cosmology predicts that events occurring on a receding emitter will appear time dilated by a factor, $\gamma_{GR(z)} = 1 + z$ ". In other words, $\gamma_{GR(z)} = \lambda_{observed} / \lambda_{emitted} = \Delta t_{observed} / \Delta t_{emitted}$. Moreover, in case of *SR* "The relationship between proper time at the receding emitter and proper time at the observer is identical to the *GR* time dilation equation if we consider an extra factor describing how long light take to traverse extra distance of the receding emitter" [283], *part 4.1*. In the latter case, the H particle-paths in a cell of *Fig. 5(8) of Sec. 5(16)1b1, part A* is contracted towards the deeper region of gravitational field.

Comment 2(1)1b3- Through this assumption if the rectilinear uniform motion is in the x (or x') direction, only directional time component, t_{0x} along x-axis is altered to $t_{x'}$, on the basis of , *Sec. 2(10), Eq. 2(116) to 2(118),* considering path-length constancy, *Sec. 2(1)2,* i.e. inseparable time and space; whereas:
$y = y', z = z'$ and $t_{0y} = t_{y'}, t_{0z} = t_{z'}$, *Experiment 2(1)1b1*
Therefore, the γ^{-1} factor, *Sec. 2(6)5b,* only applied to the initial number of H particle-paths in the orthogonal direction to motion direction, i.e. $N_0 \gamma^{-1}$, *Eq. 2(38),* or, in other words, the transverse frequency $\upsilon_\perp$ must be replaced by υ_0 in the *Eq. 2(52),* i.e.:
$$\varepsilon_\perp = h\upsilon_0$$
According to above result, the intensity of the emitted light in transverse direction altered and its frequency remained unchanged. Moreover, a part of internal H particle-paths of a moving mass-body normal to the motion direction, *Sec. 2(1)1c,* (or better to say

H particle-paths with orthogonal components) is revealed as returned ones respect to rest state; please refer to *Sec. 2(2)1, Eq. 2(44).*
As we will see later the initial time magnitude (or its components) is applied for two reference frames R and R' relatively of equal inertia from view point of H particle-paths hypothesis, *Sec. 2(6)2a, Sec. 5(16)7a,* and *Sec. 5(16)7c.* In the other cases, a relatively preferred reference frame must be taken into account, *Secs. 2(1)4, 2(6)2b.* Factually, time components can be regards as time's arrow, *Sec. 5(16)7a*, components in related spatial directions; please refer to *Example 2(1)1b3.* According to *Sec. 8(9),* the stated above preferred reference fame is the *CMPRF* of reference frame *R, R'* along with its own time, and *3* spatial coordinates respect to the observer of *CMPRF*. Therefore, the reference frame *R, R'* must be regarded as *LFRF, Sec. 2(6)2c*, respect to the *CMPRF*'s observer.

Comment 2(1)1b4- The frequency equivalent number, e.g., n_0 in mass medium, can be regarded as rate of state changing in that medium, *Remark 3(1)1c;* Please refer also to *Sec. 7(4)4, item G.*

Remark 2(1)1b1 – "Physicist take for granted that if one were to move away from the Earth at relativistic velocity and return, more time would have passed on Earth than for the traveler, so in this sense it is accepted that relativity allows *travel into the future* (although according to relativity there is no single objective answer to how time has really passed between the departure and the return" [350], *time travel in theory*. The Delta Effect, that is based on path-length constancy, *Sec. 2(1)2,* is explained by Van Flandern in an alternate manner. "It says, is to discard Einsteinian relativity and to assume that *there is a light-carrying medium.* When a clock moves through this medium, it takes longer for each electron in the atomic clock to complete its orbit. Therefore, *it makes fewer ticks*, in a given time than a stationary clock. Moving clock slow down, in short, because they are ploughing through this medium and working more slowly. It's not time that slow down. It's the clocks."[435]. Factually, according to *Sec.2(6)2a,* item

2(1)1c- A proposed mechanism

During interaction of an external effect on a mass-body at rest, (e.g., collision, *Sec. 6(2)1a,* force applying, *Secs. 6(2)2*), an appropriate part of the orthogonal component of H particle-paths of the latter is split (or returned) in the co-direction and counter-direction of initiated motion direction, *Remark 2(1)1c1.* The motion of the mass-body at rest is due to co-direction H particle-paths and its combination according to. *Sec. 3(1)1, Fig. 3(3),* with that of external effect; whereas, the counter-direction one is exit into external H system as impulsion, *Remark 2(1)1c2*. The above example can be compared with Stern-Gerlach experiment of electron spin measurement, *Sec. 8(7)2,* from viewpoint of indeterministic feature of internal H particle-paths of interacted mass-bodies. The exit of H particle-paths from a mass-body is accompanied by space expansion and time's arrow, *Sec. 5(16)7a*, whereas entrance of them to a mass-body is along with space contraction and time's arrow reversal that can be resumed to handedness and handedness reversal, *Sec. 5(16)9b*. Therefore in case of the above example, there is an equilibrium between handedness and its reversal during an interaction of this kind; please refer to *Sec. 6(2)3.*

Remark 2(1)1c1- As a result obtained from least action principle, *Sec. 2(4),* the N_{in} number of H particle-paths related to internal energy, E_{in} , of the moving mass-body must be in equilibrium at all of the directions in such a manner that the magnitude of its linear momentum in the three spatial coordinates are the same, i.e. analogous to that of mass-body at rest, N_0 .

Remark 2(1)1c2 – According to *Sec. 8(7), Sec. 8(9), paragraph 4,* during an interaction (or measurement, *Sec. 8(7)2*) of a one of the pair of entangled photon through an external effect, the reverse handedness of the pair is released at opposite direction. Here, co-direction H particle-paths, i.e. measured photon, can be regarded as interacted one and counter-direction H particle-paths with a reverse handedness of the former can be regarded as released photon (i.e. impulsion).

2(1)1d – Right- and left-handed H particle-paths intrinsic spin as extra- dimensions

The three straight directions (right-left, up-down, and forward backward) can be viewed as three spatial-dimension x, y, z. Noteworthy, to each of their, one can attributed a right-, or, left-handed microscopic circulating motions as a wrapped fourth spatial-direction (or dimension, *Comment 2(1)1d1*). It can be revealed as spin of wave-like H particle-paths in three stated above straight direction, x, y, z; please refer also to *Sec. 8(8)2, paragraph 8,* and *Comment 2(1)1d2*. This assumption by a far analogy can be compared with fourth spatial dimension (or spin) of a particle regardless of right-, or, left-handed feature of H particle-paths, *Note 2(1)1d1*. "In *1926*, Oscar Klein proposed that the fourth spatial dimension is curled up in a circle of very small radius, so that a particle moving a short distance along this axis would return to where it began. The distance that a particle can travel before reaching its initial position is said to be the size of the dimension" [413] *overview.* This extra dimension can be revealed ultimately as particle spin in vacuum medium, e.g., photon, and spirally expanding gravitational spheres, *Sec. 5(16)5* (i.e. expandons, *Sec. 5(16)1c, part A3*) spin from viewpoint of H particle-paths hypothesis. Please refer also to *Sec. 3(1)2, Figs. 3(4), 3(5).* Resuming any kind of motion of H particle-paths in a mass-body at rest due to principle of equilibrium and symmetry can be regarded as reversible back and forth internal motion of H particle-paths in all direction of the stated above mass-body for a detailed information, please refer to *Sec. 5(16)4*.
"Klein suggested that there is a little circle at each point in four-dimension space-time" [416] *section 2.* Charge conjugation is just parity transformation $y \to -y$ in fifth-dimension; the radius of the circle must be very small. The Planck size 10^{-35} meters which satisfactory accords with our everyday experience of living in four space-time dimensions. In summary, it seems that a five dimensional world with one of its dimension compactified (.e.g. on a circle) is operationally is distinguish from four-dimension

world with a very particular (albeit infinite) mass spectrum" [416] *section2*. Noteworthy, the parity transformation in fifth-dimension correspond to the handedness reversal, *Sec. 5(16)9b*, from viewpoint of H particle-paths hypothesis.
Summering there is:

I) There is a correlation between the stated above dimensions that leads to Delta Effect, *Sec. 2(1)1b,* and path-length constancy, *Sec. 2(1)2*, of H particle-paths in an H hall quantized package, *Sec. 5(16)3a*, of quantized path-length value h, *Sec. 5(16)3g*, and path-length-limit Γ, *Sec. 1(12),* as outstanding characteristic of H particle-paths.

II) The intrinsic characteristic and behavior of H particle-paths as a single stuff in the Universe defines the time and spatial dimensions from viewpoint of H particle-paths hypothesis.

III) The motion of H particle-paths of an isolated H system through 4-space and time medium are linked together through path-length constancy principle confined in an H hall package of path-length value h. It is based on indeterminacy or symmetry (i.e. equilibrium). Thus, an external effect cause asymmetry that leading to a phenomenon (or interaction) until a new symmetry is established (i.e. a new equilibrium), *Remark 2(1)1d1*.

IV) According to above statements, an H particle-path as one dimensional entity has an additional micro circular dimension, i.e. right, or, left-handed spin along its motion direction. Therefore, in all over this article, one can find these two spatial directions as intrinsic characteristics of H particle-paths. Noteworthy, H particle-paths move in all spatial directions in its single, and reversible motional directions, *Sec. 1(3).*

V) The single direction motion of H particle-paths defines the spatial dimensions, whereas the reversible one is represented by time dimension, *Sec. 1(3).*

Note 2(1)1d1- "String theory intriguingly suggests that six more dimensions exists, but are somehow hidden from our senses. They could be all around us, but curled up to be so tiny that we have never realized their existence."[523] *Secret dimensions*. At microcosm level, the right or left spin of an H particle-path in a 3 translational spatial directions corresponds to 6+3 spatial dimensions along 1 time dimension, i.e. 10 dimensions. Therefore, at macrocosm, the six dimensions of spirally motion (related to spin) of H particle-paths can be neglected as curled dimensions. The right-handed dimensions of these compactified ones are intrinsically expanding. Whereas, the left-handed ones are intrinsically contracting at equal magnitude path-lengths in our matter Universe, *Sec. 5(16)11*, i.e. *6* spatial degrees of freedom."String theory suggests the physical world could have 9 spatial dimensions, with six of them curled up from our perspective."[583] *Strange Physics.*

s- Each dimension originally curled, *Sec. 2(1)1d*, during its evolution successively undergoes on any of its point expanding and contracting phenomena of types *R & L* H particle-paths cells along with expandon, *Sec. 5(16)1c, part A3*, of path-length value $2\hbar$ emission, and contracton, *Sec. 5(2)1c, part c,* of path-length value $-2\hbar$, releasing, *Sec. 2(4)4a*. Please refer also to *Fig. 5(8) of Sec. 5(16)1b, part A,* in case of a spherical dimension, *Comment 2(1)1d2*. Factually, during each stay time interval ΔT, *Sec.7(4)2f, part A,* a right-handedly expanding expandon is emitted in spatial medium that is along with left-handedly contracting contracton releasing towards mass medium, *Sec. 5(7)8*.

Comment 2(1)1d2- A degree of freedom or a dimension of spherical configuration of a set of H particle-paths in our expanding matter universe as in case of *Fig. 5(8) of Sec. 5(16)1b, part A*, related to reversible motion of H particle-paths of gravitational field can be regarded. It expands from a compactifed configuration up to infinity.

Remark 2(1)1d1- "Symmetry breaking is what *creates the phenomenon*. Generally, the breaking of certain symmetry does not imply that no symmetry is present, but rather that the situation where this symmetry is broken is characterized by a low symmetry than the situation where this symmetry is not broken. In group-theoretic terms, this means that the initial symmetry group is broken to one of its subgroup" [417] *symmetry breaking*. In fact, at any equilibrium state (or symmetry) of an H system according to H particle-paths hypothesis, there is a correlating (or exchange) between H particle-paths of the H system with that of vacuum quantized texture. In other words, the entrance of an H particle-path from vacuum texture is accompanied by an exit of H particle-path of the H system (or vice versa) based on Mirror Image Effect, *Sec. 6(2)3*. "According to an ontological viewpoint, symmetries are seen as substantial part of the physical world" [417] *part 5*.

2(1)2- Path constancy

Supposing R' the reference frame at it's origin o', is located an H system (e.g. a mole of iron atoms A') with N_0 initial particle-paths and at the zero time $t' = 0$ the origin o' of R' is coincided with origin *O* of reference frame *R* (at rest) and at time t', *Figs. 2(1) ,2(2) :*

I) the sum of internal paths of N_0 particle –paths of the H system A' moving at velocity *C*, after t' time respect to observer o' at R'

$$path\ \ I = N_0 \times ct' \qquad 2(23)$$

In the respect of observer *O* at *R*, this path is equal to the difference of path *III* form path *II*, i.e. path constancy or invariance, as following:

II) The sum of internal- external paths of N_t particle- path H system A' respect to reference frame *R* during time *t*:

$$path\ II = N_t ct \quad , \quad N_t = N_0\gamma \qquad E_{q.}\ 2(21) \qquad 2(24)$$

III) The sum of common external path traveled by N_α single direction H particle–paths (entered at H system A')after time t, with common velocity v at the direction of x axis $(oo' = x)$:

$$pathIII = N_0\alpha \times x \qquad N_\alpha = N_0\alpha \qquad E_{q.}\ 2(22) \qquad 2(25)$$

$$path\ I = path\ II - path\ III\ , \text{Consequence 2(1)2a} \qquad 2(26)$$

$$N_0ct' = N_0\gamma ct - N_0\alpha x$$

$$t' = \gamma t - \alpha \frac{x}{c} \qquad 2(27)$$

The inverse equation, x, t, as a function of x', t' can be obtained by changing v to $-v$ (*R* is traveling with-v velocity respect to R')

$$t = \gamma t' + \alpha \frac{x'}{c} \qquad 2(28)$$

The relationships *Eqs. 2(18) 2(28),* are nominated Lorentz transformations [1], *part 4*; [201].
Moreover, the Planck constant h, e.g., of dimension $J.s$ in *SI* Unit can be regarded as a physical quantity unit of path-length in this article, *Sec. 5(16)3g*.
In case of path-length in different media, please refer to *Sec. 5(16)11*, and *Sec. 7(4)3*. According to these sections, there are two types of path-lengths in matter Universe, the type R_e through vacuum medium along with type L_c through the mass medium of equal magnitude, and opposite sign.
According to H particle-paths hypothesis, all the laws of nature obey of the path-constancy principle. We encounter with its different applications all over this article in both micro and macro scales. The natural philosophers believed that there is a physical reality of nature which when find it will tell us the origin of the natural laws and the connection between microphysics and cosmology."[503] *Abstract*. "Our knowledge of science and the Universe is based on few natural laws that govern the behavior of particles. These laws are the rules for calculating electricity, gravity, relativity, quantum mechanics and conservation of energy and momentum."[503] *Introduction*.

Consequence 2(1)2a- The relationship, *Eq. 2(26),* can be regarded as path-constancy in round trip (two-way method); please refer to *Sec. 2(10)1*, path-constancy related to purely single direction H particle-paths in one-way method.

