MiTiempo

My Time

Natures of the time and the universe

Part-2

Verification of the 4-D spherical model of the universe

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This Part-2 volume is a sequel to the Part-1 "What the time is", prior reading of which is premised.

In the Part-1, we discussed natures of the time such as the tracing dimension, the imaginary order of freedom, and the definition of the time. Subsequently, the 4-D spherical model of the universe was proposed. According to it, the space energy spreads with expansion in the 3-D surface of the 4-D sphere, and the time we observe passing commonly at a constant speed is the radius of the 4-D sphere for the distribution of the space energy.

URL for MiTiempo:
http://www3.plala.or.jp/MiTiempo/index.html

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Ch. 3. Verification of the light speed invariance and the special relativity

1. All the issues started from the Michelson-Morley experiment

The issues on modern physics, which I am pointing out, are traceable to the Michelson-Morley experiment. The experiment done late 19th century measured an interference wave of light that split to two beams from one and then returned to the same position. It failed to detect a change of location or pattern of the interference fringe. However, it was appraised as the most successful experiment that proved the absence of a medium for light and the light speed invariance. According to the model of the universe that I propose, the light is a vibration of the space energy and there exists a medium for the light propagation. I started to verify whether this interpretation of the Michelson-Morley experiment is correct indeed or not.

By early 19th century, it turned out that the light was an electromagnetic wave. They expected its medium "ether" for the wave of light. Electromagnetics had achieved huge progress by that time, which was integrated to the Maxwell equations later. From the equations, we can derive the formula giving the light propagation speed. The expression of electromagnetic equations by the light speed gives common forms independent of measuring coordinates. However, scientists at that time did not consider the light speed as invariant. They expected that the light speed should vary by a relative motion of the observer to the ether.

Following the reports in 1881 and 1887 of the results that the Michelson-Morley experiments failed to detect a light speed difference between the two light paths, physicists of those days concluded that there was no medium for the light. They became to regard the light speed invariant. One of those who pointed out an issue from the finding was Hendrik Lorentz. If the light speed is invariant in the Maxwell equations, there arises a discrepancy between a stationary measuring frame and another frame in motion.

Lorentz then proposed a conversion rule between different measuring frames called “Lorentz transformation”. His first report on it was in 1899. He reported the final formulas for the transformation in 1904 after partial correction. In a rapidly moving coordinate system, the length and the time duration are longer than in a stationary frame. The prolongation ratio is the “Lorentz factor” shown as follows.

$$\text{Lorentz factor:} \quad \gamma = \frac{1}{\sqrt{1 - v^2/c^2}}$$

It is likely that Lorentz himself thought the factor would be effective only in the special case of electromagnetics but such prolongation would not be in general cases.

Albert Einstein separately reported the special relativity in 1905 from the light speed invariance and the Maxwell equations. He said that he had not known the report of the Lorentz transformation. He derived equations for coordinate transformation based on the two premises; “the principle of relativity”, which indicates physical laws are invariant by frame selection, and “the light speed invariance”. The results were same as the Lorentz transformation. Einstein received high praises from all over the world as the discoverer of the special relativity, which revealed the physical meanings of the Lorentz transformation.

Many groups carried out Michelson-Morley type experiments in early 20th century. In 21st century, there were reported modern experiments, which used optical resonators instead of half and end mirrors, and a detector of a beat note at a difference frequency instead of an interferometer. However, the fundamental basis for detection was same for all cases. In the following section, I will explain why this type of experiments failed to detect a light speed variation.

Since the universe is expanding, the farer a galaxy is, the faster it goes away from us (Hubble’s law). It is not easy in reality to calculate the distance from us of a very far galaxy or star. The type Ia supernovae exhibit

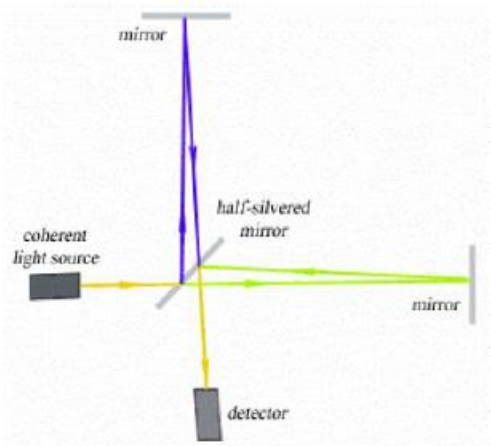
the common maximum luminosity. Therefore, we can know the distance of a supernova from its maximum brightness. The Supernova Cosmology Project (SCP) to obtain details of the Hubble's diagram, which plots maximums of brightness and redshifts of supernovae Ia, was carried out. The redshift correlates to the recession velocity from us. The observed data, reported from 1997 to 1999, indicated surprisingly that the expansion of the universe is accelerating despite the prior expectation that it should decelerate due to gravity. It is yet unknown what accelerates the space expansion. Physicists have newly introduced an unknown energy called "dark energy" for causing the acceleration, which accounts for more than 70 % of the total energy of the universe. This interpretation is on the premise of the light speed invariance. The maximum brightness of a supernova primarily indicates its distance, the division of which by the constant light speed gives the time duration to reach us since the supernova exploded.

