

Acceleration factor for propagation of a stationary wave in its wave medium: movement of energy in the 3-D space¹

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Abstract. According to the formerly reported 4-D spherical model of the time and universe, any energy in the 3-dimensional space is a vibration of the intrinsic space energy. There is a special frame stationary to the space energy and the principle of relativity is no longer valid. Accordingly, abandonment of the Special Relativity and then introduction of a factor of acceleration for energy in the 3-D space are proposed.

1. Introduction

The author of this article has been proposing a model of the time and universe, in which the space energy is spread with expansion in a 3-dimensional surface of a 4-dimensional sphere (referred to as the "4-D Spherical Model" or "4DS Model") [1, 2]. What we detect as energy or mass in the 3-D space is a vibration of the intrinsic space energy in the 3-D space. What we observe as the time passing at a constant speed (referred to as the "Time") is the radius dimension of the 4-D sphere for the distribution of the space energy. The most notable consequence expected from the 4DS Model is the perfect linearity of the space expansion by our observed Time. The model also insists on the changing speed of light propagation in accordance with the expansion of the universe. By adjusting the light speed, the Hubble plots from the Supernova Cosmology Project has successfully turned to show a perfect linearity, which is evident for the fact that the universe has been expanding at a constant speed by our observed Time [2].

The 4DS Model for the universe insists the wave medium for any energy in the 3-D space. Therefore there is a special frame, which is stationary to the medium, differentiated from other frames in an inertial motion to the medium. Furthermore, for energy in the 3-D space, there should be special requirements in its mechanics for motion, which are not applied for the expansion of the universe, because it is a movement of a vibration in its wave medium.

In this article, firstly abandonment of the Special Relativity and then respective mechanics for energy in the 3-D space and for the space energy in the 4-D sphere are discussed.

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2. Special Relativity

2.1. Propositions of Special Relativity

The Special Relativity (referred to as the "SR") is based on the two propositions; one is the Principle of Relativity and the other is the Principle of Invariant Light Speed [3]. If the light is a vibration of the intrinsic space energy (referred to as the "Spacia") as I strongly propose, there is a special frame stationary to the medium Spacia, differentiated from other frames in an inertial motion to the Spacia. The Principle of Relativity is no longer valid. The Principle of Invariant Light Speed implies that the light propagating speed is independent from the state of motion of the emitting body. This is rather rationale as a feature of wave that the propagation speed to the medium is constant independent from the emitter's speed. However, combined with the Principle of Relativity, it becomes to signify that the light speed is constant even when the observer is moving. The light speed invariance by selection of frame to measure was believed to be proven by the Michelson-Morley experiment [4]-[6]. However, no change in the location of interference fringe can be expected theoretically from the Michelson-Morley experiment. In my previous article [2], there were wrong explanations for the invalidity of the Michelson-Morley experiment. New interpretation for it is as follows.

In the experiment, a coherent light beam is split by a half-mirror into a straight beam and a reflected right angle beam. Both beams are reflected at the respective ends of arms, return to the half-mirror and are combined for detection. The apparatus is moving at speed v to the light medium. Take the reference frame stationary to the medium. Propagation image of the two beams are shown in the Figure 1.

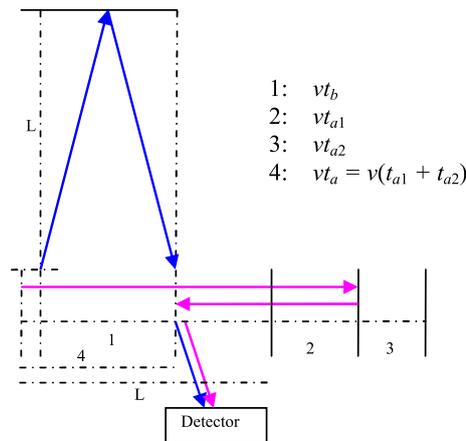


Figure 1. Michelson-Morley experiment by the frame stationary to the medium

The split beam A parallel to the apparatus movement takes t_a to return to the half-mirror since released from it. The beam B perpendicular to the movement takes t_b to return. The traveled distance of the beam B is given as