2(1)3- Linear momentum and total energy

In equation *2(7)*, α has two $\pm$ signs, the positive sign is the stated above case and minus one will be the case that α H particle-paths are leaving the H system through an H hall package based on *Sec. 1(16).*

$$\left.\begin{matrix}1+\alpha\rangle\gamma \\ 1-\alpha\langle\gamma\end{matrix}\right\} or \sqrt{c+v}\rangle\sqrt{c-v} \qquad 2(29)$$

At the case of $\alpha < 0$, its magnitude is lower than one unit:

$$|\alpha|\langle 1$$

The total linear momentum (*P*) of N_α , $E_{q_\circ}$ *2(22),* H particle –paths that moving at single direction at total constant velocity *C* in the H system is obtained as follow:
According to *Eqs. 2(2), 2(7),* $p = Qc$, i.e. the momentum of a single H particle-path, the total linear momentum of the system is obtained as:

$$P = N_\alpha p = (N_0\alpha)(Qc) = (N_0Q)(\alpha c) = m_0\alpha c = \frac{mv}{\sqrt{1 - v^2/c^2}} \qquad 2(30)$$

Where:
Q , i.e. equivalent rest mass of an H particle-paths, *Remark 2(1)3a,* is a constant and $N_0Q = m_0$ (rest mass or initial mass of H system at rest that depends on N_0 total initial number of H particle-path system), $E_{q_\circ}$ *2(2).*

Total energy of the H system, *Note 2(1)3b,* is the sum of magnitudes of momentum, $|P_\gamma|$ of N_t , $E_{q.}$ *2(21)* (total number of H particle- paths moving at c speed, *Comment 2(1)3a*) in a H system multiplied by *C*, *Remark 2(1)3b*:

$$|P_\gamma| = N_t|p| = N_t(Qc) = (N_0\gamma)(Qc) = (N_0Q)(\gamma c) = m_0\gamma c = \frac{m_0c}{\sqrt{1 - v^2/c^2}} \qquad 2(31)$$

$$E_t = |P_\gamma| \times c = (QN_0\gamma c) \times c = m_0\gamma c^2 = \frac{m_0c^2}{\sqrt{1 - v^2/c^2}} \qquad , \text{Remark 2(1)3c} \qquad 2(32)$$

Please refer to *Sec. 2(2)2, Comment 2(2)2b.*
Energy of single H particle:

$$H = \frac{E_t}{N_t} = \frac{m_0 \gamma c^2}{N_0 \gamma} = \frac{m_0 c^2}{N_0} \quad , N_t = N_{0\gamma} \qquad 2(33)$$

According to Sec. 1(2):

$$H = a_1 h = \frac{m_0 c^2}{N_0} \qquad 2(34)$$

$$n_0 = a_1 N_0 = \frac{m_0 c^2}{h} \qquad 2(35)$$

n_0 - The frequency equivalent number of H particle-paths internal motion (hereafter abbreviated as frequency equivalent) through mass m_0 at rest state, *Example 2(101b2*
Please refer also to *Sec. 5(7)7.*
According to the stated above equations and *Fig. 2(1),* the internal energy or total energy at rest ($v=0$) of N_0 particle –paths in an H system:

$$E_0 = N_0 \gamma H = N_0 H = m_0 c^2 \quad , \quad \gamma = 1 \quad \text{if} \quad v = 0 \qquad 2(35)1$$

but after entrance of $N_\alpha, E_{q_\circ}$ *2(22)* H particle-paths in the H-system along x, x' coordinate, the total energy of forward motion of H system:

$$E_F = (\gamma + \alpha) N_0 H = (\gamma + \alpha) E_0 = (\gamma - \alpha)^{-1} E_0 \qquad 2(36)$$

At the same time of entrance, N_α H particle –paths leaving the H system in the opposite direction, *Note 2(1)3a,* and the total energy of backward motion of H particle-paths the H system.

$$E_B = (\gamma - \alpha) N_0 H = (\gamma - \alpha) E_0 = (\gamma + \alpha)^{-1} E_0 \qquad 2(37)$$

The total energy $E_\perp$, of reversible motion of H particle-path in each direction y and z or yz- plane of the H system with internal velocity $\sqrt{1 - v^2/c^2}$:

$$E_\perp = \sqrt{1 - v^2/c^2}\, N_0 H = \gamma^{-1} E_0 \qquad 2(38)$$

Note 2(1)3a – Principally the exit of N_α initial H particle – paths as impulsion is for the reason of constancy of light speed in order to establish the equilibrium state of the internal motions during movement of the whole H system.
Supposing an H system *A* of N_0 H particle-paths, is at rest in reference frame *R* (at rest), to transfer from it to reference frame R', *Sec. 2 (1)*, during an accelerated motion along xx' coordinate. In other words, the entrance of $N_{\alpha'}$ H particle–paths into the initial H system *A* in order to reach a linear momentum αc ; simultaneously N_α, H particle–paths with linear momentum - αc as impulsion left the system (third law of Newton), please refer also to *Note 2(1)3c.*
Considering $E_{q.}$ *2(34)* the energy changes is step- like or quantized and N_t in $E_{qs_\circ}$ *2(21)* , *2(23)* chooses only the integer number , thus , N_α and $N_0, E_{q.}$ *2(22)* are integer numbers, consequently *H*, $E_{q.}$ *1(1)* is the smallest unit of energy.

Note 2(1)3b - In fact, rest mass is related to the existence of reversible H particle-paths and linear momentum to the single direction one; thus, a moving mass can be regarded as an intermediate of rest mass and kinetic energy equivalent. Moreover, H particle-paths in the gravitational field, *Sec. 5(1),* moving at reversible counter-currency mode of motion as in, *Sec. 3(1)2, Figs. 3(4) a, b; 3(5) a, b*. Therefore, the gravitational field can be regarded as expanded form of the mass and vice versa. "Having in mind all these problems with the concept of particle in *QFT*, it is still impossible to clearly and definitely answer the question whether the world is made of particles or fields" [410] *section 9G*. According to H particle-paths hypothesis, the field is generated steadily with related particle or mass-body. In other words, the field is not static but expanding in the form of H particle-paths quantized texture through vacuum space. From the General theory of relativity viewpoint, "a gravitational field contains energy just like electromagnetic fields do. This energy also produce its own gravity and this means that unlike all other fields, gravity can interacts with itself and is not neutral" [77], *Q&A, No.11*.

Note 2(1)3c - αc and + αc may be the result of N ($N_\alpha > N > 0$) accelerated motions e.g. collision, gravitational interaction, photon and electromagnetic wave absorption or emission, etc.

Comment 2(1)3a- By assumption that in an H system, the H particle-paths are moving at c speed. There is no need for any magic mysterious conversion of mass into energy and vice versa.

Remark 2(1)3a - The linear momentum of an H particle-paths is $QC=h/c$; moreover, the angular momentum of an H particle-path in a closed path is equal to $\hbar$, *Comment 9(3)1.*

Remark 2(1)3b- In an isolated H system, the conservation energy is equivalent to the conservation of total number of H particle-paths of that H system during the time. Moreover, the conservation of linear moment means that at any direction of the space the total number of H particle-paths moving at c speed along that direction is constant and do not vary with the time.
The two stated above conservation results from the path-constancy, *Sec. 2(1)2,* or, in other words, the energy conservation means that the total path-length of an isolated H system is constant irrespective of the time; similarly, the momentum conservation means the path-length constancy in the direction of motion. Generally speaking path-length conception in H particle-paths hypothesis replacing the notion of dimension and velocity as individual physical quantities; moreover, path-length has energy dimension, i.e. momentum direction multiplied by length dimension the same as h; refer also to *Remark 5(16)3a1.*

Remark 2(1)3c - Here total energy depends exclusively on the absolute value of impulsion but not on its direction, and is obtained as a result of space isotropy respect to an insolated free moving particle, or, in other words, equivalency at all direction [171] *part 17.*

2(1)4- Inertia of an H system

The inertia of an H system at rest, or, in other words, inertial resistance to acceleration, is the result of relative competitive behavior of its inner reversible H particle-paths moving individually at c speed*, Remark 1(1)4,* respect to the entrance (e.g. moments, forces,) or exit (e.g. impulsion) of single direction H particle-paths at c speed in that H system during interaction. Moreover, from viewpoint of H particle-paths hypothesis, inertia (or inertial mass) considering Newton third law must be considered in the relativity principle, *Sec. 2(6)2a,* and *Example 2(1)4a.* Generally speaking, " In Newton equation, $F = mass \times acceleration$, mass is coefficient of inertia which you multiply with a bodies acceleration to determine the magnitude of the applied force"[77], *Q&A No. 196*; moreover please refer to *Note 2(1)4b*, and *Sec. 6(2)6c*.

In a reference frame the time interval at rest ΔT , *Sec. 5(16), Fig. 5(8),* depends inversely on the inertia (rest mass, *Sec. 6(2)6a*) of its constituents, *Note 2(3)2b1*. Moreover, two reference frames move at uniform straight motion relative to each other, the time dilate relatively more respect to that of reference frame with more inertia and vice versa, *Sec. 2(1)1b, Comment 2(1)1b3*. Thus, a relatively preferred reference, *Sec. 2(6)2b*, depends on relative inertia or masses, *Sec. 2(6)2a,* of two objects moving uniformly at a straight motion respect to each other; please refer to [65], part related to *the Forgotten Experiment*. Noteworthy, besides space-time coordinates characteristics of a reference frame, the inertia of its mass-bodies constituents must be considered as an inherent characteristic, *Comment 2(1)4a*. As a result, inertial mass affects time as non-inertial mass does in *GRT*. Noteworthy, the inertia of an H system depends on H particle-paths population density in spatial medium, *Sec. 7(4)3, part A*.

Example 2(1)4a - Besides, the transition from a frame of reference, e.g., the Earth, to another, e.g., moving spaceship cannot proceed rapidly. However, it can be performed through acceleration, *Note 2(1)4b,* in a limited time interval by entering the equal number of single direction H particle-paths, *Sec. 2(6)2a, Example 2(6)2a1*, to the two above mentioned mass bodies in the expense of their initial reversible H particle-paths. In other words, in the expense of the initial reversible H particle-paths Earth and spaceship before launching. Please refer also to *Note 2(1)4a*, history of the past event, *Fig. 2(4).*

Note 2(1)4a - Supposing an observer at *O* in reference frame *R* (at rest), *Fig. 2(1),* and an observer at O' in reference frame R' ; now, assuming an object A' located at O' [e.g. a mole of iron atoms with rest mass m_0 as in, *Sec.2(1)2*] moving along x, x' coordinate with velocity *V* respect to O . Thus, object A' beside rest energy E_0 related to mass m_0 (at rest) or N_0 H- particle- path has, N_α *, Eq.2(22)* H particle-path respect to O. Moreover, the same situation occurred when observer *O'* looking to object *A* (*e.g.* a mole of iron atoms) located at *O* and observer *O* knows that *A* has N_0 H particle –paths at rest and has no information of N_α of *A* and also observer o' has no information of $N_{\alpha'}$ of A' as $A = A'$ (iron mole), $N_\alpha = N_{\alpha'}$ in order to overcome this paradox:

I) We must relate a released impulsion H system $I_A = m_0 c\alpha$ to *A* in the same direction of $\vec{v}$ due to a previous or past event that caused *A* moves relative to A' and similarly, $I_{A'} = m_0 c\alpha'$ for A' in the opposite direction of $\vec{v}$ respectively [refer to $E_{q.}$ *2(48)];* in fact any event is caused by earlier one according to the known laws of nature (causality principle).

II) N_0 , the total H particle-paths of *A* and *A'* are equal (refer to *Note 2(1)3a*), but the shapes of paths of H particle–paths A, A' H systems differ; the supposed mass increase with velocity is denied by the action of Newton's third law. Since action and reaction are equal and opposite, no net work occurs in the energy interchange. In this case, no mass increase occurs [86]. According to [311], *Relativistic relation among mass, energy and momentum*, "Some books stating that mass and energy are equivalent, but this is some what misleading. The mass of an object, as we have defined it, is a quantity intrinsic to the object, and independent of our current frame of reference. The energy *E*, on the other hand, varies with the frame of reference".
Please refer also to *Note 5(15)3a1*.

In fact, γ is a factor related to shape of the paths; otherwise, we are encountering with the following questions propounded by J.R. Redbourne as following:
"We accelerate a particle to almost light speed, using relativity, what happen when the particle strikes the target? Does it strike with almost infinite mass, which coincidentally means infinite kinetic energy,…"[53]. Similar circumstance will be occurred for the time conception as in, *Sec. 2(6)2a, Note 2(6)2a1.*

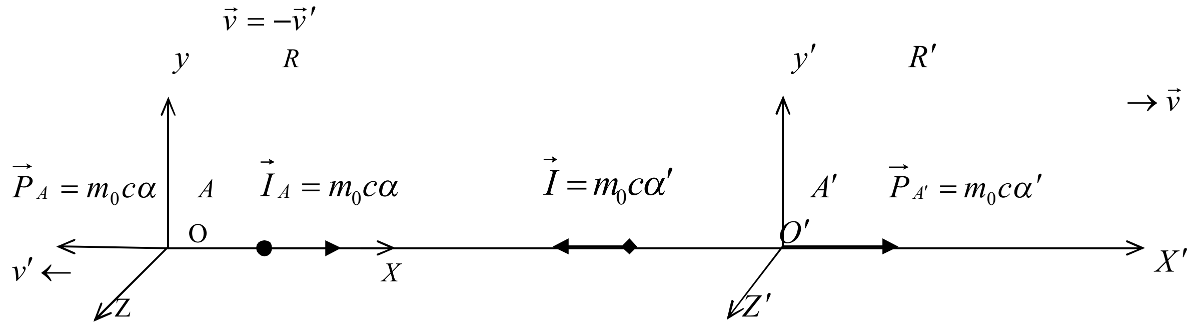

Fig. 2(4)- History of the past events

Please refer also to *Sec. 5(9)3d, part D.*

H system A+H system I_A | *H system* $A' + H$ *system* $I_{A'}$

$N_\alpha + N_0 \quad - N_\alpha$ | $N_{\alpha'} + N_0 \quad - N_{a'}$

Contrary to macroscopic mass object as above, in case of fundamental particles, microscopic scale (e.g. electron), we encountered with alternative situations as in *Sec. 3(1).* Noteworthy, in the first case, the total number of particle-paths remained unchanged, whereas its geometrical shape alters, or, in other words, the motion is related to returned internal energy, E_R, *Sec. 2(2)1, Eq. 2(44),* due to reversible characteristic of H particle-paths motion, *Sec. 7(4)4*, of the rest mass. In the second case, the total number of single direction H particle-paths increases in a straight path limit Γ, i.e. moving mass equivalent to energy increases along with geometrical shape deformation of reversible H particle-paths as in the first case, *Remark 2(1)4a*. Factually, the path-limit Γ, is contracted, wrapped, or, closed in the first case related to macro-bodies due to dense gravitational gradient, i.e. tendency toward reversibility. This is a margin that separate *GRT* from *QFT* theories. Please refer to *Sec. 5(10); Sec. 5(16)1a; Sec. 9(3)2, Note 9(3)1a*.
The *Fig. 2(3), Delta Effect, Sec. 2(1)b* can also be related to H particle-paths shape variation during an accelerated motion.