Thus, people absolutely require the light speed invariance. However, it has not been explained sufficiently why the Michelson-Morley type experiment is capable to measure the light speed variation. When the separated two beams return to interfere, there arises a difference in arrival time if the light speed is different between the two paths. There has been lack a concrete explanation why a shift in location of the interference fringe comes out in case there is such a difference in the arrival time. Later physicists have accepted the interpretation without examining this point, and they have concluded that the light speed is constant to any observers.

2. Michelson-Morley experiment

Fig. 7 shows an image of the Michelson-Morley experiment. In the experiment, a light beam splits at a half-mirror into a straight beam and a reflected right angle beam. Both beams reflect at the respective ends of each arms, return to the half-mirror, combine each other, and proceed to an interferometer. The combined beam passes through two slits with a very small distance, and then project an interference fringe on the detection screen.

The experimental assumption was as follows; there should appear a change of the location or the pattern of the fringe by rotation of the apparatus if there is a variation of difference between the two light paths in the time duration for traveling from the emitter to the detector. By the frame fixed to the apparatus, the both light paths are the same distance while their light propagation times are different. It results in a difference in the mean light speed between the two light paths. They likely expected that there would come out an alteration of the interference fringe if the difference of light speed varied. We should note that the light speeds that are different by paths are mean values. They are not light speeds at the detector of interference. In their papers, without a detailed explanation they jumped to expect that the location of the fringe should alter if the difference in the propagation time between the two paths changes.



Michelson-Morley experiment (from Wikipedia)

Figure 7

We need to validate whether we can expect such supposed result or not subject to a medium for light. The phase propagation speed of a wave toward its medium is constant as a nature of a wave in general. Therefore, the light propagates at a constant speed to its medium independent of a

motion of the light emitter. The propagation speed alters if the condition of the medium changes. Let us see the experiment firstly by the frame stationary to the medium.

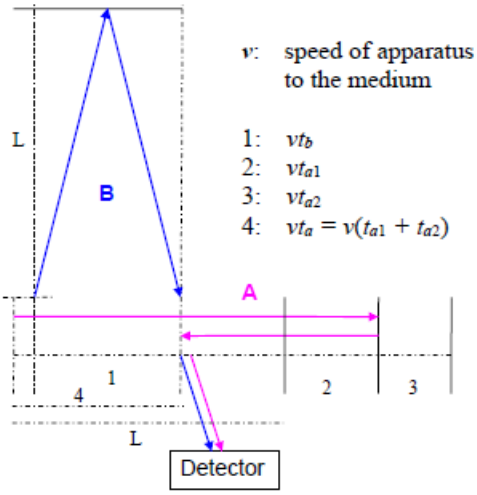


Figure 8

Fig. 8 shows the light paths of the experiment. The whole apparatus moves in parallel to the beam A at the speed of v to right. The light speed is constant by the medium frame. Take the time duration of the parallel beam A for the round trip between the mirrors as t_a and that of the perpendicular beam B as t_b. We obtain the following equation while I omit the calculations on the way. L is the distance from the half-mirror to the end mirror.

$$t_b^{\,2} = \frac{2Lt_a^{\,2}}{L + \sqrt{L^2 + v^2 t_a^{\,2}}} \quad , \quad t_b < t_a \quad \text{if} \quad v \neq 0 \quad , \quad \Delta t \equiv t_a - t_b$$

Unless v is zero, t_a is greater than t_b. Put the difference as Δt. Here is an important point. The two displacements that separated at the same time do not reach the detector simultaneously. In order to interfere, two

displacements should simultaneously arrive at the detector. Therefore, the displacement of the beam A must leave the splitter Δt earlier than that of the beam B in order for them to reach the detector at the same instance to interfere. Accordingly, in Fig. 8 there is a difference in the location of leaving from the half-mirror between the two beams.

Here we can mention the following important aspects. There is a difference of phase corresponding to Δt between the two beams. It is not the case that the beam A passes through one slit and the beam B separately passes through the other slit, but the combined wave mixed at the half-mirror goes through the both slits. From these points, we can express the combined wave at the joining point and its propagation to the interferometer respectively by the following equations in Fig. 9.