$$D_b = \sqrt{4L^2 + v^2 t_b^2}. \quad (1)$$

That of the beam A is as follows:

$$D_a = L + vt_{a1} + L - vt_{a2} = 2L + 2vt_{a1} - vt_a \quad (2)$$

From $t_a/t_{a1} = D_a/(L + vt_{a1})$, t_{a1} is eliminated and D_a is written as

$$D_a = L + \sqrt{L^2 + v^2 t_a^2} \quad (3)$$

Light speed is equal for both beams by the frame of medium, $c = D_b/t_b = D_a/t_a$. Therefore we get the following formula.

$$t_b^2 = \frac{2Lt_a^2}{L + \sqrt{L^2 + v^2t_a^2}} \quad (4)$$

Unless $v = 0$ or $t_a = 0$, $t_b < t_a$. Put $\Delta t \equiv t_a - t_b$.

The displacement of the beam A to be combined with the beam B is released Δt earlier at the splitter than the beam B is released. Respective amplitudes are given as follows.

$$U_a = A \sin(kx - \omega t) \quad (5)$$

$$U_b = A \sin(kx - \omega(t + \Delta t)) \quad (6)$$

At the point where the two beams are combined to interfere, the sum of amplitudes is given as follows.

$$U_a + U_b = -A(\sin \omega t + \sin(\omega t + \omega \Delta t)) \quad (7)$$

At the interfering point, the frequencies are the same for both the beam A and beam B. Therefore, no change in the location of fringe is theoretically expected by variation of Δt or v , whereas the maximum amplitude and the phase of the combined wave are varied by Δt or v .

To make sure, let's check measurement by a different frame fixed to the apparatus. The traveled distance is $2L$ for the both beams. The average light speed of the beam A is $2L/t_a$ and that of the beam B is $2L/t_b$. They are different unless $v = 0$. However, the respective directions of propagation of the two beams are same at the detector (interferometer). Therefore, the light speed, frequency and wave length are common for the two beams at the detector even by the apparatus frame, whereas those values depend on the apparatus speed v to the medium.

2.2. Invariance of the rest mass proposed by Special Relativity

One of the most important outcomes from the SR is the energy-mass equivalence shown by $E = mc^2$ [3][7]-[10]. This equation can be induced even without using the combination of the two propositions of the SR or other consequences from the SR, for instance from the conservation of momentum in a process that light is released from one end and captured at the other end [11].

On the other hand, the SR insisted the invariance of 4-dimensional momentum in the Minkowski space-time, and proposed the following relativistic energy-momentum equation [9][10].

$$E^2 - (pc)^2 = (mc^2)^2 \quad (8)$$

It insisted that the quantity $E^2 - (pc)^2$ is invariant from selection of the frame of reference in which it is measured, while the energy E and the momentum p depend on the frame. The mass in the equation is called the rest mass or the invariant mass, which is conserved and invariant for all observers [9]. However, is there any basis which can theoretically support the 4-D momentum or the invariance of the quantity $E^2 - (pc)^2$? I strongly insist that the total energy should be invariant for selection of a reference frame, but its breakdown to the rest mass energy and the kinetic energy should depend on a reference coordinate to express the subject.

2.3. Electromagnetics measured by a moving coordinate

A trigger of the Lorentz transformation and the Special Relativity was the covariance of Maxwell equations toward the selection of coordinates to express. However, Maxwell and other equations in the electromagnetics should be applied as they are even without Lorentz transformation if the light speed c is replaced by a relative light speed c_r , which is variable by selection of a coordinate to express. Let's check up the light speed as an example.