Note 2(1)4b - Variations of α respect to time (an equivalent of acceleration with dimension inverse time) has three main features of forces, *Sec. 6(2)6,* regarding velocity increment as follows:

I) $\frac{d\alpha}{dt}$ >0; during entrance of single direction H particle-paths in an H system, constituted of reversible H particle-paths as in, *Secs. 2, 3.*

II) $\frac{d\alpha}{dt}$ >0; by complete exit of a collection of H particle-paths as in expanding sphere, *Sec. 5(4)*, from a moving H system, *Sec. 5(15).*

III) $\frac{d\alpha}{dt}$ <0*;* by exit of H particle-paths as single direction ones, *Sec. 2(7).*

Noteworthy instead of time variation dt one can use quantized time variation, *Sec. 5(16)2a, Sec. 5(16)1c, part A4.*
Hamiltonian mechanics aims to replace the generalized velocity variable of Lagrangian mechanics with generalized momentum variables"[248] based on α [or $m_0 c\alpha$, *Eq. 2(30)*] as a physical entity, thus Hamilton's equations easier to solve than Lagrange's ones considering H particle-paths hypothesis.
According to *Sec. 7(4),* H particle-paths related to α variation confined in an H hall package, *Sec. 5(16)3a*, of h value. In other words, entrance, and exit of H particle-paths accomplish through H hall packages; please refer also to *Sec. 2(4)2.*

Comment 2(1)4a- "The experiments described in this paper probe the simultaneous affects of gravity, inertia, and quantum mechanics using a neutron interferometer of the type developed by Bonse and Hart for x-ray, we have observed quantum mechanical interference phenomena induced by the gravitational field of the Earth and by Earth's relative to the fixed star"[480]. Please refer also to *Sec. 6(2)2.*

Remark 2(1)4a- "At the *LHC*, a proton will reach energy of roughly seven Tera-electron volts (*TeV*). In accord with relation $E = mc^2$, this energy is equivalent to a mass 7000 times of the proton's rest mass" [401] *part 3.*

2(2) - Energy at its different figures

2(2)1- General aspect

The kinetic energy E_k is given as difference of total energy, E_t *Eq. 2(32)*, and rest energy E_0 :

$$E_k = E_t - E_0 = \frac{m_0 c^2}{\sqrt{1-v^2/c^2}} - m_0 c^2 = m_0 c^2 \frac{(1-\sqrt{1-v^2/c^2})}{\sqrt{1-v^2/c^2}} = (\gamma - 1)E_0$$

$$= m c^2 - m_0 c^2 \ , \quad \textit{Sec. 2(2)2,} \qquad 2(40)$$

The total energy can be regarded as the sum of two other energies as follow [1] *part 9*:

$$E_t = E_{ex} + E_{in} = \vec{P}.\vec{v} - L \quad , \textit{Note 2(2)1a} \qquad 2(41)$$

The external energy (E_{ex}) is related to the v velocity as following:

$$E_{ex} = \vec{P}.\vec{v} = \frac{m_0 \vec{v}}{\sqrt{1-v^2/c^2}}.\vec{v} = \frac{v^2}{c^2}\gamma E_0 = (\gamma - \gamma^{-1})E_0 \qquad 2(42)$$

Expressing, $E_{q_\circ}$ *2(41)* as:

$$E_{in} = E_t - E_{ex} = \frac{m_0 c^2}{\sqrt{1-v^2/c^2}} - \frac{m_0 v^2}{\sqrt{1-v^2/c^2}} = m_0 c^2 \sqrt{1-v^2/c^2} = E_0 \sqrt{1-v^2/c^2} \qquad 2(43)$$

$$= \gamma^{-1} E_0 = -L$$

L is the Lagrange function in the stated above equations. In fact, E_{in} is the internal energy of the H system and in case of $v = 0$ (at rest) equaled to E_0. Moreover, the returned energy E_R can be regarded as revealing a part of internal energy E_0 (at rest) during motion of a particle respect to its internal energy E_{in} at movement.

$$E_R = E_0 - E_{in} = (1-\gamma^{-1})E_0 = (1-\sqrt{1-v^2/c^2})E_0 = E_{ex} - E_k$$

$$= \frac{v^2}{c^2}\gamma E_0 - (\gamma - 1)E_0 = (1-\sqrt{1-v^2/c^2})E_0 \text{, } \textit{Comment 2(2)1a} \qquad 2(44)$$

Expressing E_t in the $E_{qs.}$ *2(40), 2(41)* as:

$$E_t = E_k + E_0 = E_{ex} + E_{in}$$

Manipulation of $E_{qs.}$ *2(40), 2(44)* gives:

$$\frac{E_k}{E_0} = \frac{E_R}{E_{in}} = \frac{(\gamma - 1)E_0}{E_0} = \frac{(1-\gamma^{-1})E_0}{\gamma^{-1}E_0} = \gamma - 1 \qquad \textit{, Note 2(2)1b} \qquad 2(45)$$

$$\frac{E_0}{E_{in}} = \frac{E_t}{E_0} = \gamma \qquad 2(46)$$

if $v \to c$, $E_{in} \to o$ and if $v \to o$, $E_{in} \to E_0$

E_{imp} can be regarded or defined as energy that left the H-system during impulsion process, $(-\alpha c)$. According to $E_{qs_\circ}$ *2(40), 2(42), 2(44):*

$$E_k = E_{ex} - E_{imp} = \vec{p}.\vec{v} - E_{imp} = (\gamma - \gamma^{-1})E_0 - E_{imp} = (\gamma - 1)E_0 \qquad 2(47)$$

$$E_{imp} = (1-\sqrt{1-v^2/c^2})E_0$$

$$E_{imp} = E_R \qquad 2(48)$$

Or impulsion energy equals to returned energy; please refer also to *Sec. 7(5)* for additional information.

In all of the above equations, the following relation is established for energy E_w of an H system:

$$\frac{E_w}{H} = N_w \qquad 2(49)$$

Where:

1) $H = a_1 h$ $E_{q.}$ *1(1).*

2) E_w may be $E_0, E_t, E_{ex}, E_{in}, E_{imp}, E_k$ and E_R in the different expressions or form of energies and

3) N_w is the number of H particle- paths of E_w.

In case of low speed $c \rangle\rangle v, E_{ex} = m_0 v^2$ and $E_k = E_{imp} = E_R = 1/2 m_0 v^2$

Note 2(2)1a- The additive characteristic of exterior and internal energies of an H system of rest mass at rest as in, *Eq. 2(41),* can be expressed by analogy with its energy with that of the photon, i.e. pc product of photon momentum and its velocity as it's exterior energy (zero internal energy). Thus, we can express , $\vec{p}\vec{v}$ as exterior energy of H system at v speed, or, in other words, internal energy at this case is equal to *–L*. Moreover, at $v \rightarrow c$, the exterior energy of the H system will be $pv \rightarrow pc$. Since, at the case of $v = 0$, (rest state), E_t will be equal to E_{in}, (i.e. reversibility), or *–L.*

Comment 2(2)1a- Factually, all of the H particle-paths are contributed in reversible motion; whereas, the internal energy component related to reversible motion of H particle-paths is diminished from E_0 to E_{in} due to returned energy E_R. It is a direct result of invariance of interval ds , *Comment 2(5)1*, in all inertial reference frame moving at rectilinear motion respect to each other.

Note 2(2)1b - According to *Eq. 2(45)*, $\gamma - 1$ is equal to kinetic energy per unit of rest energy, E_0, *Eq. 2(35)1*. On the other hands, it is also equal to the returned energy per unit of internal energy. Moreover as $E_0 > E_{in}$, thus, we have $E_k > E_R$. According to *Eq. 2(44),* some part of exterior or common motion of H particle-paths energy is the returned form of initial internal energy (at rest), i.e. E_0, *Eq. 2(35)1,* due to the exit of H particle-paths from the H system as impulsion, *Eq. 2(48).* For more information at the latter case, please refer to *Sec. 6(2)3*

2(2)2- The equivalence of mass and energy

"The term m in the equation $E = mc^2$, does not represent rest mass, it represents relativistic mass, which is the inertial mass, of a body when it is a state of motion relative to an inertial frame [106], *section1*; please refer to *Sec. 2(1)3, Eq. 2(32); Sec. 2(1)4*, and *Comment 2(2)2a*. "The stronger claim that a body mass lose all of its rest mass as it radiates energy is not a consequence of *SRT*" [106], *section 1.* Whereas, according to H particle-paths hypothesis all the rest mass of a body in a process such as collisions between electrons and positron can be converted to energy. Thus, the entire mass of particle is radiated away as energy in the form of light. "The second interpretation of mass-energy equivalence is that it entails that there is merely one fundamental stuff in the world. I will call this view the one-stuff interpretation hereafter"[106], *section2*; please refer to *Sec. 1(6), Comment 1(6)1.* In this article, "H particle-paths assumption" in its two different aspects reversible motion, i.e. mass, single direction or irreversible motion, i.e. energy. The equivalence of mass and energy is then taken to show that we no longer distinguish between matter and field"[106] *section 2(2).* In viewpoint of H particle-paths hypothesis, the field is interpreted as expanded form of the mass and vice versa, *Note 2(1)3a.*

Comment 2(2)2a - The proportionality between the frequency of emitted photon, υ_0, with that of inner motion of H particle-paths number N_0, and its frequency equivalent n_0 of a particle or atom is a direct result of *Mossbauer Effect* [202]. In other words, the frequency of emitted (or absorbed) photon is proportional to the frequency of inner motion of H particle-paths moving in the same direction, the latter is depend also to the number n_0 of H particle-paths of the particle or mass-body. The proportionality factor K_Γ is related to particle wave duality discussed in *Sec. 7(4)2e*. Therefore, inner motion of H particle-paths of a particle's main body must not be confused with that of particle matter wave counterpart all over this article. By the difference that, the frequency through the particle main body is related to the successive changing of its type *L* or *R* configurations. H.E. Ives performed an experiment using ionized hydrogen as a frequency source. This was reported in *1938*, measurements were made with the emitting source moving directly toward the observer, and another set of measurements made with the source moving directly away. The two effects were superimposed and the results compared with the calculation. An internal frequency reduction in matter equivalent to that found in case of the atomic clock was measured. The interpretation as a transverse *Doppler Effect* has no meaning; but the reduction of the internal frequency of matter with velocity is experimentally confirmed"[86]; please refer also to *Secs. 9, 10.* and reference [203]. The degree of this proportionality depends on inertia.

Comment 2(2)2b- According to H particle-paths hypothesis the relativistic mass m at macroscopic scale contrary to reference [106] is simulation of returned internal motion (or geometrical shape) of H particle-paths, *Sec. 2(2)2,* and *Notes 2(1)5, 2(2)2.* “There is no inertial mass increase predicted by *SRT* if a body B_1 moves at a speed *v* relative to another body B_2 ”[108]. According to [199],” Furthermore, early spectrometric experiments with particle trajectories in magnetic fields led to the erroneous conclusion that mass increased with velocity”. According to *HPPH*, apparent mass increment in case of charged particles are related to aggregated, *Sec. 7(5)3d, part B*, electromagnetical contractons; while, neutral contracton leading to decay of related contracton.

2(3) Length and time concept
2(3)1- General aspect

Supposing R the reference frame at rest with origin o and a source A of photon emission (*e.g.* Hydrogen atom) located at origin o' of the reference frame R' and the latter displaced with the *V*= v velocity (source speed) along xx' axes. The frequency of emitted photon by source *A* at rest or in the o location is υ_0 and its energy $\varepsilon_0 = h\upsilon_0$ *[2], but in case of moving source, if $\frac{\overrightarrow{oo'}}{|oo'|} = \vec{i}$, three cases may be occurred a follows: (In the respect of an observer at o)

I) o' is approaching to o at v velocity $\frac{\overrightarrow{oo'}}{|o'o|} = -1$. The photon frequency is υ_F at o and it's energy ε_F :

$$\varepsilon_F = h\upsilon_f = (\gamma+\alpha)h\upsilon_0 = (\gamma+\alpha)\varepsilon_0 = (\gamma-\alpha)^{-1}\varepsilon_0 \qquad 2(50)$$

II) o' is moving away respect to o at v velocity , thus $\frac{\overrightarrow{oo'}}{|o'o|} = +1$. The photon frequency is υ_B at o and its energy ε_B :

$$\varepsilon_B = h\upsilon_B = (\gamma-\alpha)h\upsilon_0 = (\gamma-\alpha)\varepsilon_0 = (\gamma+\alpha)^{-1}\varepsilon_0 \qquad 2(51)$$

III) o is passing o' thus $\frac{\overrightarrow{oo'}}{|o'o|} = 0$;The photon frequency is $\upsilon_\perp$, along *y, z* coordinates or y', z' and it's energy $\varepsilon_\perp$:

$$\varepsilon_\perp = h\upsilon_\perp = \gamma^{-1}h\upsilon_0 = \gamma^{-1}\varepsilon_0 \text{ , } \textit{Remark 2(3)1a} \qquad 2(52)$$

The E_{qs} *2(50), 2(51), 2(52)* are obtained according to E_{qs} *2(36), 2(37), 2(38)*, respectively. Please refer to *Note 2(3)1a*

Note 2(3)1a – According to E_{qs} *2(32), 2(50), 2(51), 2(52)*, the wavelength of emitted or absorbed photon of a moving H system of N_0 number of inner H particle-paths , and its frequency equivalent number n_0 is obtained as follows:

$$\lambda_F = \frac{c}{\upsilon_F} = \frac{ch}{\varepsilon_F} = \frac{h}{p_F} \qquad 2(53)$$

$$\lambda_B = \frac{c}{\upsilon_B} = \frac{h}{p_B} \qquad 2(54)$$

$$\lambda_\perp = \frac{c}{\upsilon_\perp} = \frac{h}{p_\perp} \qquad 2(55)$$

Also, according to E_{qs} *2(32), 2(36), 2(37), 2(38)* and the proportionality, *Comment 2(2)2a*, of photon energy with that of related moving H system (e.g. Hydrogen atom) in each direction, we have:
The latter H system, i.e. moving source *A,* may be assumed as a packet of waves, *Comment 2(3)1a,* with the proportional frequency (or wavelength) as photon in that direction, the ratio of proportionality based on *Eqs. 1(1), 2(35)* will be:

$$\frac{\varepsilon_F}{E_F} = \frac{(\gamma+\alpha)h\upsilon_0}{(\gamma+\alpha)hn_0} = \frac{\upsilon_0}{n_0} \qquad 2(55)1$$

Where:

n_0 - The frequency equivalent through mass m_0 , *Note 2(1)3, Eq. 2(35)*

υ_0 - The frequency of photon absorbed or emitted by H system at rest (*V=0)* per time unit in a path P . The latter is proportional to path-limit Γ , *Sec. 2(6)4b, part A;* thus, the proportionality ratio depends on υ_0, n_0 ratio, *Comment 2(2)2a*.

By analogy, supposing υ_0 is the matter wave frequency, *Sec. 7(4)2e*, of mass m_0 at rest state constituting of N_0 initial H particle-paths, we have:

$$\frac{\varepsilon_\tau}{E_\tau} = \frac{\upsilon_0}{n_0} = \frac{\upsilon_\tau}{n_\tau} = K_\Gamma \text{ , } \textit{Remark 2(3)1b,} \quad \tau = F, B, \perp, \alpha \qquad 2(56)$$

$$\lambda_\tau = \frac{h}{p_\tau} = \frac{c}{n_\tau K_\Gamma} = \Lambda_\tau K_\Gamma^{-1} \quad \text{, please refer to } \textit{Remark 3(1)1c} \qquad 2(57)$$

Where:

*[2] $\overline{\text{Einstein's}}$ *Photon Theory*

λ_τ - The matter wavelength of an H system (e.g. hydrogen atom) in τ direction

n_τ - The frequency equivalent number through mass m_0 at the τ direction related to internal motion frequency Λ_τ of its H particle-paths.

K_Γ - The proportionality factor of matter wave frequency υ_τ with that of n_τ frequency equivalent of related particle (or mass-body), please refer to *Sec. 7(4)2f* in this regards

Therefore, Λ_τ is the wavelength of internal motion of H particle-paths related to frequency equivalent n_τ ; please refer also to *Sec. 4(6)2*.

During a reversible motion of H- particle-path:

I) the mean of the forward and backward energies of H particle-paths in an H system is calculated as follows:

$$\overline{E_{FB}} = \frac{E_F + E_B}{2} = \gamma E_0 = E_t \qquad 2(58)$$

II) The mean of forward and backward energies difference in an H system is calculated as follows:

$$\Delta E_{FB} = \frac{E_F - E_B}{2} = \alpha E_0 \qquad 2(59)$$

According to $E_{q_\circ}$ *2(42)*:

$$E_{ex} = (\gamma - \gamma^{-1})E_0 = \overline{E_{FB}} - E_\perp$$

III) The proper time interval Δt is related to internal energy of an H system, i.e. its reversible internal motions of H particle-paths, as in the following:

$$\frac{E_{in}}{E_0} = \frac{\Delta t'}{\Delta t_0} = \gamma^{-1}, \textit{ Consequence 2(3)1a} \qquad 2(60)$$

Please refer also to *Note 6(2)1a2,* and *Sec. 5(6)1*, in case of different aspects of energy of a particle.