Sum of amplitudes of Beam A and Beam B at the combined point:

$$\begin{aligned} U_a + U_b &= A\sin\omega t + A\sin\omega(t+\Delta t) \\ &= A\sin\left(\omega t + \frac{\omega\Delta t}{2} - \frac{\omega\Delta t}{2}\right) + A\sin\left(\omega t + \frac{\omega\Delta t}{2} + \frac{\omega\Delta t}{2}\right) \\ &= 2A\cos\frac{\omega\Delta t}{2}\sin\left(\omega t + \frac{\omega\Delta t}{2}\right) \end{aligned}$$

A : Maximum amplitude
ω : Angular frequency (of Beams A, B)

Propagation of the combined wave to the detector:

$$U_a + U_b = 2A\cos\frac{\omega\Delta t}{2}\sin\left(kx - \omega t - \frac{\omega\Delta t}{2}\right)$$

$$k = \omega / c$$

x Distance from the combined point in the direction to the interferometer
k : Angular wave number
c : Current light speed

Figure 9

Compare the first line with the third line in the first equation. Mixing two waves, which have different phases and a common frequency, gives a single wave of the same frequency and the phase equal to the mean of originals. Its maximum amplitude varies by the phase difference of the two beams. Even if the phase varies by alteration of Δt, neither the frequency nor the

wavelength varies. I confirmed this aspect also by the graphs of the first line for various phase differences. These situations are same for the lower equation in Fig. 9, which represents the propagation of the combined wave to the detector. There arises no change of location or pattern of the fringe at the interferometer by the combined wave reaching there. Only the maximum amplitude, that is, the brightness of the fringe should vary. Wikipedia for the Michelson-Morley experiment once mentioned that the fringe had easily disappeared due to a vibration by a carriage running by or thunder. However, the instability of the fringe might have been, at least partly, due to a variation of the brightness by a circadian change or a rotation of the apparatus direction.

Next, let us see the experiment by a frame fixed to the apparatus. The round trip distance from the half-mirror to the end mirror is common for the both beams being $2L$ by the apparatus frame. The time passage is same as that in the case of the medium frame. Therefore, there is the difference of Δt in the time duration for the round trip. As a result, the average speed of the beam A for the round trip is $2L / (t_b + \Delta t)$ whereas that of the beam B is $2L / t_b$. The two average speeds are different. However, once they turn to the common direction to the detector, the light speeds become same for the two beams. In the apparatus frame of reference, the light propagation speed is set by the moving speed of the apparatus and the direction of light propagation toward the medium. After all, the equation for the propagation to the detector of the combined beam by the apparatus frame becomes the same form as that by the medium frame, shown as follows.

$$U_a' + U_b' = 2A\cos\frac{\omega\Delta t}{2}\sin\left(k'x' - \omega t - \frac{\omega\Delta t}{2}\right)$$

$$k' = \omega / c'$$

U_a', U_b', x', k' : measured by the apparatus' frame

c' : Light speed by the apparatus' frame in the direction of x'

The letters with a dash for variables above represent respective values by the apparatus frame. The frequency, the phase and the maximum amplitude are same as those by the medium frame. The wave number and the light speed

differ between the two frames. As shown in the equation, neither the frequency nor the wavelength varies by the alteration of Δt in the apparatus frame. Therefore, we cannot detect a change of position of the interference fringe through the two slits by this frame, either.

Even if there is a difference in the average light speed for the round trip by the apparatus frame, the both beams are finally combined to a common direction for measurement. Therefore, both beams show the same light speed at the detector. This is the reason why the Michelson-Morley like experiments failed to detect a shift of the interference fringe. The difference in the routing of a light beam in the way causes a difference in the phase but not in the speed, the frequency or the wavelength at the detector if its final direction is the same.

S. Hermann et al reported a modern experiment in 2009. They used two laser emitters and two crossed orthogonal optical resonators instead of a half-mirror splitter and end mirrors. They measured a frequency difference in place of an interference fringe. By repeatedly traveling round in the resonator, the light became unique in wavelength and phase. They split off fractions from the two resonators periodically, combined them to a common direction and detected a difference frequency by generating a beat note. In the experiment, the frequency in a single resonator did not reach completely stable but showed a relative frequency fluctuation around 1×10^{-15} in one second. However, a relative light speed difference by direction (anisotropy) $\Delta c/c$, obtained from a frequency difference after overlapping the two beams, was less than 1×10^{-17}, which was smaller by two digits than the relative frequency instability of a single resonator. The authors said that the relative frequency stability was currently limited by thermal noise of the resonators. However, I suppose there would be a possibility that a light speed difference between the inward and the outward in a resonator or a rotation of the apparatus might cause the frequency unstable. Similar to the Michelson-Morley experiment, the light speed becomes common for the two beams when they overlap for beat note generation because their light

directions are the same.

3. Special relativity

The special relativity discerns the following two propositions,

1) the principle of relativity, and
2) the principle of invariant light speed.