The light speed is given as follows from Maxwell equations for vacuum where the electric charge density $\rho = 0$ and the electric current density $j = 0$.

$$\nabla^2 \mathbf{E} - \mu_0 \epsilon_0 \frac{\partial^2 \mathbf{E}}{\partial t^2} = 0, \quad \nabla^2 \mathbf{B} - \mu_0 \epsilon_0 \frac{\partial^2 \mathbf{B}}{\partial t^2} = 0 \tag{9}$$

\mathbf{E} , \mathbf{B} , μ_0 and ϵ_0 denote electric field, magnetic field (or magnetic flux density), vacuum permeability and vacuum permittivity, respectively. A solution of the wave equation is

$$\Psi(x, t) = A \sin \left(x \pm \frac{1}{\sqrt{\mu_0 \epsilon_0}} t \right) = A \sin(x \pm ct) . \tag{10}$$

$$\mu_0 \epsilon_0 = \frac{1}{c^2} \tag{11}$$

By a frame in an inertial movement at a speed v toward the Spacia, the relative light speed c_r should be given as

$$c_r = c - v \cos \theta \tag{12}$$

, where θ is the angle between the light propagation and v . By replacing c , μ_0 and ϵ_0 respectively by relative ones c_r , μ_{0r} and ϵ_{0r} measured in a given coordinate system, the equations (9), (10) and (11) are applicable in same form without using Lorentz transformation, because c_r becomes a constant once a coordinate system and a direction of light propagation are given.

3. The 4-D spherical model of the universe

The 4DS Model of the universe previously reported is summarized in the Figure 2 as follows [1][2]. Any energy is a vibration in multiple dimensions. The gravitational force works between

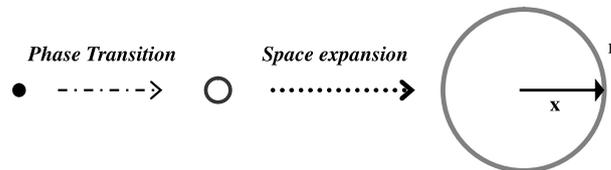


Figure 2. Expansion of the energy distribution of the space

any pieces of energy in accordance with the Newtonian equation of gravity. At the Big Bang, the energy distribution transformed to be spread with expansion in a 3-dimensional surface of a 4-dimensional sphere in tracing by the original tracing time dimension (referred to as the "time" or "t"). The time we observe passing constantly (referred to as the "Time" or "T") is the movement of the space energy in the radius dimension (x in the Figure 2) of the 4-D sphere. The "Tracing" dimension (or coordinate) is defined as a dimension, by variance of which a value-change (movement) of the resting other dimensions is expressed. To work as a Tracing dimension, any single value of it should correspond to a single value of any resting dimension for a movement [1].

The Tracing dimension can be expressed as an imaginary number component of a spatial movement. A movement in e_k space traced by e_0 can be expressed as

$$d\mathbf{A}^k = idx^0 + dx^k e_k . \tag{13}$$

Its corresponding movement in e_{k-1} space traced by e_1 can be expressed as follows if e_1 shows the Imaginary order of freedom when it is traced by e_0 . Here the "Imaginary order of freedom"

is defined that there is no freedom of selecting a value and furthermore the value is not a constant but is moving in a single direction [1].

$$d\mathbf{A}^{k-1} = idx^1 + dx^{k-1} \mathbf{e}_{k-1} \quad (14)$$

For the universe, a movement in the 4-D space traced by the original tracing dimension t can be expressed as

$$d\mathbf{A}(4)_t = idt + dx\mathbf{e}_x + dr\mathbf{e}_r, \quad (15)$$

where \mathbf{e}_x and \mathbf{e}_r denote a base vector for the radius vector \mathbf{x} and that for a position vector \mathbf{r} in the 3-D surface space, respectively. Multiplying the imaginary component by $v_x \equiv dx/dt$, we get the following vector

$$d\mathbf{A}(4)_t = iv_x dt + dx\mathbf{e}_x + dr\mathbf{e}_r \quad (16)$$

so that its metric for the space expansion in the radius x becomes zero as shown by

$$ds^2 = -\left(\frac{dx}{dt}\right)^2 dt^2 + dx^2 = 0. \quad (17)$$

A movement in the 3-D space \mathbf{r} can be expressed as follows with tracing respectively by t and T .