The linear momentum in forward, backward, and y, z-directions are as follows:

$$\overrightarrow{P_F} = (\gamma - \alpha)^{-1} P_{0F} \qquad 2(61) \qquad\qquad \vec{P}_{oF} = -\vec{P}_{oB} = \vec{P}_0 \qquad 2(64)$$

$$\vec{P}_B = (\gamma + \alpha)^{-1} \vec{P}_{oB} \qquad 2(62) \qquad\qquad \vec{P}_0 = N_0 p_0 = m_0 c \qquad 2(65)$$

$$\vec{P}_\perp = \gamma^{-1} \vec{P}_{o\perp} \qquad 2(63) \qquad\qquad \vec{P}_\tau = (\gamma + i\alpha)^{-1} \vec{P}_0 \qquad \tau = F, B, \perp \qquad 2(66)$$

During a reversible motion of H particle- paths:

I) The mean of momentum along x - axis :

$$\vec{P}_{FB} = \frac{\vec{P}_F + \vec{P}_B}{2} = \frac{1}{2}\left[(\gamma + \alpha) - (\gamma - \alpha)\right]\vec{P}_0 = \alpha \vec{P}_0 = \vec{P}_\alpha \qquad 2(67)$$

That is equal to the total momentum of moving H system.

II) The mean of internal momentum along y,z- axes

$$\vec{P}_\perp = \frac{1}{2}(\vec{P}\perp_{up} + \vec{P}\perp_{down}) = \frac{1}{2}(\gamma^{-1} - \gamma^{-1})\vec{P}_0 = 0 \qquad 2(68)$$

III) The mean of momentum change along $x-$ axis.

$$\Delta\vec{P}_{FB} = \frac{1}{2}(\vec{P}_F - \vec{P}_B) = \frac{1}{2}\left[(\gamma + \alpha) + (\gamma - \alpha)\right]\vec{P}_0 = \gamma \vec{P}_0 = (\gamma N_0)\vec{p}_0 = N_t \vec{p}_0 \qquad 2(69)$$

That is proportional to the total internal momentum at each direction of the same H system at rest *(v=0)*.

IV) The mean of internal momentum change along y, z - axes:

$$\Delta\overrightarrow{P_\perp} = \tfrac{1}{2}(\vec{P}_{\perp up} - \vec{P}_{\perp down}) = \tfrac{1}{2}\left[\gamma^{-1} + \gamma^{-1}\right]\vec{P}_0 = \gamma^{-1}\vec{P}_0 = (\gamma^{-1}N_0)\vec{p}_0 \qquad 2(70)$$

$\Delta\vec{P}_\perp$ is equal to zero in a complete cycle of internal motion.

According to $E_{qs.}$ *2(57), 2(66) ,2(32), 2(35):*

$$\lambda_\tau = \frac{h}{p_\tau} = \frac{h}{(\gamma + i\alpha)^{-1} p_0} = (\gamma + i\alpha)\frac{h}{p_0} \qquad 2(71)$$

$$\frac{h}{p_0} = \frac{ch}{E_0} = \frac{ch}{m_0 c^2} = \frac{c}{N_0 a_1} = \frac{c}{n_0} \qquad 2(72)$$

$$\lambda_F = (\gamma - \alpha)\frac{h}{p_0} = \frac{h}{p_F} \quad \text{or} \quad \upsilon_F = \frac{c}{\lambda_F} = \frac{cp_0(\gamma+\alpha)}{h} = K_\Gamma n_0(\gamma+\alpha) = K_\Gamma n_F \qquad 2(73)$$

$$\lambda_B = (\gamma + \alpha)\frac{h}{p_0} = \frac{h}{p_B} \quad \text{or} \quad \upsilon_B = \frac{c}{\lambda_B} = \frac{cp_0(\gamma-\alpha)}{h} = K_\Gamma n_0(\gamma-\alpha) = K_\Gamma n_B \qquad 2(74)$$

$$\lambda_\perp = \frac{h}{p_\perp} = \frac{h}{\gamma^{-1}p_0} = \frac{c}{an_0}\gamma \quad \text{or} \quad \upsilon_\perp = \frac{c}{\lambda_\perp} = \frac{c\,p_0\gamma^{-1}}{h} = K_\Gamma n_0 \gamma^{-1} = K_\Gamma n_\perp \qquad 2(75)$$

$$\upsilon_\alpha = \frac{\upsilon_F - \upsilon_B}{2} = \frac{cp_0}{2h}(\gamma+\alpha-\gamma+\alpha) = \frac{cp_0\alpha}{h} = p_\alpha \frac{c}{h} = K_\Gamma \frac{n_F - n_B}{2} \qquad 2(76)$$

$$\lambda_\alpha = \frac{c}{\upsilon_\alpha} = \frac{h}{p_\alpha} = \frac{h}{\alpha p_0} = \frac{c}{K_\Gamma n_\alpha} = \frac{c}{K_\Gamma n_0 \alpha} = \Lambda_\alpha K_\Gamma^{-1} \qquad 2(77)$$

Generally: $\lambda_\tau = \frac{h}{p_\tau} = \frac{c}{K_\Gamma n_\tau} = \Lambda_\tau K_\Gamma^{-1}$, *Remark 2(3)1a*, $\tau = F, B, \perp, \alpha$ 2(77)0

Where:

υ_α - The mean frequency difference of H particle-paths of wave counterpart of a mass-body, *Sec. 7(4)2e*, moving at c speed through gravitational field medium, *Sec. 7(4)3, part A*, forward (co-direction) υ_F, and backward (counter-direction) υ_B respect to the motion direction in an H system of rest mass.

λ_α - The wavelength related to frequency υ_α nominated as de Broglie's wavelength of matter [refer to *Sec. 3(1),* $E_{qs.}$ *3(19), 3(20), Note 3(1)5*, and *Sec. 5(6)*] through vacuum medium. It is proportional to Λ_α, the wavelength of H particle-paths through mass medium of related mass-body.

$n_F, n_B, n_\perp$, are frequency equivalent components of reversible internal motion of H particle-paths at forward, backward, and normal direction respect to the direction of motion (or common single direction motion of H particle-paths of frequency equivalent n_α) of the related the mass-body that are abbreviated as n_τ ($\tau = F, B, \perp, \alpha$), Moreover the λ_τ is the related wave-matter wavelength of the H system.

Considering, *Eq. 2(77),* a certain wavelength can be ascribed to the motion of each body. Remarkably, this wavelength is due to the single direction H particle-paths wavelength; then, the idea of traveling wave along with the moving body has no sense.

According to *Eqs. 2(73), 2(74), 2(33),* we have:

$$n_F + n_\beta = n_{0\gamma} = n_t \qquad 2(77)1$$

Where, n_t the total frequency equivalent in an H system of rest mass.

Multiplying the two sides of *Eqs. 2(73), 2(74),* one by one, we have:

$$\upsilon_F \cdot \upsilon_B = \upsilon_0^2 \qquad 2(77)2$$

Consequence 2(3)1a – The proper times (or clock ticks) $\Delta t, \Delta t'$ are proportional to the inertia, *Sec. 2(1)4*, of an H system constituted of n_0, n_{in} H particle-paths at their rest states in two reference frames *R, R'* respectively. In other words, proper time of an H system is proportional to inertia of that system. As a result, the time in an inertial reference frame is depended on the inertia of related mass-bodies. Please refer to *Sec. 2(6)2a*. Factually, mass has a dual inertial and gravitation inseparable characteristic, *Sec. 5(3)1*, that reveal depending on its kinds of interactions.

Comment 2(3)1a- In case of a particle regarded as a packet of waves, the group velocity is equal to particle speed denoted by v in case of particle of rest mass should not be confused with phase velocity that is equal to the product of the particle's frequency and its wavelength, i.e. $\upsilon\lambda = c$. Moreover, the speed of matter wave, *Sec. 5(6)*, of a particle is equal to the light speed.

Remark 2(3)1a – According to [205], on the basis of work done by Thim et al, there is no transverse Doppler shift at microwave frequencies. In other words, the frequency of emitted photon orthogonal to the motion direction remain unchanged, i.e. frequency υ_0 instead of $\upsilon_\perp$, *Eq. 2(52)*; please refer to *Sec. 2(1)1b, Comment 2(1)1b3*, in this regards.

Remark 2(3)1b- The frequency equivalent n is the apparent frequency of internal motion of H particle-paths within its mass medium, *Sec. 7(4)3, part D*, respect to the observer at the lab medium. According to path-length constancy, *Sec. 2(1)2*, in case of an isolated particle:

$n.\Delta T_{mass} = \upsilon.\Delta T_d$, or 2(77)3

$$\frac{\upsilon}{n}=\frac{\Delta T_{mass}}{\Delta T_d}=\frac{a_d}{a_{mass}}=K_\Gamma=1.95\times10^{-34} \qquad 2(77)4$$

Please refer to *Comment 5(16)2c4*, and *Sec. 5(16)1a, part A*.
Where:
a_d, a_{mass} - are the values of media coefficient a , *Note 1(2)1*, in free vacuum, and mass medium respectively.
$\Delta T_d, \Delta T_{mass}$ - The partial time intervals related to vacuum, mass media respectively.
According to *Sec. 1(12), Eq. 1(3):*

$$\frac{a_d}{a_{mass}}=\frac{\Gamma_{mass}}{\Gamma_d}=K_\Gamma \qquad 2(77)5$$

Where,
- Γ_d, Γ_{mass} , The path-limits related to free vacuum, mass media respectively
- υ , the matterwave, *Sec. 5(6),* frequency of the particle through vacuum spatial medium, *Sec. 7(4)3, part A*

2(3)2-Discussion

2(3)2a- Dependence of time and length on path-length

The proper time $\Delta t'$ and length l' of an H system are intrinsically related to internal energy [or Lagragian, *L*, *Sec. 2(4)*]; thus, as internal energy of a moving H system E_{in}, *Eq. 2(43),* is the difference of internal energy at rest of the same H system E_0 and the returned internal energy E_R , E_{q_0} *2(44).* The proper time and length of a moving H system are the difference of time and length at rest of the same system $(\Delta t_0, l_0)$ and the returned time δT and length δl $E_{qs.}$ *2(14), 2(13)* respectively; thus:

$$E_{in}=E_0-E_R \quad \text{or} \quad E_R=E_0-E_{in} \qquad 2(78)$$

$$\Delta t'=\Delta t_0-\delta T \quad \text{or} \quad \delta T=\Delta t_0-\Delta t' \qquad 2(79)\,1$$

$$l'=l_0-\delta l \quad \text{or} \quad \delta l=l_0-l' \qquad 2(79)\,2$$

Comparing, elements of *Eq. 2(78),* with that of *Eq .2(79)1,* one can concluded that δT is related to single direction returned energy and Δt to reversible internal energy. Moreover, Δt time interval is an scalar quantity as internal energy; ΔT decrease by reversibility decreasing that accompanied by δT increase through single direction increasing and vice versa*, Note 2(3)2a1;* please refer to *Consequence 2(1)1b1, paragraph 3c*.
According to $E_{qs.}$ *2(15), 2(16)* and *2(43) to 2(46),* we can write:

$$\frac{E_k}{E_0}=\frac{E_R}{E_{in}}=\frac{\delta T}{\Delta t'}=\frac{\delta l}{l'}=\gamma-1 \qquad 2(80)$$

$$\frac{E_0}{E_{in}}=\frac{E_t}{E_0}=\frac{\Delta t_0}{\Delta t'}=\frac{l_0}{l'}=\gamma \qquad 2(81)$$

As a result:
I) the proper time interval, Δt*, Note 2(3)2b1,* in a reference frame is proportionally depends on the total internal paths of forward and backward motions of H particle-paths (i.e. regardless of the path directions). Moreover it is linked proportionally with the internal energy E_{in}, or, in other words, a factor of reversibility of H particle-paths in all of the three space directions; please refer to *Sec. 2(10)*.
II) The space dimension is related to the back and forth characteristic of H particle-paths in the related space coordinate directions, or, in the other words, the means of a back and forth paths cycle in each space direction accompanied by the following cases:
A) The reversible forward-backward path cycles of internal motions in case of a rigid body, *Remark 2(1)3a,* at rest in each space direction.
B) The reversible forward-backward cycles of internal motions plus single direction or irreversible external motion path in case of a moving rigid body at v speed.
Thus, the proper length, l_o, or, scale is related to the mean of a cycle of back and forth of the total path of H particle-path motion (i.e. along the length) after subtracting its external path, *Comment 2(3)2a1*.
According to the above statements and *Eqs. 2(57), 2(72) to 2(75)*, we have:

$$\lambda_F=\frac{c}{K_\Gamma n_F},\lambda_B=\frac{c}{K_\Gamma n_B},\lambda_\perp=\frac{c}{K_\tau n_\perp},\lambda_\alpha=\frac{c}{K_\Gamma n_\alpha} \qquad 2(82)$$

$$\lambda_B-\lambda_F=\frac{2h}{p_0}\alpha=\frac{2\alpha c}{K_\Gamma n_0}=\delta l \qquad \textit{Comment 2(3)3a, and Note 2(3)2a1} \qquad 2(83)$$

$$\lambda_F + \lambda_B = \frac{2h}{p_0}\gamma = \frac{2\gamma c}{n_0} = 2\gamma\,\lambda_0 \qquad \text{, Note 2(3)2a1} \qquad 2(84)$$

$$\Delta L = 2\alpha c\, K_\Gamma^{-1} = n_0 \delta l \qquad 2(85)$$

Note 2(3)2a1- The $\delta l, E_{q.}$ *2(83),* has a distinct effect in electromagnetism, *Sec.4*, considering, n_0 the initial frequency equivalent of an H system at rest, and Λ_0 the symbolic wavelength of that, we have:

$$n_0 \lambda_0 = cK_\Gamma^{-1} \qquad \text{or} \qquad \lambda_0 = \frac{c}{K_\Gamma n_0} = \Lambda_0 K_\Gamma^{-1} \qquad 2(86)$$

λ_0 - The wavelength of deBroglie wave matter attached to the H system. Please refer also to *Sec. 7(4)2e*.