The principle of relativity states that fundamental forms of physical laws do not change by choice of an inertial coordinate system. Any reference frames in uniform motion each other are equivalent. It denies the existence of a preferred frame such as a medium for the light. The second proposition is that the light propagates in the vacuum with a definite velocity c independent of the state of motion of the emitting body. It is a general property of waves in general, and primarily signifies that the light speed is constant toward the medium. However, joined with the principle of relativity, it turns to insist that the light speed is constant toward any measuring frames in uniform motion. Take a frame by which the light emitter is stationary. By another frame moving at a uniform speed to the first one, we detect the emitter moving. Because the two frames are equivalent from the principle of relativity, the light speed is the same for the both frames independent of the emitter's motion. I am questioning the principle of relativity. There exists a special frame stationary to the medium if the light is a propagation of a wave in the medium. Why did Einstein assume the two propositions? It should have been from the results of the Michelson-Morley experiment. It is likely that the light speed invariance from choice of a frame existed beforehand, for which Einstein discerned the two propositions.

What he derived from the propositions was the Lorentz transformation for inertial frames. If there is anything wrong in the propositions, the Lorentz transformation loses its validity. The other important outcome from the special relativity is the mass-energy equivalence shown by

$E = mc^2$. In fact, we can derive this energy-mass relation without using the two propositions of the special relativity or the Lorentz transformation. For instance, take a case that a light is released from one end and is captured at the other end of an apparatus. From the points that the light possesses a momentum and the total momentum of the apparatus and the released light is preserved during the whole process, we can derive the energy-mass equation. This aspect is written in many books on the special relativity. Thus, even if the Lorentz transformation is wrong, the mass-energy equivalence is correct, I expect, from yes or no of using the propositions.

The special relativity (referred to as the "SR") perceives the rest mass peculiarly. Take a case that a substance of the mass *m* is stationary. By another frame moving at the speed *v* to the stationary frame, the substance has a kinetic energy. From the Lorentz transformation, the substance becomes harder to be accelerated in the moving frame. The apparent mass called the relativistic mass is given as follows.

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

This is simply an apparent one corresponding to acceleration, which the Lorentz transformation induces. The mass that a force affects remains the rest mass. The SR further insists that the rest mass is common for any inertial frames. A substance of the rest mass *m* in a stationary frame exhibits also *m* of the rest mass in another frame in inertial motion. The SR does not regard it inconsistent but insists that the difference of the total energy minus the kinetic energy is preserved, which corresponds to the rest mass. The value given by the following relativistic energy-momentum equation is invariant, according to the SR.

$$E^2 - (pc)^2 = (mc^2)^2$$

By an inertial coordinate transformation, the mass m and the light speed c in the equation are invariant whereas the total energy E and the momentum p vary. The rest mass is called also as the "invariant mass" because it is invariant by a choice of its measuring frame.

The above equation is derived from the preservation of the 4-momentum in the Minkowski space-time. Is it true that the value shown by the equation is preserved but the total energy is not? I cannot find a clear ground for the 4-momentum preservation. I expect that a coordinate transformation should preserve the total energy and should change its distribution to the rest mass and the kinetic energy.

With the special relativity, the quantum mechanics is one of the two greatest achievements of modern physics established in the 20th century. The quantum mechanics brought huge progresses to the particle physics and the chemistry. It can explain phenomena in those areas without a contradiction. The time used in the quantum mechanics is not a time invariant by the Lorentz transformation but is the same as the time in the Newtonian mechanics. The Hamiltonian is the total energy, which is the sum of the kinetic energy and the potential energy. Adding properties and conditions as a wave to it gives the Hamiltonian operator in the quantum mechanics. The Schroedinger equation is an example of the required equation of state including the Hamiltonian operator. Paul Dirac gave an equation of the real total energy by adding the rest mass energy to the kinetic energy and the potential energy. Thanks to the equation, it became possible to approach the particle physics, the cosmology and so on quantum-mechanically. The Dirac equation is sometime called as a quantum mechanics added by the special relativity because it includes the rest mass energy. However, it does not use the SR in terms of the Lorentz transformation. Thus, there is a discrepancy between the SR and the quantum mechanics. However, most of physicists consider the both are correct while we do not know yet the natures bridging them. In the field of theories of gravity, there comes up a new view that the quantum mechanics

is correct but the general relativity, which is a gravity theory derived from the SR, may be wrong rather than assuming a unified theory of the general relativity and the quantum mechanics.

Ch. 4. Acceleration factor of stationary wave and light speed

4. Acceleration factor of a stationary wave

If energy we observe in the 3-D space is a vibration of the space energy, there should exist a limitation for its acceleration as a wave propagation in a medium. The maximum moving speed of energy should be the speed of the phase propagation in the medium, that is, the light speed. When a vibration of energy becomes a steady state, we can treat the energy corresponding to the stationary wave as a substance having a mass. To what a law does the acceleration of a substance, that is, a stationary wave accord? There are many examples of stationary waves, the boundary conditions of which are from the outside of the medium. However, it is not easy to find an example of a stationary wave without anything other than its medium. A solitary wave or a group wave in the water may be such an example. However, affecting a force to it and detecting an acceleration result seems hardly possible. There would have been no report of a general law on the acceleration of a stationary wave. We may understand that the light is the phase propagation of a wave in the space energy and a quantum particle is a vibration in a steady state, which high-energy lights result by their gravitational, electromagnetic or other interaction. Let us think of the propagation of such a stationary wave in the space energy.