$$d\mathbf{A}(3)_t = iv_x dt + dr\mathbf{e}_r, \quad d\mathbf{A}(3)_T = idx + dr\mathbf{e}_r = idT + dr\mathbf{e}_r \quad (18)$$

Respective speeds of the movement traced by t and T are

$$v_r \equiv \frac{dr}{dt}, \quad V_r \equiv \frac{dr}{dT} = \frac{dr}{dx}. \quad (19)$$

The speed traced by t can be expressed by T as follows.

$$v_r = \frac{dr}{dt} = \frac{dx}{dt} \frac{dr}{dx} = v_x V_r \quad (20)$$

In our usual observation in the 3-D space, the expansion speed of universe v_x can be regarded as a constant because the observation period is extremely short compared with the time scale of the expansion of universe. Making the current v_x be v_{xc} , we can regard $v_x \approx v_{xc}$ for our usual observation in the 3-D space. We obtain the following correspondence between tracing by t and T .

$$d\mathbf{A}(3)_t \approx iv_{xc} dt + dr\mathbf{e}_r \quad (21)$$

$$d\mathbf{A}(3)_T = idT + dr\mathbf{e}_r \quad (22)$$

$$v_r \approx v_{xc} V_r \quad (23)$$

4. Mechanics of energy in the 3-D space in a stationary frame to the Spacia

From now, let us discuss mechanics in a fixed frame stationary to the space energy Spacia. In this section 4, use just "time" or " t " for our observed Time or T , and call the original tracing dimension as the "original tracing time".

Even if gravitational interaction is same for both the expansion of the universe in the 4-D sphere and the energy in the 3-D space, the motion equations for them may differ because there should be limitations in kinetics for energy in 3-D space as it is a propagation of a wave in its medium. There are important features as follows for our consideration:

- Any non-zero energy can not be accelerated to the maximum speed of light speed c .

- In addition that the light speed is not accelerated, it is not decelerated by gravitational force.
- Light receives acceleration by a massive star to a direction perpendicular from its propagation, that is, gravitational lens effect.

In order to comply with them, it is reasonable to expect the followings:

- Any inertial movement of a stationary wave in the medium receives no resistance from the medium.
- However, acceleration of a stationary wave by force would be affected by a factor depending on its speed to the medium. The maximum speed is the propagation speed of a phase in the medium.

I propose that the Newtonian equation of motion shown by (24) is no longer valid for energy in 3-D space, but acceleration is multiplied by a certain factor (referred to as the "acceleration factor" or " f_a ") as shown by (25).

$$F = m\alpha \quad (24)$$

$$\alpha = \frac{F}{m}f_a, \quad F = \frac{m}{f_a}\alpha \quad (25)$$

From the fact that light is not decelerated and the maximum speed is c , the following formula would be expected as the acceleration factor.

$$f_a = \left(1 - \frac{v^2}{c^2}\right)^n \quad (n \text{ is a positive real number}) \quad (26)$$

I previously proposed that the working mass for gravitational interaction would be corresponding to the total energy because light receives the gravitational lens effect. However, there is a possibility that the rest mass may be for gravity if f_a exists. Before searching what n is, let's clarify mass for which, the rest energy or the total energy, is applied for the Newtonian gravitational equation and the equation of motion (25). Take a case of a subject with rest mass of m_0 being accelerated by a huge mass M . At $r = \infty$, $v = v_0$. m_t is the mass for total energy of the subject. In the movement from $r = \infty$ to $r = r$ the total energy H is preserved. The rest mass energy is also conserved as the observation frame is fixed to be stationary to the Spacia.