Λ_0 - an imaginary wavelength of the H system in that all of its H particle-paths are arranged successively in a path of length equal to $\Gamma = \frac{c}{a}$, *Sec. 1(12).*

i f we suppose:

$$\delta\lambda_\tau = \lambda_\tau - \lambda_0 \qquad 2(87)$$

$$\delta n_\tau = n_\tau - n_0 \qquad 2(88)$$

$$\frac{\delta\lambda_\tau}{\lambda_\tau} = \frac{\lambda_\tau - \lambda_0}{\lambda_\tau} \qquad 2(89)$$

$$\frac{\delta\lambda_F}{\lambda_F} = \frac{n_0[(\gamma-\alpha)-1]}{n_0(\gamma-\alpha)} = \left[1-(\gamma-\alpha)^{-1}\right]$$

$$= \frac{n_0}{n_0}[1-(\gamma+\alpha)] = \frac{-\delta n_F}{n_0} = \frac{E_{RF}}{E_0} = \frac{E_{impF}}{E_0} \qquad 2(90)$$

$$\frac{\delta\lambda_B}{\lambda_B} = \frac{n_0}{n_0}[1-(\gamma-\alpha)] = \frac{-\delta n_B}{n_0} = \frac{E_{RB}}{E_0} = \frac{E_{impB}}{E_0} \qquad 2(91)$$

$$\frac{\delta\lambda_\perp}{\lambda_\perp} = \frac{\frac{c}{n_0}\gamma - \frac{c}{n_0}}{\frac{c\gamma}{n_0}} = \frac{\gamma-1}{\gamma} = (1-\gamma^{-1})\frac{n_0}{n_0} = -\frac{\delta n_\perp}{n_0} = \frac{E_R}{E_0} = \frac{E_{imp}}{E_0} \qquad 2(92)$$

Generally:

$$\frac{\delta\lambda_\tau}{\lambda_\tau} = \frac{-\delta n_\tau}{n_\tau} \qquad \tau = F, B, \perp, \alpha, 0, \text{ Comment 2(3)2a2} \qquad 2(93)$$

$$\frac{\delta n_F + \delta n_B}{2n_0} = \gamma - 1 = -\frac{\delta n_\perp}{n_0}\gamma \qquad 2(94)$$

$$\frac{\delta n_t}{n_0} = \frac{n_t - n_0}{n_0} = \frac{n_t}{n_0} - 1 = \frac{n_0\gamma}{n_0} - 1 = \gamma - 1 = -\frac{\delta n_\perp}{n_0}\gamma \qquad 2(95)$$

According to $E_{qs.}$ *2(90) to 2(95)*

$$\delta n_F + \delta n_B + 2\gamma\delta n_\perp = 0 \qquad 2(96)$$

$$\delta n_F + \delta n_B + \gamma\delta n_\perp = -\gamma\delta n_\perp = \delta n_t \qquad 2(97)$$

Comment 2(3)2a1 - In fact, apparent time $\Delta t'$, (or Δt_0 at rest) is the manifestation of reversible motion of H particle-paths at all direction, *Note 2(3)2b1*; whereas, spatial dimension l' (or l_0 at rest) is the manifestation of single direction motion of H particle-paths at any specified direction. The path-length from view point of H particle-paths or space-time, *Sec. 2(3)2b*, from view point of relativity can give an appropriate insight in this regards. In other words, time and space interchange within path-constancy, *Sec. 2(1)2*, during mechanical motion and transformation between reference frames. Furthermore, proper time and length affect by γ^{-1} factor in case of reversible motion of H particle-paths, *Sec. 2(6)5b*.

Comment 2(3)2a2- According to *Comment 2(2)1a*, all of the H particle-paths in an H system are contributing in both external and internal motion without any preference, *Sec. 5(6), item IV*. Therefore, the frequencies equivalent number of $n_F, n_B, n_\perp, n_t$, can be interpreted as components of H particle-paths equivalent energies in its different aspect of motion.

2(3)2b- Space-time

As a result, in the case *II(B), Sec. 2(3)2a,* we are encountered with space-time according to Lorentz transformation rather than initial space and time, (x, t) separately. The space-time of a moving object is the intermediate (combined) stage of the two above cases *(I & II)* of *Sec. 2(3)2a*. In the other words, the motion of an object with initial rest mass at a velocity $0< v < c$ depends on the both related internal energy, i.e. internal reversible motion of H particle-paths, and external momentums, i.e. external or common motions of H particle-paths. Noteworthy, the path-length is space-time equivalent according to H particle-paths hypothesis. The path-length is constructed steadily based on conversion of H particle-paths of *SM* configuration to H particle-paths of SN_r and SP_l configurations along with time and space generation in spatial medium, *Sec. 7(4)3, part A*; please refer also to *Sec. 5(15)2b* in this regards.

Generally, space and time in space-time viewpoint, are manifestation of internal and external motions of H particle-paths, *Sec. 1(3),* and *Note 2(3)2b1*. Moreover, expressing the time as individual coordinates is for the reason of simplicity of physical phenomena or data expressions in this respect, *Sec. 2(1)1b, Sec. 5(16)7j*. Space and time are generated steadily through path-length generation mainly through conversion of mass to gravitational field, *Sec. 5(16)1b, part A*, in an expanding Universe, or, through H hall package appearance based on second law of thermodynamics, *Sec. 5(16)7a*. As a result, spatial expansion is proportional to time's arrow as an intrinsic characteristic of our matter Universe. This covariance cannot be disturbed by any physical effect.

According to the above discussion the space and time regarding *Sec. 2(3)2a* are inseparable, nominated" space-time, it can be compared with path-length of H particle-paths hypothesis with the difference that the latter varies at quantized units nominated" H hall quantized package", *Sec. 5(16)3a* of h value, *Sec. 5(16)3g*. By the way, it is generated as matter converted from its compacted form, e.g., mass to its expanded form, *Note 2(1)3b*, i.e. field and energy, *Sec. 5(16)9a, Comments 5(16)9a2, 3*. Therefore, it differs from abstract concept of space-time in relativity theory, *Remark 2(3)2b1*.

"The idea of a coincidence of well-defined events in space-time points being replaced by that of unsharply defined individuals within space-time regions" [369], *parts 3, 2.* The path-length, *Sec. 2(1)2*, of a free particle that is by far analogy equivalent to space-time of relativity has a minimum value h. Thus, it is indivisible to its lower fraction due to the existence of H hall package, *Sec. 5(16)3*. As a result, the path-length has quantized value h, *Sec. 5(16)3g*. According to *Sec. 7(4)1, paragraph 5*, each particle of intrinsic path-length value h obeys the relationship $E.\Delta T = h,\ P.\Delta x = h,$ *Simulation 8(7)2, E5a,* where, $E, P,$ are its total energy, linear momentum respectively, and $\Delta T, \Delta x,$ the internal time, spatial intervals respectively, *Sec. 2(10),* related to H particle-paths motion, *Sec. 7(4)4,* of the particle, *Remark 2(3)2b2*. Therefore, according to H particle-paths hypothesis there is no well-defined time and position of a particle (regarded as non point-like, *Sec. 4(3)1, part B*) within space-time regions, because of presence of its H hall package's cell.

Finally, *Secs, 2(3)3, 5(16)1, 2; 5(16)6 to 9,* dealing with time concepts.

Note 2(3)2b1- Supposing a mass-body at rest state is moving; thus, according to *Sec. 5(6)1*, and *Sec. 2(1)4,* a part of its reversible H particle-paths is converted to single direction H particle-paths respect to an observer at the origin of a relatively moving linear inertial reference frame. As if, the mass of rest mass of a mass-body is diminished, *Note 2(1)4a, item II*, and *Sec. 2(2)2, Comment 2(2)2b,* i.e. no mass increases. Therefore, according to *Sec. 7(4)2f, part A, Eq. 7(29)3*, the stay time interval of the mass body is increased accordingly. In other words, the time interval of two successive beats, *Sec. 7(5)3d, part D*. is increased. Thus, the clock (proper time) in a moving reference due to time dilation, *Sec. 2(1)1a, Eq. 2(12),* ticks slower than our reference (out of the frame, *Sec. 2(8)2*) clock. Factually, according to *Sec. 5(6)1*, the reversible H particle-paths is independent of its irreversible one. For this reason, we must take into account the inertia in each of a reference frame, *Sec. 2(6)2a*, in case of two inertial reference frame moving linearly at constant speed. As a result, the true time in a reference frame is time respect to its *LFRF*, *Sec. 2(6)2c*, observer which depends on the total inertia of that system. Thus, the stay time interval in an H system respect to non-*LFRF* observer can be considered as natural (or universal) time unit Δt_Γ, *Note 7(4)1a*, in this system; while, the proper (or apparent) time respect to its owns' (or In the frame, *Sec. 2(8)2, case A*) observer. Thus, according to above discussion the proper time in both *SRT & GRT* can be respond based on *HPPH*. Please refer also to *Sec. 5(16)1b, part G.*

Remark 2(3)2b1 – Space-time has an equivalent path-length from viewpoint of H particle-paths hypothesis. "In general relativity, space-time is assumed to be smooth and continuous- and not just in the mathematical sense. In the theory of quantum mechanics, there is an inherent discreteness presented in physics. In attempting to reconcile these two theories, it is sometimes postulated that space-time be quantized at the very smallest scales. Current theory is focused on the nature of space-time at the Planck scale" [430] *Quantized space-time*. Noteworthy, to the path-length besides space and time, one can related to it energy as in case of vacuum texture, *Sec. 5(16)3b, part A,* and *Secs. 5(16)3c, d.* Factually, according to *Sec. 7(4)1*, the path-limit Γ through expansion along with time's arrow Δt_Γ generation.

Remark 2(3)2b2- It must not be confused the click rate, and proper time Δt in an H system with time's arrow, and internal time interval ΔT related to inner motion of H particle-paths, the former is shown with small letter *t*, the latter by capital letter *T* all over this article.

2(3)3- Time reversal symmetry

"T-symmetry is the symmetry of physical laws under a time-reversal transformation"[278]; "T-symmetry will exist if the equation describing the physical law involves only the acceleration, (such as with Newton's law of physics) and will be broken if the equation include any terms that involve velocity (such as with laws which include friction) [139]. According to *Sec. 5(15),* any mass body in real word has acceleration, *Note 2(1)4b*, please refer also to *Note 2(3)3a*.

"Physicists use an alternative more sophisticated definition of *T*-symmetry. Physical laws can almost always be separated in *2* parts: a" static" part describing the possible state *S* and a dynamical part *U(t)* describing the dynamics of moving from one state to another" [139].

According to H particle-paths hypothesis the stated above separation is done on the basis of reversible, i.e. mass-body statically at rest in an inertial frame (lab) and single direction, i.e. mass body-moving dynamically respect to an inertial reference frame (lab), *Sec. 2(1)1b, Consequence 2(1)1b1,3c.* Therefore, H particle-paths hypothesis by dividing the motion into *2* parts, *Sec. 1(3).*

"T-symmetry appears to be violated, by the decay of neutral Kaon [139]. It can be related to irreversible space expansion and time's arrow generation; please refer to *Secs. 5(16)6*, *5(16)7, 9* for additional information.

As a result, T-symmetry is a result of time's arrow and time's arrow reversal, *Sec. 5(16)7a*, at equal magnitude, i.e. zero time's arrow variation, *Sec. 5(16)7c*, due to back-to-back matter and antimatter Universes equilibrium, *Sec. 5(16)9b*. In other words, it is better to say, the path-lengths variation in such a system is zero, i.e. constant entropy regardless of entropy increasing due to space expansion; please refer to *Sec. 2(4)* in this regards. Please refer also to *Note 2(3)3b*. According to *Sec. 2(4)1*, there is two kinds of path-length, the reversible, and irreversible ones, the former is related to time reversal symmetry, and the latter to time's arrow (or its reversal). As a result, the *T*-symmetry in an H system depends merely to its motion, *Sec. 2(6)2a, item c*.

Note 2(3)3a - Considering reference frame *R'* moving at a constant straight velocity v in the direction of *x*-axis respect to *R*. Now, supposing reference frame $R_1^{'}, R_2^{'}, R_3^{'}, ..., R_n^{'}$, at velocities, $v+dv, v+2dv, v+3dv, ...v+ndv$ and times, $t_1^{'}, t_2^{'}, t_3^{'}, ...t_n^{'}$, during entrance of distinct numbers of H particle-paths in the same mass-body of rest mass m in uniform and straight motion of *R'* in the same *x*-axis direction respect to *R,* rest frame; regarding, *Note 2(1)4a*. Therefore, we encountered with n inertial reference frames; the speed of light in vacuum has the same constant value c in all of them. Now, supposing the mass m is under an uniform acceleration as above. Thus, from viewpoint of H particle-paths hypothesis we encountered with an accelerating (non inertial) reference frame *R'* as in *Fig. 2(3),* Delta Effect, *Sec. 2(1)1b,* through that the speed of light (or its H particle–paths) is equal to c. Moreover, the speed v and time t' changes , but at a non continuous manner contrary to special theory of relativity, i.e. quantized at integer number of h (or *H*), *Eq. 2(21), 2(22).* In the, *Sec. 5(16), Fig. 5(8),* we can see that the same result is valid for a non linear accelerating reference frame in viewpoint of H particle–paths behavior; please refer to *Sec. 5(16)5.* As a result, the total velocity of each H particle–path in an H system is equal to c in all reference frames; however, the shape of its path differs as in *Figs. 2(3*).

Note 2(3)3b, (proposal) - According to *Sec. 2(1)1b, Consequence 2(1)1b1*; *Sec. 2(3)2, Eqs. 2(78), 2(79),* and *Sec. 5(16)1c, part B* the time interval of an H system is consist of two parts as following:

I) Scalar time related to reversible internal motion, nominated as proper time $\Delta t'$, according to *Sec. 2(1)1*, *Eq, 2(16),* in an inertial reference frame; or, tangential time, Δt_t, according to *Sec. 5(16)1c, part B,* in a non inertial reference frame, i.e. *T*-symmetry, *Sec. 2(3)3*.

II) Directional time related to the returned single direction motion, nominated as returned time, δT according to *Sec. 2*, in inertial reference frame; or radial time, Δt_r, according to *Sec. 5(16)1c, part B,* in non inertial reference frame i.e. time's arrow, *Sec. 5(16)7.*

The sum of the two stated above time intervals, will be:

$\Delta t_0 = \Delta t_t + \Delta t_r$ or 2(97)1

In case of non-inertial reference frame; *Sec. 5(16)2ab, paragraph 3,* and*:*

$\Delta t_0 = \Delta t' + \delta T$ in case of inertial reference frame; *Sec. 2(1)1b, Eq. 2(14),* 2(97)2

Please refer to *Sec. 5(16)1c, part B*

The returned time δT , *Eq. 2(97)2,* evolved as $\pm\,\delta T$ later in the, *Sec. 2(6)2a, Note 2(6)2a1*and *Sec. 2(6)5b;* please refer also to *Sec. 2(1)1, Examples 2(1)2, Sec. 2(6)2a, Example 2(6)2a1.*

As an example of directional time, we can refer to the cases of Sagnac Effect, *Sec. 2(6),* and stellar aberration; and scalar one to the proper time in an H system; moreover, the present note is regarded as a proposition.

Comment 2(3)3a - Relativistic longitudinal Doppler Shift depends on α , *Eq. 2(7),* that is confirmed by well-known Ives-Stilwell experiment, and the emission theory fails in this regards; please refer to [203], and also to *Eqs. 2(7), 2(22).*

2(4) - Least action principle in respect to an isolated particle

2(4)1 – General aspect

Assuming an isolated H system of N_0 H particle-paths moving at v speed, the total energy of that, E_t, *Eq. 2(32),* according to *Eq. 2(41)*, is the sum of two energies i.e. external, E_{ex}, and internal, E_{in}, or, in other words each H particle-path is engaged in an exterior and internal motions. Therefore, according to the equivalency, we can suppose N_{ex}, H particle-paths are in a single direction common motion at c speed, *Sec. 1(3);* moreover, the remainder of the H particle-paths, i.e. N_{in}, are in a closed reversible motion at c speed. Thus, according to *Eq. 2(49):*

$N_t = N_{ex} + N_{in}$

According to *Eq. 2(43)*, the least action principle:

$$S = \int_{t_1}^{t_2} L dt = -a_1 h \int_{t1}^{t2} N_{in} dt = -a_1 h \frac{N_0}{c} \int ds = -mc \int ds \qquad \textit{Note 2(4)1a1} \qquad 2(99)$$

Where, *S, s, L, m,* are the action, interval, *Sec. 2(5),* Lagrange function, and particle mass respectively; please refer to *Secs.. 2(3)2a, 2(10), and part 8* of reference [1]. Thus, the action is proportional to the sum (or integral) of intervals on universal line of an isolated H system (constituted of matter and its field, *Sec. 5(41)*), or, in other words, the total closed path *I (Eq 2(23)* or, *Eq. 2(26)*) of H particle-paths inner the stated above moving H system. Moreover, the action integral, *S,* is stationary (extremum) for an effective motion respect to space-time events on universal line, *Comment 2(4)1a*, thus:

$\delta S \approx -h\delta N_{in} = 0$, or 2(100)

$\delta N_{in} = 0$ during related time interval δt 2(101)

Where, a_1, the constant of media coefficient, *Note 1(2)1*

According to *Eq. 2(15), we* have:

$N_0 \Delta t' = N_{in} \Delta t_0$ = constant , *Note 2(4)1a,* 2(102)

In fact, N_0 and N_{in} are the internal H particle-paths of H system m in the reference frames *R'* and *R* respectively; according to *Eqs. 2(12), 2(102),* we have:

$$N_0 \Delta t_0 \sqrt{1 - v^2/c^2} = [\, N_0 \sqrt{1 - v^2/c^2}\,] \Delta t_0 = N_{in} \Delta t_0 \qquad 2(103)$$

Thus as another result, an isolated H system moves in such a manner that its internal path, i.e. path *I*, *Eq. 2(23)*, or, *Eq. 2(26),* is always minimum, [refer to *Note 2(5)2,* as an example] and constant during an arbitrary reference frame transformation, *Note 2(4)1a.* Moreover, interval, *s,* is related to the reversible characteristic of inner H particle-paths motion, *Sec. 7(4)4,* of the related H system. In other means, the total path of N_0 initial H particle-paths at $\Delta t'$ time interval, (reference frame *R'),* is equal to the total path of N_{in} *H* particle-paths at Δt_0 time interval, (reference frame *R*); please refer to *Sec. 9(4)2*.