To start investigation, I considered the following key points.

- Any non-zero mass substance cannot accelerate to the light speed.
- Not only the light speed cannot accelerate, but also it cannot decelerate.
- The light receives a gravitational force in a direction perpendicular to its propagation, and bends to that direction.

The third one is known as gravitational lensing, a phenomenon that the light bends by a massive object. The general relativity by Einstein insists that this is because the space-time bends by a huge mass. Although the light

does not receive a gravitational force since its mass is zero, its route bends because the space-time is curved by a massive object. On the other hand, from the acceleration factor I am proposing here, we can perceive that it is because the component of light speed in the perpendicular direction is zero.

In order to comply with the factors mentioned above, I thought it should be reasonable to expect the followings.

- Any inertial movement of a stationary wave in its medium receives no resistance from the medium.
- On the other hand, as for acceleration of a stationary wave, a factor depending on its speed to the medium would affect the acceleration. The maximum speed is the propagation speed of a phase in the medium, that is, the light speed in the space energy.

From the fact that the light cannot decelerate, I proposed to introduce the following "***Acceleration factor*** (***f_a***)".

$$\alpha = \frac{F}{m} f_a \quad , \quad F = \frac{m}{f_a}\alpha \qquad \text{(New equation of motion)}$$

$$f_a = \left(1 - \frac{v^2}{c^2}\right)^n \qquad (n \geq 1) \quad \text{(Acceleration factor)}$$

You may think the acceleration factor is similar to the Lorentz factor. However, we can demonstrate that n in the formula is at least equal or greater than one whereas n in the Lorentz factor is 1/2. It is a more fundamental difference from the Lorentz factor that the acceleration factor is introduced from the nature of a wave that there is the upper speed limit, that is, the phase velocity.

By the way, let us firstly examine what the mass receiving acceleration by a force is. Before introduced the acceleration factor, I had thought that not the rest mass but the total energy mass would receive a force because there is gravitational lensing. However, if the acceleration factor exists,

there arises a possibility that a force may affect the rest mass. The total energy H of a substance is the sum of its kinetic energy E_k, potential energy E_p and rest mass energy E_r. If we fix the measuring frame for a change of state by gravity, there is no change of the rest mass and exists the following relation.

$$\Delta H = \Delta E_k + \Delta E_P + \Delta E_r = \Delta E_k + \Delta E_P + 0 = 0, \quad \Delta E_k = -\Delta E_P$$

Take a case that to a huge mass M, a small mass m accelerates from v_0 at the infinity distance to v at the distance r. The difference of the potential energy in the state change shall be as follows.

$$-\Delta E_P = \frac{GM}{r} m$$

In the case of the light, the speed is constant, and the kinetic energy difference is zero. Therefore, the potential energy difference should be also zero, which requires that the mass m in the above equation must be zero. On the other hand, the light has a kinetic energy and its total energy is not zero. Hence, the mass m that effects the gravitational force cannot be the total energy mass m_t but should be the rest mass m_0. Not only for the light but also for any energy, the mass on which a force works should be the rest mass.

In the case of the huge mass M and the small mass m above mentioned the total energy amounts as follows.

$$H = E_k - \frac{GMm_0}{r} + m_0 c^2 = m_t c^2$$

Omitting the calculation* on the way, the kinetic energy is given by the below equation of a logarithm in the case of $n = 1$. (* See at page 17 of the Presentation Part-1 in http://www3.plala.or.jp/MiTiempo/content.html .) Its Taylor expansion gives the second line of the equation. For small values of the speed v, it gives the kinetic energy by the Newton's equation of motion.

When v approaches to the light speed, it diverges to infinity.

$$E_k = -\frac{m_0 c^2}{2}\log\left(1-\frac{v^2}{c^2}\right)$$
$$= \frac{1}{2}m_0 v^2\left(1+\frac{1}{2}\frac{v^2}{c^2}+\frac{1}{3}\frac{v^4}{c^4}+\frac{1}{4}\frac{v^6}{c^6}+\cdots\right)$$

We do not know yet the value n of the acceleration factor. If $n>1$, the kinetic energy is given by the following equation.

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

From now, let us examine the case that the light receives a gravitational force from a direction perpendicular to its propagation. From the definition of a "perpendicular" direction, the component of speed in the direction should always be zero. (If a propagation direction alters, its perpendicular direction also changes but keeps perpendicular to propagation.)

A) Gravitational force parallel to the light propagation direction:
The velocity is c, the rest mass is zero, and the kinetic energy is equal to the total energy.

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

B) Gravitational force perpendicular to the light propagation:
Because the kinetic energy in the perpendicular direction is zero and the total energy is preserved independent of a choice of measuring frame, the rest mass in the perpendicular direction is equal to the mass for the total energy.