$$H = E_k + E_p + E_r = m_t c^2 \quad (27)$$

$$E_r = m_0 c^2 \quad (28)$$

$$|H|_{\infty}^r = |H|_{v_0}^v = |E_k|_{v_0}^v + |E_p|_{\infty}^r + |E_r|_{\infty}^r \quad (29)$$

$$|E_k|_{v_0}^v + |E_p|_{\infty}^r + 0 = 0 \quad (30)$$

$$|E_k|_{v_0}^v = -|E_p|_{\infty}^r \quad (31)$$

In case of light, $v_0 = c$ and $v = c$. Therefore, from the equation (31),

$$0 = - \left| -\frac{GM}{r}m \right|_{\infty}^r = \frac{GM}{r}m. \quad (32)$$

The potential energy at any r is zero. Therefore, $m = 0$. Because $m_t \neq 0$ for light, the working mass m should be the rest mass $m = m_0$. This is not only for light but for any subject. We can conclude as follows:

- Working mass for force is the rest mass.

- In case of light, the rest mass is zero and the potential energy is zero. Light does not receive gravitational force in the direction of propagation. The total energy is equal to the kinetic energy.

$$m_0 = 0, \quad E_p = 0, \quad E_r = 0 \quad (33)$$

$$H = E_k = m_t c^2 \quad (34)$$

Next let's check a possibility of n for f_a . For any positive real number n except $n = 1$, the kinetic energy is given as

$$E_k = \frac{m_0 c^2}{2(1-n)} \left(1 - \left(1 - \frac{v^2}{c^2} \right)^{1-n} \right). \quad (35)$$

The integration constant is given from $E_k = 0$ at $v = 0$. If $n < 1$, the kinetic energy for light ($v = c$) becomes zero as $m_0 = 0$. Therefore $n < 1$ for f_a is denied, and at least $n \geq 1$ is required.

In case $n = 1$ for f_a ,

$$f_a = 1 - \frac{v^2}{c^2} \quad (36)$$

$$F = \frac{m_0}{f_a} \alpha = m_0 \left(1 - \frac{v^2}{c^2} \right)^{-1} \alpha. \quad (37)$$

The kinetic energy is given as follows.

$$\begin{aligned} E_k &= \int F dr = \int m_0 \left(1 - \frac{v^2}{c^2} \right)^{-1} \frac{dv}{dt} dr = \int m_0 \left(1 - \frac{v^2}{c^2} \right)^{-1} v dv \\ &= -\frac{m_0 c^2}{2} \log \left(1 - \frac{v^2}{c^2} \right) + k \end{aligned} \quad (38)$$

At $v = 0$, $E_k = 0$. Therefore, $k = 0$.

$$E_k = -\frac{m_0 c^2}{2} \log \left(1 - \frac{v^2}{c^2} \right) \quad (39)$$

By Taylor's expansion, the equation (39) is rewritten as

$$E_k = \frac{1}{2} m_0 v^2 \left(1 + \frac{1}{2} \frac{v^2}{c^2} + \frac{1}{3} \frac{v^4}{c^4} + \frac{1}{4} \frac{v^6}{c^6} + \dots \right). \quad (40)$$

The equation for the total energy is given as

$$\begin{aligned} H &= E_k + E_p + E_r \\ &= -\frac{m_0 c^2}{2} \log \left(1 - \frac{v^2}{c^2} \right) - \frac{GMm_0}{r} + m_0 c^2 = m_t c^2. \end{aligned} \quad (41)$$

If $m_0 \neq 0$, $E_{k(v \rightarrow c)} = \infty$ in the equation (39). It signifies that non-zero energy can not be accelerated to the light speed c . If $m_0 = 0$, that is light, $E_{k(v \rightarrow c)} = -0 \cdot (-\infty)$ in (39). It does not conflict with $E_{k(v=c)} = m_t c^2$. $n = 1$ for f_a is not yet proven but I speculate a possibility of $n = 1$.