According to [1], *part 32*, in an isolated system of particles along with electromagnetic field, its integral of action can be written in general form as follow, *Remark 2(4)1b*:

$$S = \int \Lambda\left(q, \frac{\partial q}{\partial x_i}\right) dV dt = \frac{1}{ic} \int \Lambda d\Omega \qquad 2(103)1$$

Where, Λ is a function of generalized coordinates, q, of system states and the derivatives of the latter respect to spatial and time coordinates; moreover, for electromagnetic field the quantity q are the 4-potential components. According to the above statement, Λ/h can be considered as path-length, *Sec. 2(1)*2, density and $\Lambda d\Omega / h$ path-length magnitude in a 4-dimensional volume $d\Omega$ per path-length unit of h value, *Sec. 2(4)2b*. Therefore, S/h, *Sec. 2(4)4a, Note 2(4)4a1*, can be considered as dimensionless total path-length per unit of path-length value h, *Sec. 5(16)3g,* of our closed system and is constant at any time interval for a closed and spatially expanding (or contracting) system, *Remark 2(4)1b*, i.e. constant (or maximum) entropy-negentropy, *Note 2(4)2a,* at equilibrium state, *Sec. 5(16)9b, Sec. 5(16)9c, part B*, *Sec. 5(16)9d, part A.* Please refer also to *Sec. 2(4)3,* and *Sec. 5(9)3, Example 5(9)3a.* The path-length variation [i.e. time's arrow, *Sec. 2(4)2,* and related space variation] in the latter system is zero; please refer also to *Sec. 5(9)3d,* and *Secs. 5(16)7a, c*. In other words, there is no H hall quantized package generation, *Secs. 5(16)3a, e*; therefore the system obeys the time symmetry, *Sec. 2(3)3*. Alternately, any path-length generation (i.e. time's arrow along with space expansion) in a region of this system compensated by equal path-length contraction (i.e. time's arrow reversal and space contraction) in other region of it, or vice versa, *Remark 2(4)1c, Sec. 8(6)2*; please refer also to *Sec. 5(9)3d*. Thus, the action variation of the whole system in each location of 4-dimensional space-time is zero, or, in other words, the action is extremum, i.e. $\delta S = 0$ in the 4-space, *Remark 2(4)1b.* Moreover, according to *Sec. 2(10)2, Eq. 123*, the relationship *2(102)* can be considered as a result of path-length constancy, *Sec. 2(1)2*. Moreover, there are two kinds of path-length, the reversible, and irreversible ones, *Sec. 2(4)4b*, the latter has two types, expanding type R_e, and contracting type L_c path-lengths that are responsible to spatial expansion along with time's arrow, and mass contraction along with time's arrow reversal respectively, *Secs. 5(16)7, 5(16)10, 11*. Noteworthy, the time reversal symmetry, *Sec. 2(3)3*, is linked with reversible path-length. As an example of this kind of path-length, please refer to *Sec. 5(9)3d, part A*.

The additive characteristic of the action of an isolated H system consisting of the field, mass, mass-field interaction implies that the field, mass, and their related interactions have a unique base, i.e. H particle-paths at its three aspects, *Sec. 1(1),* and *Note 2(4)1b.* Please refer also to [1], *part 27,* in case of electromagnetic field. In other words, there is a summation of path-length densities of three different aspects of H particle-paths.

Consequence 2(4)1a – "Fast moving subatomic particles travel from point A to point B not by a single path but by all possible paths. Also see the Feynman sum-over-paths"[571] *The CGI Universe*. Factually, rectilinear path (most probable path) of photon travel between two points *A, B* has a determined path-length, the other non-rectilinear paths between two points *AB* have a path-length increments along with equally path-length decrement in such a way that the related path-length averaging is equal to that of rectilinear one. This path-length averaging is controlled through equilibrium governed between matter and antimatter countercurrent Universes, *Sec. 5(16)9b*, that make the more deviated path the more improbable one. Moreover, for the reason of simplicity, the more probable one is assumed through the full text and the related figures (e.g., *Fig. 4(8),* etc.). Noteworthy, the transmission of energy between two points *A, B* is defined by path-length value h (Planck's constant) the proposed dimensionless magnitude of its h-bar is as following:

$$\|\hbar\| = \frac{1}{2A\,k_G\,R_n} = \frac{4\pi^2 G}{Ac^3}\left(\frac{a_s}{b}\right) \qquad 2(103)1a$$

Where:

- $a_s = 1s^{-1}$, *Note 1(2)1,* $b = 1kg^{-1}, u = 1m^{-1}$ of inverse dimensions based on units of dimensions in *SI* units.
- *A*, Correction factor, *A= 0.9262*; please refer to *Sec. 5(16)1c, part A1*, and *Sec. 5(16)1a, Remark 5(16)1a3, Eq. 5(49).*

Noteworthy, according to *Sec. 5(16)3b, part B*, the rectilinear path, main track, *e.g. AB,* is expanding to different sub-tracks between *AB*. Moreover, the *A, B* points, *Remark 2(4)1a*,can be located on the emitter source and detector respectively or vice versa (i.e. real locations).By the way, any two points *AB* on main track can be regarded as expanding sub-tracks (or path). Any two points on this sub-track also can be regarded as an expanding sub-track and so on. Ultimately, according to *Sec. 8(9)*, the main track, and sub-tracks (or paths) confined to real locations have physical meaning. Noteworthy, $2A\hbar = K_\Gamma$, please refer to *Note 2(3)1a, Eq. 2(56),* and *Sec. 7(4)2f, Eq. 7(29)* in this regards. Noteworthy, according to *Sec. 8(7)2, part E2*, an electron during its travel from point A to B has an stay time interval ΔT_P. In other words, the electron does not travel all of the paths between A to B at once; but, it chooses merely a single path from all of the paths during any stay time interval ΔT_P from *HPPH* viewpoint. Moreover, the least *AB* distance in a medium, *Sec. 7(4)3*, is the path-limit Γ in that medium along with its stay time interval ΔT_P; please refer also to *Sec. 1(2)*, and *Sec. 7(4)1*.

Note 2(4)1a- The total number of initial H particle-paths of an H system, in an arbitrary reference frame at rest respect to its observer, is remaining unchanged. In other words, by no means such as increasing the velocity of a particle of rest mass constituted of reversible H particle-paths (or any inertial reference frame transformation) one can remove the internal motion.

Note 2(4)1a1- "What Planck did was to set action to a series of finite valued steps and attempt reproduce a continuous variable by reducing the size of the steps. He could only reproduce the spectrum of a red-hot poker if the size of the steps was a small but finite value, now known as Planck's constant, or the unit or quantum of action. This also implies that both time and energy also come in quanta. If either time or energy were continuous then action would be a continuous variable." [618] *Comments*.

Note 2(4)1b- In fact, the interacting H systems constitutes a unique H system, *Sec. 8(5),* (or path-length, *Note 3(1)2a*) through mutual H particle-paths exchange of its constituents by considering *EPR Paradox*, *Sec. 8(4).* Moreover, the applying forces *Sec. 6(2)6*, regardless of its source (e.g. electromagnetic, impulsion, gravitational) have unique effect on the mass i.e. motion. The equivalence of inertial and gravitational mass, *Sec. 5(3),* implies the H particle-paths behavior in its different aspects.

Remark 2(4)1a – To any path between two points *A, B* related different time contraction respect to time *AB* at rectilinear path, *Note 5(16)3b4*, in such a manner that the H particle-paths speed is equal to *c* and all of the H particle-paths at initial point *A* reach to point *B* simultaneously. Please refer to *Sec. 2(1)1b, Fig. 2(3), Eq. 2(16); Sec. 4(3)1, part B.* "The state of the system as it moves from point A to point B along the Lagrangian follows the *path of least action* (in other words, the shortest distance between the two points - see here)"[560] *Quantum Gravity: The Wheeler-DeWitt Equation*. Noteworthy, any path-length increment, respect to rectilinear *AB* one is accompanied by time's arrow increment and space expansion accordingly or vice versa, *Comment 2(4)1b*. The rate of expansion is governed by rate of expanding spheres, *Sec. 5(4)1*, in case of an isolated particle at vacuum medium. The most probable rectilinear path is depends on the nature of flat texture of vacuum gravity free quantized texture. In case of curved texture, *Sec. 2(4)2*, the most probable path is the geodesics of curved 4-space, *Sec. 5(16)3b, part B*. Please refer also to *Sec. 5(2)2, Fig. 5(2)1.* Finally, according to *Sec. 8(7)2*, *part G2*, a moving particle is guided by its track texture through vacuum medium, *Sec. 5(16)3b, part B*.

Remark 2(4)1b – In fact integration of, *Eq. 2(103)1*, is performed in whole 3-dimensional space and between two given instants, i.e. in infinite region between two hyper-surfaces.

Remark 2(4)1c- The total path-length decrement is related to path-length increment of contracting type L_c, and its increment is due to expanding type R_e path-length, *Sec. 5(16)11*. In other words, the algebraic sum of the two types of path-length has a constant value, i.e. the degree of spatial expansion has an equal value of contraction degree through (or towards) the normal mass.

Comment 2(4)1a- "The infinitesimal, Lorentz-invariant path-length swept out by the particle is $dl = (-ds^2)^{\frac{1}{2}}$, where l is the properties of the particle in the flat Minkowski metric. The action for a particle of mass m is given by the total length of the trajectory swept out by the particle in spacetime. The minimum of this action determines the trajectories of the particle with the smallest path length, and therefore the solution of the classical equations of motion is the geodesic of the free particle in spacetime". [456] *section 3.1, the relativistic particle*. According to H particle-paths hypothesis, the path length of a particle is regarded as the total path swept by its H particle-paths that in a flat vacuum medium obeys the geometrical aspect of quantized texture of the latter, *Sec. 5(16)3b, part B*.

Comment 2(4)1b – Alternately, it is better to say that the H hall package splitting is not performed during such a geometrical expansion in any of individual subtract respect to main one. Therefore, the path-length of each track conserve its value h. Resuming a main track with path-length, e.g., h, is split to e.g., *N* sub-tracks of path-length h, i.e. Nh path-length generation, *Sec. 7(2);* but each subtract during its expansion conserve its path-length value h as stated above. It is divided to more subsidiary sub-tracks each of path-length value h , and so on. Please refer also to *Sec. 5(16)1b, part A*, and *Sec. 5(16)3b, part B*.

2(4)2 – Path-length density

2(4)2a- General aspect

The intrinsic time's arrow variation of a closed system is apart from time symmetry and time's arrow, which we normally attribute for that H system. It depends merely on the entropy variation of the whole system. Similarly, to a closed H system, in case of a system at equilibrium state of initially constant entropy, the path-length variation is zero (i.e. the time's arrow variation and its related space variation is zero). In other words, there is equilibrium between H particle-paths at handedness and handedness reversal mode; please refer also to *Sec. 5(16)9*.

The *Fig. 5(2)* of *Sec. 5(2)1b*, can be regarded as one of the examples of reaching to an equilibrium state after a set of preliminary interaction of a mass-body m in the gravitational field of mass *M*. According to that the internal H particle-paths of the mass m taking the geometrical shape and curvature of the external gravitational field of the mass *M*, or vice versa. This external effect is considered by inserting the factor $\sqrt{-g}$ in the action integral, *Eq. 2(103)1,* of total mass, i.e. $S_m = \int \sqrt{-g}.\Lambda d\Omega$, in order to obtain the path-length constancy at the equilibrium states, where, g is metric tensor determinant of curved 4-space; please refer to [1], *parts 94, 95*. We must consider the path-length related to total gravitational field, i.e. action of total gravitational field, $S_g = \int R\sqrt{-g}d\Omega$, where *R* is 4-space curvature scalar [1], *part 94*. In other words, the mass-bodies and their gravitational fields are two different aspects of a same issue, i.e. single stuff H particle-paths, *Sec. 2(1)1d*, therefore in the both S_m, S_g action integrals, its path-length characteristics must be considered. Now considering the action *S* of a closed system at equilibrium constituting of mass *M*, and their gravitational field; therefore, according to principle of stationary action:

$\delta S = \delta(S_m + S_g) = 0$,   please refer to *Sec. 5(16)3g*, and *Note 7(4)2e3*   2(103)2

That is a result of total path-length constancy of a closed system including the gravitational field regarded as unique H system, *Sec. 8(5).* Therefore, the path-length variation along with action variation, δS , become zero accordingly between any given instant on this curved 4-space*, Note 2(4)2a*.

As a result, δS_g is positive relating to appropriate right-handed expansion in gravitational field; whereas, δS_m is negative sign with equal magnitude related to contraction in the mass-body in each 4-space infinitesimal volume $d\Omega$ during an expanding Universe, *Sec. 2(4)4a*. Therefore, path-length density in an expanding Universe is constant, or, scale invariant; please refer also to *Sec. 5(16)1c, part A; Sec. 5(16)10, Remark 5(16)10b*. In fact, space geometry is defined by vacuum quantized texture, *Sec. 5(16)3b*. In other words, The H particle-paths texture (or better to say path-length texture) is flat in the absence of gravitational field (i.e. background texture), that become curved by the superimposition and collaboration of H particle-paths of external field (or gravitational potential) as in, *Sec. 5(16)1b, part A, paragraph 7c, Fig. 5(8).* Please refer also to *Sec. 5(16)3b, part D1*. "More fundamental to the problem, however, is the very existence of a fixed background, which Einstein describes as "the fixed stars". Modern relativists see the imprints of Mach's principle in the Initial-Value Problem. Essentially, we need to separate spacetime into slices of constant time. When we do this, Einstein's equations can be decomposed into one set of equations, which must be satisfied on each slice, and another set, which describes how to move between slices. The equations for an individual slice are elliptic partial differential equations. In general, this means that only part of the geometry of the slice can be given by the scientist, while the geometry everywhere else will then be dictated by Einstein's equations on the slice"[512] *Mach's principle in modern General Relativity*. Factually, by some analogies, the H hall quantized package, *Sec. 5(16)3a,* of path-length value h , and constant time interval ΔT_Γ , *Note 7(4)1a,* and path-length limit Γ in spatial medium, *Sec. 7(4)3, part A*, can be compared with such slices.

Noteworthy, in case of charged particle interaction, the path-length is varied also by h values, *Sec. 4(3)1d*.