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

In the case of the light, respective values in the perpendicular direction

are as follows.

$$v_{(\perp)} = 0\,, \quad m_{0(\perp)} = m_t\,, \quad E_{r(\perp)} = m_t c^2\,, \quad E_{p(\perp)} = 0\,, \quad E_{k(\perp)} = 0$$

In conclusion:

- In a direction perpendicular to propagation, the light has the rest mass corresponding to its total energy. A gravitational force in a perpendicular direction does not alter the magnitude of the speed but bends the propagation direction of the light.

From the contents in the chapters 3 and 4 so far, have you felt a possibility of a new system derived from natures of waves according to classical mechanics but not based on the special relativity that denied a medium for light? What should be the most emphasized is that the Michelson-Morley experiment, which is said to have proved the absence of a medium for light, cannot detect a light speed difference by the set indicator. Most of the experimental evidences raised for the special relativity are a variation of a time duration or a distance under the premise that the light speed is invariant. We can understand the same results as due to a variation of the light speed where a time duration and a distance are invariant by a frame choice. As for gravitational lensing, we can explain it by introducing the rest mass in the direction of the force, which is more natural than thinking that the space-time is curved. On the acceleration of a substance, we have newly introduced the acceleration factor as a property of a wave. From the following section, we will proceed to talk on verifying the 4-D spherical model of the universe by real observed data of the universe.

5. Light propagation speed

The current light speed to the medium is constant. However, in the process of the universe expansion, the light speed has been varying along with the state change of the medium. I investigated to obtain an equation

expressing the light speed.

The light is a transverse wave, the amplitude of which is vertical to its propagation. However, it is different in nature from such a vibration of a string like a guitar well known as a transverse wave. In case of such a string, the string itself moves up and down to an area where it does not lie, and the fluctuation propagates in the direction of the string. On the other hand, the light is a vibration in a part within the area filled with the medium. It is more resemble to the sound propagation in the air, though which is a longitudinal wave.

The sound propagation speed in the air is proportional to the square root of the absolute temperature of the air. From its analogy, I proposed an equation that the light propagation speed is proportional to the square root of the density of the space energy that is the medium. I named the influence of the medium density on the light speed as the "***Energy density factor***" shown by f_D.

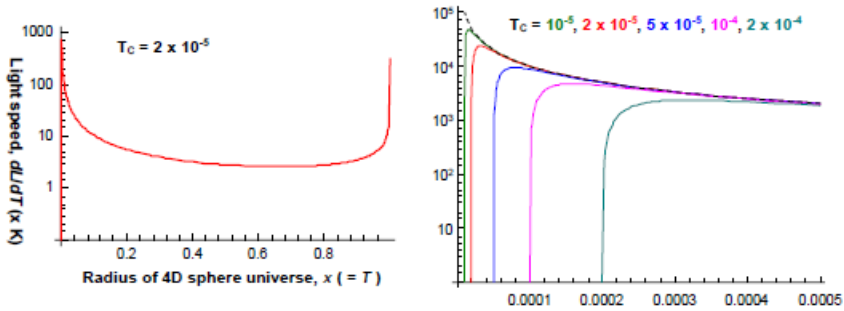
After the Big Bang, the temperature of the universe fell down by its expansion, and quantum particles and nucleons were generated. At the early time, electrically charged electrons and nucleons (protons) were moving apart in a plasma state, where the light could not go straight due to its electromagnetic interaction with the charged particles. When the temperature further fell down and protons captured an electron to form hydrogen atoms, the light became to go straight. It is called the clearing up of the universe, which means that the space became transparent to the light transmission. It is generally said that the Cosmic Microwave Background (CMB) radiation started to go straight around 370,000 years after the Big Bang. The temperature of the universe was around 3,000 K at the time, corresponding to an energy of about 0.25 eV, which is much less than the 13.6 eV ionization energy of hydrogen. This suggests that the light could not go straight for a while due to interaction with highly dense hydrogen atoms even after the completion of plasma conversion to atoms. We ordinarily see this phenomenon, that is, the light scatters, refracts or reflects

by substances. The scattering is the electromagnetic interaction of the light with the outer-shell electrons of atoms composing a substance. In a star, as the material density is extremely high, the scattering is very significant. In the whole universe, on the other hand, we can ignore the effect of scattering since the material density is as close to zero as can be. However, up to a certain time of the early universe, the light could not go straight because scattered by highly dense substances in the space. Just after the clearing up of the universe when light started to go strait, the light speed was slow down by the influence of scattering since the material density was high, we can expect. The decrease of light speed by scattering is well known such as on the light speed in the water or the air. I thought the effect of scattering should not be negligible during a very short period after the clearing up of the universe. I named this second factor affecting the light speed as "***Electromagnetic interaction factor***" shown by f_{EM}.