What we discussed above is the case that force direction is parallel to the wave propagation. Force in a perpendicular direction to the light propagation, for instance, works to light in a different manner as its speed to the force direction is not the light speed c . Comparison of the two directions of force to light is given as follows.

(i) In the parallel direction to light propagation

$$v_{(//)} = \pm c, \quad m_0 = 0, \quad E_r = 0, \quad E_p = 0, \quad E_k = m_t c^2$$

(ii) In a perpendicular direction to light propagation

The light speed in the perpendicular direction to the light propagation $v_{(\perp)}$ should always be zero from the definition of the perpendicular direction even if light propagation is bent. It should be reminded that the perpendicular direction is not constant to the medium but changes by time.

$$v_{(\perp)} = 0 \quad (42)$$

The momentum of light to the perpendicular direction is also zero. Therefore, the kinetic energy of light can be regarded as rest mass energy of light for force in the perpendicular direction. We can confirm it as follows.

The kinetic energy of light, which is equal to the total energy, can be divided into the kinetic energy and the rest mass of light for the perpendicular direction to the propagation.

$$E_k = E_{r(\perp)} + E_{k(\perp)} \quad (43)$$

Because $v_{(\perp)} = 0$,

$$E_{k(\perp)} = 0 \quad (44)$$

Therefore,

$$E_k = m_t c^2 = E_{r(\perp)} + E_{k(\perp)} = E_{r(\perp)} + 0 \quad (45)$$

$$E_{r(\perp)} = m_t c^2 \quad (46)$$

We can conclude that the rest mass of light for the perpendicular direction is equal to the total energy mass.

$$m_{0(\perp)} = m_t \quad (47)$$

In the perpendicular direction to propagation, light has the rest mass corresponding to the total energy and receives gravitational attraction, which changes the direction of propagation. This is the process of gravitational lens effect. Light cannot be accelerated in propagation speed but can be bent by a massive substance.

Not only for light, but the relation shown by

$$E_{r(\perp)} = E_{r(//)} + E_{k(//)} \quad (48)$$

should be effective also for any substance or energy in 3-D space since $E_{k(\perp)} = 0$. In a case of circular motion like a satellite orbiting around the earth, the satellite has the rest mass for the centripetal force equal to the sum of the rest mass and kinetic energy mass for the direction of the orbit.

5. Mechanics of the space energy in the 4-D sphere

Subsequently think of mechanics of the space energy traced by the original tracing time. Let's come back to use time or t for the original tracing time and Time or T for our observed Time in the 3-D space.

The movement of the space energy in the radius dimension of the 4-D sphere is not a propagation of a wave in a medium but a movement of the space energy itself without a medium. Therefore some limitations posed to wave propagation in the 3-D space should not be applied for it. We can expect key features for mechanics of the space energy in the 4-D sphere as follows:

- There is not a maximum limit of speed like light speed c .

- The acceleration factor f_a for wave propagation is not applied.

Accordingly, the Newtonian equation of motion (24) should be applied. The formula of Einstein's energy mass equation $E = mc^2$ is no longer valid, while energy mass equivalence remains valid. For the process of space expansion-shrink, the light speed is not constant but varies by time [2]. Put k for the proportionality factor of energy mass equivalence.

$$E = mk \quad (49)$$

Take an area of universe defined by a 4-D spherical coordinate system $(x, \theta, \varphi_1, \varphi_2)$. A vector \mathbf{r} in the 3-D space is expressed by $(x\theta, \varphi_1, \varphi_2)$. The total energy of a unit angular area defined by constant angles of coordinates remains constant in the expansion of universe. The rest mass, which is defined from a frame stationary to the center of the universe, is also conserved in the process. Let the rest mass of the area be m_0 and the mass for the whole universe be M . The kinetic, potential and rest mass energies are expressed as follows.

$$\begin{aligned} H &= E_k + E_p + E_r \\ &= \frac{1}{2}m_0v_x^2 - \frac{GMm_0}{x} + m_0k = m_t k \end{aligned} \quad (50)$$

The total energy mass m_t should be very close to the rest mass m_0 because the maximum x , at which $v_x = 0$, is very huge.