"Early attempts at quantizing general relativity by Dirac, Wheeler, DeWitt and others in the 1950s and 1960s worked with a seemingly natural choice for configuration variables, namely geometric variables g_{ij} corresponding to the various components of the 'three-metric' describing the intrinsic geometry of the given spatial slice of spacetime. One can think about arriving at this via an arbitrary slicing of a 4-dimensional "block" universe by 3-dimensional spacelike hypersurfaces. The conjugate momenta π_{ij} then effectively encode the time rate-of-change of the metric, which, from the 4-dimensional perspective, is directly related to the extrinsic curvature of the slice (meaning the curvature relative to the spacetime in which the slice is embedded). This approach is known as 'geometrodynamics'. "In these geometric variables, as in any other canonical formulation of general relativity, one is faced with constraints, which encode the fact that the canonical variables cannot be specified independently. A familiar example of a constraint is Gauss's law from ordinary electromagnetism, which states that, in the absence of charges, $\cdot \boldsymbol{E}(\boldsymbol{x}) = 0$ at every point $\boldsymbol{x}$. It means that the three components of the electric field at every point must be chosen so as to satisfy this constraint, which in turn means that there are only two "true" degrees of freedom possessed by the electric field at any given point in space. (Specifying two components of the electric field at every point dictates the third component.)". "The constraints in electromagnetism may be viewed as stemming from the $U(1)$ gauge invariance of Maxwell's theory, while the constraints of general relativity stem from the diffeomorphism invariance of the theory. Diffeomorphism invariance means, informally, that one can take a solution of Einstein's equations and drag it (meaning the metric and the matter fields) around on the spacetime manifold and obtain a mathematically distinct but physically equivalent solution. The three 'supermomentum' constraints in the canonical theory reflect the freedom to drag the metric and matter fields around in various directions on a given three-dimensional spacelike hypersurface, while the 'super-Hamiltonian' constraint reflects the freedom to drag the fields in the "time" direction, and so to the "next" hypersurface. (Each constraint applies at each point of the given spacelike hypersurface, so that there are actually $4 \times \infty^3$ constraints, four for each point.) In the classical (unquantized) canonical formulation of general relativity, the constraints do not pose any particular conceptual problems. One effectively chooses a background space and time (via a choice of the lapse and shift functions) "on the fly", and one can be confident that the spacetime that results is independent of the particular choice. Effectively, different choices of these functions give rise to different choices of background against which to evolve the foreground. However, the constraints pose a serious problem when one moves to quantum theory" [599] *Geometric variables*. "All approaches to canonical quantum gravity face the so-called problem of time in one form or another (Kuchař (1992) and Isham (1993) are excellent reviews). The problem stems from the fact that in preserving the diffeomorphism-invariance of general relativity — depriving the coordinates of the background manifold of any physical meaning — the "slices" of spacetime one is considering inevitably include time, just as they include space. In the canonical formulation, the diffeomorphism invariance is reflected in the constraints, and the inclusion of what would ordinarily be a 'time' variable in the data is reflected in the existence of the super-Hamiltonian constraint. The difficulties presented by this constraint constitute the problem of time" [599]*Problem of time*

Note 2(4)2a- Factually, in our matter Universe, the path-length variation δS_g through gravitational field medium, *Sec. 7(4)3, part B*, has expanding configuration of right-handed type R_e; while, the path-length variation δS_m through mass medium *Sec. 7(4)3, part D,* has contracting configuration of left-handed type L_c at equal magnitude and opposite signs, *Sec. 5(16)11.*

According to *Eq. 2(103)2*, path-length increment in the mass medium is accompanied by equivalent path-length increment in gravitational field at opposite configurations, and signs, or vice versa, *Sec. 5(16)1c, part A* in order to establish path-length constancy of total H system that resulting constant entropy-negentropy algebraic sum, *Sec. 5(16)9d*. But according to H particle-paths hypothesis, the total entropy of such a system is increasing according to gravitational expanding closed surface, *Sec. 5(4)4,* of the total H system m along with spatial expansion and time's arrow generation, *Sec. 5(16)7,* i.e. disorder. It is accompanied by equal magnitude of negentropy increasing in the internal H particle-paths of the related mass, i.e. ordering, that resulting a constant value; please refer, to *Sec. 5(16)1b, part A, Remark 5(16)1b, A2.*

2(4)2b- Path-length density and the role of S/h

Factually in action integral, path-length must be regarded as its product by unit of path-length of h value, *Sec. 5(16)3g*, (i.e. equivalent unit of action); therefore, Λ/h, S/h must be considered as path-length density, total path-lengths integer numerical value respectively. "In Bohr- Sommerfeld Theory (old quantum mechanics), all Jacobi actions are quantized in integers $\oint pdq = 2\pi n\hbar$. The above logic then clarifies why the classical Jacobi actions are adiabatic invariant" [452] *horizon area as an adiabatic invariant section*, please refer to *Sec. 2(4)4a*. This argument can be extended to macroscopic scale as stated above, i.e. path-length density. By the way, action is a scalar and analogous to path-length its dimension in *SI* unit is $kg.m^2.s^{-1}$; please refer also to *Sec. 9(4), Remark 9(4)1a* and *Comment 5(2)1b1.*

According to [288], *part 1.1*, Quantum amplitude from viewpoint of Feynman path integral, the amplitude for some event is given by adding together all the histories which include that event; moreover, the amplitude a certain history is proportional to $e^{i\frac{S}{h}}$. According to above assumption that contribute to the quantum amplitude any path, *Consequence 2(4)1a*, can be attributed to a certain group of H particle-paths of a particle moving from point *A* (initial point) at some time t_o to point *B* (final point) at some other time t_1 instead of probability amplitude of that particle. Thus, the probability for any fundamental event is given by the absolute square of this complex amplitude (that is proportional to $e^{i\frac{S}{h}}$). In order to find the overall probability amplitude for a given process then one ad up or integrate the amplitude $e^{i\frac{S}{h}}$ over, the space of all possible histories of the system in between initial and final state. According to *Sec. 2(4)4a*, S/h is equivalent to δN_g, number of expandons in a location during time interval dt. Therefore, considering the wave function $\Psi = e^{i\frac{S}{h}}$, [36] *section 24*, it can be regarded as a evaluation of expandons in a location during time interval dt. In other means, the particle wave function can be regarded as a function of expandons

population of two types W_R, W_L, *Simulation 7(4)2e1*, due to matter-wave counterpart of an isolated particle in different locations of spatial medium during time t. Similarly, its complex conjugate, *Sec. 8(1)2,* can be attributed to contracton conjugate evaluation of types PR & PL in a location during time interval dt. Therefore, its square amplitude can be considered as expandons (or contractons) population density in a location in one hand. In other hand, the population density of expandons has a hard link with the presence of its emitter, i.e. particle during stay time ΔT_p, *Sec. 7(4)2f, part A*, in a location. Please refer to *Sec. 7(4)3, part E1*, for more information. Factually, the matter-wave frequency of an particle in a medium, e.g. vacuum, gravitation field, *Sec. 7(4)3,* according to *Sec. 2(3)1* is proportional to frequency equivalent of the particle through its mass medium by K_Γ factor in the related medium. Therefore, S/h in a wave function is depending on the frequency equivalent components of particle in different direction and during time interval, e.g. stay time ΔT_p, please refer also to *Sec. 8(1)1.* Noteworthy, the matterwave frequency of a particle is also depends on the related medium, e.g. gravitational field medium, *Sec. 7(4)2f, part A*.
Noteworthy it is a law of nature that particle chooses the minimum path of related H particle-paths during its evolution (or motion). Conversely there is no control to the rate of expansion process, *Sec. 5(16)2b*, toward higher path-lengths related to time's arrow, *Sec. 5(16)7a,* along with space generation. As we see there is a controlled rate of expansion at the present time that depend on light speed and gravitational constant as in *Sec. 5(16)2a, Eq. 5(67)15a*.

2(4)3 – A step towards gauge theory

According to *Sec. 2(1)2, Eq. 2(26),* the Lorentz transformation of an H system from inertial frame of reference *R* to *R'*, reduces the path-length of transformation, i.e. *Path R, R'* from initial path-length, *Path R* of the H system in reference frame *R* in order to obtain the *Path R'* of the H system in new reference frame *R'* respect to the observer o at reference frame *R*.

Path R = path RR' + Path R' 2(103)3

$$L_R = L_{RR'} + L_{R'} \qquad 2(103)4$$

Noteworthy, the total path is the sum of path of mono (or single) direction and reversible motion. Moreover, *Eqs. 2(27), (28)* of *Sec. 2(1)2*, are the result of path-length constancy in special case of spatial time dimensions transformation, i.e. Lorentz transformation.
To each path-length is related a Lagrangian $L_R, L_{RR'}, L_{R'}$, respectively with the following properties:

I) By multiplication a 4-space volume value $d\Omega$ to *Eqs. 2(103)3, 4,* each path-length or Lagrangian, (i.e. path-length density), is increased proportional to this value because of its constancy during transformation. Thus, we have:

$$L_R d\Omega = L_{RR'} d\Omega' + L_{R'} d\Omega' \qquad d\Omega = dV.dt = d\Omega' = dV'.dt' \qquad 2(103)5$$

II) By analogy with item *I,* multiplication each of *Eqs. 2(103)3, 4* by a constant number, it is increased (or decreased) proportional to this constant number.

As an example, considering a charge e is at rest in reference frame *R*. Therefore, there is a vector potential $\vec{A}$, *Sec. 4(6)3*, due to the motion of *R'* respect to observer *R*, and $\vec{A}'$ respect to observer *R'*.
According to *Sec. 4(6)3, Eq. 4(3)2*, and *Sec. 2(101b, Eq. 2(25),* and *Eq. 2(103)3* we have:

$$PathRR' = -PathR' \qquad \text{or} \qquad a\,N_\alpha.dx = -\frac{e}{h}A_x.dx = -\frac{e}{h}A'_x\,dx' \qquad 2(103)6$$

Since the part of Path *R* due to charge e at rest is zero. In other words, regardless of any variation of the total path-length of an H system at reference frame *R* that has an equivalent variation at reference frame *R'* we must insert a proportionality factor due to path-length *RR'* equal to $-\frac{e}{h}A_x$ in this variation base on above conclusion. An appropriate covariant derivative in the form of $D_\mu = \partial_\mu - i\frac{e}{\hbar}A_\mu$ is given according to [411] *a simple example*, that can be compared with result obtained from H particle-paths hypothesis, *Note 2(4)3a*.

"Some theories are distinguished by the mathematical property of *gauge invariance*, which means that transformations, so-called gauge transformations, of certain terms do not change the observable quantities. The requirement of gauge invariance has the mathematical advantage that it provides an elegant way to introduce terms for interacting fields. Moreover, requiring gauge invariance plays an important role for the selection of theories. The prime example of an intrinsically gauge invariant theory is the theory of the electromagnetic field. It is well-known from the classical theory that Maxwell's equations can be stated in terms of the vector potential **A** and the scalar potential φ or in terms of the 4-vector potential $A^\mu = (\varphi, \mathbf{A})$. The link to the electric field $\mathbf{E}(\mathbf{x},t)$ and the magnetic field $\mathbf{B}(\mathbf{x},t)$ is given by

2(103)7 $\mathbf{B} = \nabla \times \mathbf{A}$

2(103)8 $\mathbf{E} = -(\partial\mathbf{A}/\partial t) - \nabla\varphi$

or covariantly

$F^{\mu\nu} = \partial^{\mu} A^{\mu} - \partial^{\nu} A^{\mu}$ 2(103)9

Where $F^{\mu\nu}$ is the electromagnetic field tensor. The important point in the present context is that given the identification (*Eq.2(103)7*) or (*Eq.2(103)9*), there remains a certain flexibility or freedom in the choice of **A** and φ, or A^{μ}. In order to see that, consider the so- called *gauge transformations*.

2(103)10 $\mathbf{A} \rightarrow \mathbf{A} - \nabla\psi$

2(103)11 $\varphi \rightarrow \varphi + \partial\chi/\partial t$

or covariantly

$A^{\mu} \rightarrow A^{\mu} + \partial^{\mu}\chi$ 2(103)12

where χ is a scalar function (of space and time or of space-time) which can be chosen arbitrarily. Inserting the transformed potential(s) into *Eqs.2(103)10*,or *Eq.(2(103)12*), one can see that the electric field **E** and the magnetic field **B**, or covariantly the electromagnetic field tensor $F^{\mu\nu}$, are not effected by a gauge transformation of the potential(s). Since only the electric field **E** and the magnetic field **B**, and quantities constructed from them, are observable, whereas the vector potential itself is not, nothing physical seems to be changed by a gauge transformation because it leaves **E** and **B** unaltered. Note that gauge invariance is a kind of symmetry that does not come about by space-time transformations"[597] *Gauge invariance*. Please refer also to *Sec. 4(6)3* in case related to vector potential based on *Sec.5(16)1b, part F.Note 2(4)3a* -In fact, according to *Sec. 4(3)1, part D*, magnetic flux is quantized in units of $\phi = \frac{h}{e}$ that is equivalent to the unit of path-length in electrodynamics. Therefore, the path-length *RR'*, i.e. $-\frac{e}{h}A_x$ is divided by this unit to be consistent with total path-length variation. As a result, the path-length constancy can be regarded as a tool in the domain of gauge theory based on idea of symmetry transformation. Moreover, according to *Eq. 2(103)4*, and by analogy with it respect to observer *R'*, we conclude that:

Path R'R = - Path RR' 2(103)13

Generally speaking, the physical properties obeying gauge symmetries are based on path-constancy. The path-length of a falling object in a gravitational field has an equal path-length, when this object undergoes an equivalent accelerating motion (e.g., by exerting a force in a medium excluded of gravitational field). According to *Sec. 5(16)1d, Comment 5(16)1d1*, the gauge theory is applied merely to the cases that H particle-paths mode of motion of an H system manifesting as single direction (or irreversible) ones. Therefore, the gravitomagnetism, *Sec. 5(2)1c*, can be regarded as single direction manifestation of H particle-paths at the domain of gravity. Moreover, in a moving inertial frame of reference, time has a single direction aspect, i.e. mono-directional part, please refer to *Sec. 2(1)1b, Consequence 2(1)1b1, part c, case II*, that reveal as path-length (its energy-time aspect).

2(4)4- Path-length characteristic

2(4)4a- Types of path-length variation in different media

According to reference [1] *part 93*, the gravitational field action S_g must be expressed under the form of a scalar integral $\int R\sqrt{-g}d\Omega$, the action variation can be written as following:

$$\delta S_g = \frac{c^3}{16\pi G}\delta \int R\sqrt{-g}.d\Omega$$

Where:

- G is the gravitational constant.
- R, the 4-space curvature scalar of dimension m^{-2} in SI system of units.
- g, the determinant with dimensionless elements of g_{ik}, $i.k = 0,1,2,3$, *Comment 2(4)4a1*.

According to *Consequence 2(4)1*, *Eq. 2(103)1a*, $\frac{4\pi^2 G}{Ac^3}\left(\frac{a_s}{b}\right) = K_\Gamma$ has the same magnitude as $2\hbar$ through a dimensionless correction factor A, *Comment 2(4)4a2*. Therefore, $\frac{\delta R\sqrt{-g}.d\Omega}{2\hbar}\left(\frac{a_s}{b}\right) = \delta N_g$, *Note 2(4)4a1,* and *Sec. 2(4)4b*, can be regarded as flow variation number of expandons, *Sec. 5(16)1c, part A3*, each of path-length value $2\hbar$, *Note 2(4)4a2,* and of population density n_g through *3*-space volume dV during time interval dt. In other words, any close-ended expandon imparts a path-length of $2\hbar$ value, *Remark 5(16)1a5*, to path-length variation within *4*-space volume $d\Omega$ of the related gravitational field through vacuum gravitating medium, *Sec. 2(4)4b*. "The strength of coupling between matter and gravity is determined by gravitational constant" [475]. According to H particle-path hypothesis, this coupling is based on path-length constancy as stated above through path-length value $2\hbar$ of close-ended expandons; please refer also to *Sec. 5(15)2c*. According to *Sec. 8(7)2, E5, item 9*, in case of particle, any expandon emission is along with H or nH energy; while, contracton releasing imparts $-H$ or $-nH$ energy respectively of equal magnitude and opposite sign as energy fluctuation in case of a particle.