I expected that the light propagation speed should be proportional to the two factors. I proposed the following equation for **the light speed by the Observed Time *T*** while omitting the details on the way.

$$C(T) = C(x) = {dL}/{dx} = K * f_D * f_{EM}$$
$$= K * \frac{1}{x\sqrt{1-x}} * \left(1 - \frac{{T_C}^3}{x^3}\right) \qquad (T_C \le x < 1)$$

Here x denotes the radius of the 4-D sphere universe, L is the light propagated distance, K is a constant, and T_C (Time Clear) represents the Time when the space became transparent to light. When the cosmic expansion stops by gravity, x (= T) takes its maximum value 1. Fig. 10 shows the graph of this equation in a semi-logarithmic scale. The left graph is for the whole range, and the right part is an enlarged graph in very small area of x for plural T_C values.



Time-course of light speed by the Time

Left: Whole range graph of light speed for the Time Clear $T_C = 2\times10^{-5}$. The maximum in small x (= T) value area is not correctly shown due to limitation of sampling points. *Right:* Enlarged graphs in small x (= T) value area for $T_C = 10^{-5}$ to 2×10^{-4}. The dotted line in black is for the case of $f_{EM} = 1$.

Figure 10

The dotted line in black represents the light speed graph for $f_{EM} = 1$. As shown in the enlarged graph, for the area of x greater than 0.0005, we can ignore the effect of f_{EM} and treat the light speed as follows.

$$C(x) = K * \frac{1}{x\sqrt{1-x}} \qquad (\text{if } \ 0.0005 \le x < 1)$$

Ch. 5. Redshift of supernovae and expansion of universe

6. Redshift of light

As an alteration of the wavelength of light, there is so called the Doppler effect, which occurs by rapid moving of the emitter or the observer. In the case of a very far object such as an inter-galaxy observation, while the distance from us is stretching by the space expansion, we can regard that both the emitter and the observer are stationary to the wave medium at their respective positions. Therefore, for an inter-galaxy observation we can ignore such a Doppler effect in a sense of a relative speed to the medium. The main reason of a redshift of light from a distant galaxy is the stretch of the wavelength by the space expansion. People sometimes call the effect also as a Doppler effect, but let us call it as the space expansion effect.

Not only for the light but also for any wave, another important factor causing an alteration of its wavelength is a change of its propagation speed. When a sound transmits from the air to the water, there is no change of the frequency but the propagation speed becomes faster (f_D-dependent) and the wavelength gets longer. In the case of the light transmission from the air to the water, the interaction of the light with molecules increases, the scattering increases, and the propagation speed becomes slower (f_{EM}-dependent). Accordingly, the wavelength becomes shorter, and the so-called refraction occurs. The propagation speed of any wave is equal to the product of the frequency and the wavelength. The frequency is invariant by a change of state of the medium, but is dependent only on the generator (emitter).

$$v = f * \lambda$$

In the current cosmology, they consider only the space expansion as a factor causing a redshift on light from a distant star along with a correction from the theory of relativity because they treat the light speed has been constant. However, I insist that we need to add a factor derived from the

light speed variation. Then, I propose as follows.

- From the **factor of light speed variation**, the wavelength prolongs in proportion to the speed.
- On the other hand, from the **factor of the space expansion**, the speed does not vary and the wavelength is stretched.
- Combined the two factors, the prolongation ratio of wavelength comes to the product of the space expansion ratio (n) and the change ratio of the light speed, as shown below.

$$\frac{\lambda(T_P)}{\lambda(T_E)} = n \times \frac{C(T_P)}{C(T_E)} \quad , \quad n \equiv T_P / T_E$$

T_P (Present Time): present Time from the Big Bang
T_E (Time of Emission): Time when the light was emitted

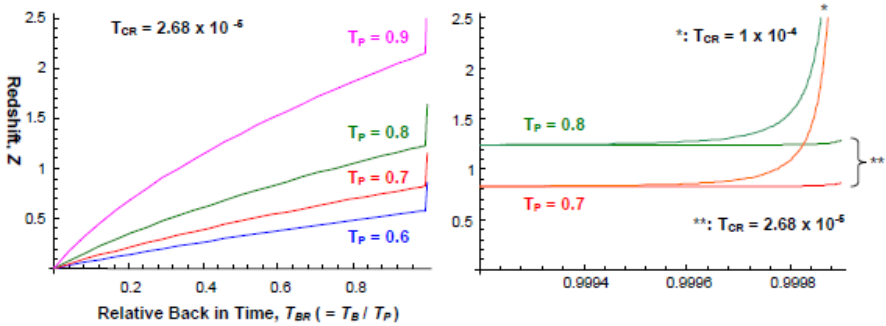
The **redshift *z*** is defined as the prolongation ratio of wavelength minus one. Substituting the light speed equation to the above equation, we can obtain an equation on the redshift. Here we define $\boldsymbol{T_B}$ (**Back in Time**) as the **Present Time $\boldsymbol{T_P}$** minus the **Time of Emission $\boldsymbol{T_E}$** when the light was emitted, and $\boldsymbol{T_C}$ (**Time Clear**) as the Time when the space became transparent to light. Furthermore, we define their relative ratios to T_P as follows.

$$T_B \equiv T_P - T_E \quad , \quad T_{BR} \equiv T_B / T_P \quad , \quad T_{CR} \equiv T_C / T_P$$

I obtained the relationship of the **redshift *z*** toward the **Relative Back in Time $\boldsymbol{T_{BR}}$** as the following equation.

$$z = \sqrt{1 + \frac{T_P T_{BR}}{1 - T_P}} \times \frac{1}{1 - \left(\frac{T_{CR}}{1 - T_{BR}} \right)^3} - 1$$

The graph of the equation is shown in Fig. 11.