The expansion speed of the universe formerly reported [1] is as follows. Let the initial values of x and v_x at the Big Bang be x_0 and v_{x0} . The expansion speed v_x of the radius of universe is given as follows.

$$\frac{1}{2}m_0v_{x0}^2 - \frac{1}{2}m_0v_x^2 = GMm_0 \left(\frac{1}{x_0} - \frac{1}{x} \right) \quad (51)$$

$$\begin{aligned} v_x &= \pm \sqrt{v_{x0}^2 + 2GM \left(\frac{1}{x} - \frac{1}{x_0} \right)} = \pm \sqrt{\frac{2GM}{x} + v_{x0}^2 - \frac{2GM}{x_0}} \\ &\equiv \pm \sqrt{\frac{2GM}{x} + k} \end{aligned} \quad (52)$$

Use the unit for x as 1 at its maximum.

$$v_x = \pm \sqrt{2GM + k} = 0 \quad (53)$$

Therefore,

$$v_x = \pm \sqrt{2GM \left(\frac{1}{x} - 1 \right)} \quad (x_0 \leq x \leq 1) . \quad (54)$$

From $x = x_0$ to $x = 1$, the universe expands and then shrinks in accordance with the formula (54) in the radius.

3-D space expansion is given as

$$\begin{aligned} r &= x\theta \\ v_r &= \frac{dr}{dt} = v_x\theta = \pm \theta \sqrt{2GM \left(\frac{1}{x} - 1 \right)} . \end{aligned} \quad (55)$$

Lastly let's confirm the expansion of the universe by our observed Time. Because $dT = dx$, the expansion speed of the 3-D space is constant as shown by

$$V_r \equiv \frac{dr}{dT} = \frac{dr}{dx} = \theta . \quad (56)$$

An evidence of the constant speed of the 3-D space expansion was shown in my previous article from the Hubble plots of the Supernova Cosmology Project [12] with adjustment for changing light speed by Time [2].

6. Conclusion

The 4-D Spherical Model of the universe insists the presence of wave medium for any energy in the 3-D space and the changing speed of light along with space expansion. The Special Relativity is denied from the disaffirmance of its propositions and that of the Michelson-Morley experiment. There would be arguments that the time prolongation according to the Special Relativity is experimentally proven. However, once the invariance of light speed by selection of frame becomes invalid, the results can be interpreted as combination of constant time and different light speed in a moving frame to the space energy.

As a feature of wave, the acceleration factor for movement of a wave in its medium shown by the formula (26) is newly introduced and the new equation of motion expressed by the formula (25) is proposed. The number n for the acceleration factor is not yet determined, while I speculate $n = 1$ without a clear ground. The kinetic energy is accordingly expressed by the formula (39) if $n = 1$ and by the formula (35) if $n > 1$. The new motion equation accords nicely with various features of light and gravitational lens effect even based on the Newtonian equation of gravity.

The process of expansion of the universe based on the original tracing time complies with the Newtonian equation of motion without the acceleration factor because it is not a wave-propagation but a direct movement of the space energy itself without a medium. The universe is proposed to repeat the process of expansion and shrink.

By our observed Time, which is the radius of the 4-D sphere of the universe, the 3-D space expands and then shrinks at a constant speed. Its evidence from the Supernova Cosmology Project data [12] was reported in the previous article [2]. According to this 4-D Spherical Model of the universe, we can exclude the Dark Energy.

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