As a result, the type R_e path-length flow through vacuum gravitating medium, *Sec. 7(4)3, part B,* defines the space and time geometrical aspect of that medium. It induces an equivalent type L_c path-length flow related to δS_m, *Sec. 2(4)2, Eq. 2(103)2,* through the mass media, *Sec. 7(4)3, part D,* of interacting mass-bodies at equal magnitude and opposite signs, *Sec. 5(16)11*, that appear as impulsion-energy within mass media, *Sec. 2(4)4c*. Please refer also to *Sec. 5(2), Figs. 5(1), 5(2)*, and *Sec. 2(4)1* in this regards. Noteworthy, the motion of a particle at micro-world through a track texture, *Sec. 5(2)1e*, in a vacuum gravitational field free, *Sec. 5(16)3b, part B*, obeys a similar mechanism. Moreover, the motion of particle at micro-world contrary to mass-bodies at macro-world is not continuous and steady, please refer to *Sec. 7(4)2e* in this regards. Note that, according to *Secs. 7(4)2a, d*, the path-length varies by integral of h units just during an interaction (or measurement, *Sec. 8(7)2*). In other words, before interaction the whole interacting system can be regarded as a unique H system, *Sec. 8(5)*. Therefore, the interaction gives form to unit of path-length of h values of stored path-length, *Sec. 7(4)1, item 3*.

Note 2(4)4a1- δN_g is an integer number, it is equivalent to $\frac{S}{h}$. Moreover, $\frac{\delta N_g}{dt}$ is equivalent to gravitational acceleration in the related location that is independent of the shape, and magnitude of a test mass-body m at the stated above location. Factually, according to *Sec. 5(9)3d, Fig. 5(5)2*, any expandon of δN_g expandons of a mass-body M in a location is along with its contractons conjugate, *Sec. 2(4)4c*. Moreover, any expandon that is interacted with test mass-body induces a contracton from the latter towards the mass-body M (or vice versa). Noteworthy, $\frac{\delta N_g}{dt}$ in gravitational field of mass M is equal to $\frac{\delta N_\alpha}{dt}$ in test mass-body m, *Note 6(2)2a*. Please refer also to *Sec. 7(4)2h* in case of variation of a unit of path-length during an interaction or measurement.

Note 2(4)4a2- Expandon emission in spatial medium, *Sec. 7(4)3, part A*, during a complete beat, *Sec. 7(5)3d, part D*, in a cell may be along with an aggregated of a couple of contracton, *Sec. 7(5)3d, part B,* of path length value $-2\hbar$ via H hall package tunnel, *Sec. 5(9)3d, part c* released towards the mass medium, *Sec. 7(4)3, part D*, i.e. center of mass M,. It is ultimately transferred through H hall package tunnel towards the related black hole of the host galaxies and clusters, *Sec. 5(7)8*, and irreversibly absorbed. Please refer also to *Sec. 5(16)1b, paragraph 28*, and *Sec. 5(16)1b, part G*.

Comment 2(4)4a1- According to general relativity: "In a non-inertial reference frame, the square of interval ds is a form of general quadratic of differentials, i.e. $-d_S^2 = g_{ik}\, d x^i d x^k$. The g_{ik} elements are functions of time coordinate x^0, and spatial coordinates x^1, x^2, x^3. The g_{ik} quantities that determine all of the geometrical properties in any curvilinear coordinates specify the metric of space-time."[1] *Part 82.*

Comment 2(4)4a2- According to *Sec. 5(16)1c, part A1*, the dimensionless correction factor A is equal to *0.9262*; please refer to *Proposal 5(16)1c, A1*, and *Note 5(16)1c, A1* in this regards.

2(4)4b-Reversible and irreversible kinds of path-length

This variation depends on curvature variation through spatial medium at a constant ratio $K_\Gamma \cong 2\|\hbar\|$ and in the direction of curvature. In other words, the flow of expandons each of path-length value $2\hbar$ through a spatial medium dV during time interval dt, i.e. *4*-space $d\Omega$ is along the related curvature and proportional to its variation at that location. According to *Sec. 5(4)2*, a mass-body (or particle) of tangential velocity $\vec{T}$ moving on a curved trajectory is affected by a normal vector $\vec{T}'$ related to its acceleration and in the direction of trajectory curvature κ and proportional to it. In other means, According to *Note 2(4)4a1*, the magnitude of the curvature κ is proportional to δN_g per time unit related to number of contractons formation in the direction of curvature κ per time unit. As a result, the total path-length variation of a closed system of interacting mass-bodies, *Sec. 2(4)1, Eq. 100*, is no longer zero, but it imparts a non reversible path-length variation at a ultra low ratio, $K_\Gamma = 1.95\times10^{-34}$, *Sec. 7(4)2f*, of the reversible one of its related mass, *Consequence 2(4)4b1*. In other words, the path-length on gravitational field, or, better to say its matter-wave counterpart at the both stationary, *Note 2(4)4b1*, and non stationary cases of the related mass of an energy ratio K_Γ of matter-wave to the mass, *Note 2(3)1a, Eq. 2(56).* Please refer also to *Sec. 2(3)1, Sec. 5(6), Remark 5(16)3b, B1, and Comment 7(4)2e1.*

Resuming, the irreversible path-length increment through expanding spatial medium is quantized at $2\hbar$ units. It is along with equal magnitude of path-length decrement within contracting mass medium at $-2\hbar$ quantized units. In other words, their algebraic sum is a constant value, *Sec. 5(16)11*, in two different spatial and mass media separately. In an isolated closed H system the reversible path-length increment in a location is along with equal path-length decrement in other location through a single medium, e.g. spatial, or mass medium. The reversible path-length is also quantized, it varies at h value units.

Consequence 2(4)4b1- According to *Sec. 2(4)4a*, and *Remark 2(3)1b,* any reversible path-length in an interaction of *T*-symmetry, *Sec. 2(3)3,* has an equivalent irreversible path-length at K_Γ factor lower than its magnitude. Therefore, any geometrical variation, *Sec. 5(16)3b, part D*, related to reversible path-length also has an equivalent geometry variation in irreversible one (or vice versa). In other words, the contractons that are released during an irreversible path-length can be regarded as an evaluation of reversible one at K_Γ factor ratio. Please refer also to *Proposal 5(7)3a*.

Note 2(4)4b1- "A standing wave, also known as a stationary wave, is a wave that remain in a constant position." "It can arise in a stationary medium, as a result of interference between two waves traveling in opposite direction." "The sum of two counter-propagating waves (of equal amplitude and frequency) creates a standing wave."[505] *Standing wave*. The counter-current H particle-paths as in *Fig. 3(4)a, b*, and *Fig. 3(6),* constitute an stationary wave-like pattern; please refer also to *Sec. 8(3)4*.

2(4)4c- Discussion

Any expandon generation in spatial medium is along with its contracton conjugate within mass medium, *Sec. 5(2)1c, part c*, and *Sec. 5(9)3d, Fig. 5(5)2*. Moreover, the energy related to expandon (or contracton) is at a ratio K_Γ of total energy of the related system. Please refer to *Note 2(3)1a, Eq. 2(56).*

Factually:

I) The path-length variation through the spatial medium is of irreversible kind, i.e. path-length increment, related to entropy along with time's arrow, and spatial medium increment. Similarly, the path-length variation through the mass medium (or path-length increment) is also of irreversible kind and at opposite sign of the spatial medium related to negentropy along with time's arrow reversal and spatial decrement, *Sec. 5(16)9d*. As a result, the *Eq. 2(103)2* can be written as follows:

$\delta S_g = -\delta S_m$ or 2(103)14

Entropy increment (Through spatial medium) + *Negentropy increment* (Within mass medium) = *Constant* or

Any path-length increment through spatial medium = Related path-length increment within mass medium 2(103)15

II) The path-length variation δS_m in case of an isolated system is constituted of two parts; the non-zero parts related to irreversible kind of path-length is along with time's arrow and spatial expansion. While, its zero variation is related to reversible path-length that is along with the *T*-symmetry, *Sec. 2(3)3*. Moreover, the non-zero part of δS_m is related to gravitational mass that is indistinguishable from inertial mass related to zero path-length related to δS_m. Please refer also to *Sec. 5(3), and Sec. 6(2)2*.

III) According to *Sec. 5(2)1c, part c1*, any expandon formation in spatial medium of path-length value $+2\hbar$ is accompanied by a contracton formed through mass medium of path-length value $-2\hbar$ that is ultimately transferred to the related super massif black hole, and trapped by the latter, *Sec. 5(7)8*. Therefore, the *Eq. 2(103)14*, can be written as following:

$\delta N_g = \delta N_m$ 2(103)16

Where, δN_m is the flow rate of contracton towards the mass medium, *Note 2(4)4a1*, and ultimately to the related super massif black hole of the host galaxies or cluster through *3*-space volume dV during time interval dt, i.e. $d\Omega$.

Factually, there is a maximum δN_g flow variation number of expandon in the direction of curvature R through the spatial medium, and δN_m flow variation number of contracton generation in the radial direction to the center of mass of related mass-bodies within the mass medium at equal number and opposite direction to expandon; please refer to *Sec. 6(2)2*. Noteworthy, the maximum of space-time curvature in a location can be attributed to maximum time's arrow generation due to expandon generation at that location.

IV) According to *Sec. 5(3)1*, the inertial aspect of the mass is along with reversible path-length; while, it's gravitational aspect is accompanied by irreversible path-length.

Resuming, the path-lengths in case of interactions related merely to inertial mass (i.e. a single medium) that is due to *T*-symmetry, is of reversible kind, i.e. zero action variation. As example, the non gravitational accelerating motion, *Sec. 6(2)1,* e.g. collision, force application. While, the path-lengths in case of interactions that are along with time's arrow and space expansion in spatial medium and mass contraction through mass medium, i.e. two different media, are of irreversible kind. These interactions are along with entropy and negentropy, *Sec. 5(16)9d,* increment through spatial and mass media respectively, *Sec. 5(15)2b*. As example, the gravitational interaction, *Sec. 5*, of gravitational mass (or mass-bodies), the fuel burning, glass smashes are of this category. Noteworthy, the two kinds of path-lengths are independent of each other; thus, have additive characteristic in path-length computation.

Note 2(4)4c- $\frac{\partial S}{\partial r}$, the gradient of action S of a moving particle in gravitational field potential can be regarded as particle momentum that is proportional to $\frac{\delta N_g}{\delta r}$, i.e. expandons population variation per length unit. Moreover, $\frac{\partial S}{\partial t}$, the action variation time of the particle in gravitational field can be regarded as particle kinetic energy in a location during time δt that is proportional to $\frac{\delta N_g}{\delta t}$, i.e. expandon variation per time unit. Please refer to [36] *section 24*. According to *Sec. 7(4)2f*, the length, and time are varied through non steady path-limit Γ_G, and stay time ΔT_p at quantum level respectively; therefore, can be viewed as length and time unit respectively. As a result, the interaction of external gravitational field expandons with the particle main body induces momentum and kinetic energy to the particle that depends to population densities of related interacting H particle-paths. Therefore, in case of the motion of a particle in a medium, first of all we must define the path-limit, and stay time of the particle in that medium in each location.

2(5)-Concept of interval on the basis of H particle-paths hypothesis

Considering interval, ds, *Remark 2(5)1,* in spatial and temporal coordinates as in Cartesian reference frames *R&R', Fig. 2(1):*

$$ds^2 = c^2 dt^2 - dx^2 - dy^2 - dz^2 = c^2 dt'^2 - dx'^2 - dy'^2 - dz'^2 = \quad \textit{invariant}, \quad \textit{Note 2(5)1} \qquad 2(104)$$

I) In case of a propagating signal, *Note 2(5)2,* at c speed, *Eq. 2(15)*:

$$ds = 0 \text{ , Comment 2(5)1.} \qquad 2(105)$$

Or, in other words, zero internal path or motion.

Now at this case, considering spatial intervals $dl,\ dl'$ in reference frames *R, R'* according to *Eqs. 2(104), (105),* we have:

$$\left(\frac{dl'}{dt'}\right)^2 = \left(\frac{dl}{dt}\right)^2 = \left(\frac{dx}{dt}\right)^2 + \left(\frac{dy}{dt}\right)^2 + \left(\frac{dz}{dt}\right)^2 = \left(\frac{dx'}{dt'}\right)^2 + \left(\frac{dy'}{dt'}\right)^2 + \left(\frac{dz'}{dt'}\right)^2 = c^2 \qquad 2(106)$$

Or, in other words a result obtained according to *Eq. 2(15), Fig. 2(3).*

$$\frac{dl}{dt} = \frac{dl'}{dt'} = c \qquad 2(107)$$

Thus, we encountered with H particle-paths bending of the stated above H system in *R* respect to *R'*, or, vice versa; please refer to *Sec. 2(6),* in this regards.

II) At the case of a moving H system of rest mass at v speed respect to observer of *R* and at rest respect to observer of *R'* , ds remain unchanged in the both systems; or, in other words, as a result of the internal path constancy, *Sec. 2(1)2, Eq. 2(26);* we have:

$$N_0 ds = N_0 c dt' = N_0(\gamma c dt - \alpha x) \qquad 2(108)$$

Where, N_0, is the total number of H particle-paths at rest *Eq. 2(35)*, and ds is the path related to an internal H particle-path in that H system (i.e. a factor of inner H particle-paths shape or geometry) that is conserved during Lorentz transformation, i.e. invariant

In fact, the case *(I)* is a special instance of case *(II)* that in which the path of reversible H particle-paths is equal to zero, i.e. $ds = 0$. In other words, ds is a measure of reversible internal motion of H particle-paths, considering the path-constancy, *Sec. 2(1)2.*

Note 2(5)1- According to [1], *section 2*, "interval of two events is the same in all reference frames, i.e. an invariant of transformation of an inertial reference frame to another one". However, according to [89], *division 8-1*, "there was, anyway, no invariance (except zero one) in *SRT*, only covariance (Maxwell's equations, which scramble the electric and magnetic field, are Lorentz covariant. The clean demonstration of the incompability of *SRT* with particle dynamics is no definitive"[89], *division 8-15.* In other words, "particle dynamics is incompatible with the Minkowski invariant"[89], *division 9(7)*. According to this discussion it is proposed to consider *path constancy*, *Sec. 2(1)2* in *H particle-paths hypothesis* instead of *interval invariance* in *SRT*. Factually, path-length constancy breaks when considering an irreversible process such as space expansion and time's arrow generation as in case of expanding gravitational spheres, *Sec. 5(4)5,* and beta decay, *Secs. 5(16)6 to 5(16)8*.

Note 2(5)2- According to Fermat's Principle; a light ray traveling from one fixed point to another fixed point (here *dl* or *dl'*) follows a path such that compared with nearby paths, the time required (here dt or dt') is a minimum, or constant [4], *part 43-3*. It can be considered as an alternate interpretation of, *Sec. 2(1)1b, Delta effect, Fig. 2(3),* on the basis of bending of H particle-paths of light signal (or a mass-body) regarding internal path-constancy, *Eq. 2(108),* and path-limit as in case of *Sec. 3(1).*

Comment 2(5)1- According to H particle-paths hypothesis, the reversibility of H particle-paths is conserved during transformation from an inertial reference frame to another one moving at rectilinear motion respect to each other. It is based on invariance of interval ds , *Eq. 2(104),* of two events in all reference frames. Please refer to *Comments 2(2)1a, 2(3)2a2*. Therefore, the interval ds of a signal of c speed constituted purely of single direction H particle-paths is zero.

*Remark 2(5)1- "*Space-time entails a new concept of distance, whereas distance between any two events in space-time (called interval) may be real, zero, or even imaging" [430] *space-time intervals.*