Redshift versus the Relative Back in Time (T_{BR})

Left: Whole range graph of redshift for the Relative Time Clear $T_{CR} = 2.68 \times 10^{-5}$.

Right: Enlarged graph in high T_{BR} area for $T_{CR} = 2.68 \times 10^{-5}$ and $T_{CR} = 1 \times 10^{-4}$.

Figure 11

The right part of Fig. 11 is an enlarged graph in high T_{BR} area close to one. When T_{BR} approaches to $1 - T_{CR}$, the redshift diverges to infinity. In the range of $T_{BR} \leq 0.999$, we can ignore the influence of f_{EM} and approximate the redshift as follows.

$$z \approx \sqrt{1 + \frac{T_P T_{BR}}{1 - T_P}} - 1$$

7. Light propagated distance and redshift

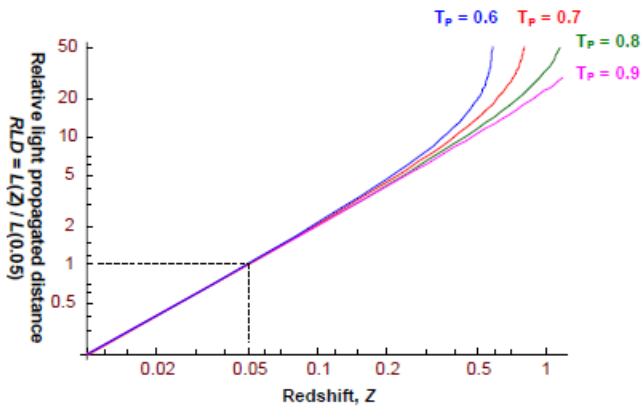
Finally, we are coming to the last stage. What the **Supernova Cosmology Project** directly measured is the **brightness** and the **redshift** of supernovae. The brightness is in inverse proportion to the square of the distance and shows the distance. At first, let us seek the light propagated distance.

We can obtain the **light propagated distance *LD*** by integrating the light speed equation by x (equal to T) from the Time of Emission T_E to the Present Time T_P. Substituting the redshift z for x there gives an equation for the light propagated distance LD as a function of the redshift z. Here we

contrive a bit. We do not know yet the constant K in the light speed equation. Accordingly, we use the ratio to a certain value for the light distance. We take the distance when z is 0.05 as the reference, and define the ratio of LD to the reference distance as the "***Relative light propagated distance***" or "***RLD***". In the end, we obtain the following equation of RLD expressed by the redshift z.

$$RLD \equiv \frac{LD(z)}{LD(0.05)} = \log\left(\frac{1-\sqrt{1-T_P}}{1+\sqrt{1-T_P}} \cdot \frac{1+\sqrt{1-T_P+(1-T_P)z(z+2)}}{1-\sqrt{1-T_P+(1-T_P)z(z+2)}}\right) \times \left(\log\left(\frac{1-\sqrt{1-T_P}}{1+\sqrt{1-T_P}} \cdot \frac{1+\sqrt{1.1025\times(1-T_P)}}{1-\sqrt{1.1025\times(1-T_P)}}\right)\right)^{-1}$$

Fig. 12 shows the graph of this equation in a dual logarithmic scale. Since the Present Time T_p is unknown yet, respective lines for plural values of T_p are shown.



Relative light propagated distance (RLD) versus redshift

Figure 12

If $T_{ER} \geq 0.001$, we can ignore the Electromagnetic factor f_{EM}. The equation and the graph in the above are an approximation under this condition. However, if RLS is less than 65, T_{ER} is at least within the

condition of greater than 0.001. Therefore, in the range shown in Fig. 12, the graphs practically show no difference from the exact values. Then, how would be the case that T_{ER} is less than 0.001? The domain of T_{ER} is greater than T_{CR} (Relative Time Clear). When T_{ER} approaches to T_{CR}, z diverges to infinity but *RLD* approaches to an upper limit not exceeding at least a certain value. If we use the T_{CR} value corresponding to 13.8 billion years as the age of the universe and 370 thousands years as the Time Clear, the upper limit of *RLD* for $T_P = 0.6$ is about 100, that for $T_P = 0.7$ is about 138, and that for $T_P = 0.8$ is about 197. Namely, when the *RLD* value becomes greater than the range of Fig. 12, the line slopes get smaller, the lines approach to respective upper limits and then become almost horizontal.

(***Revised and supplemented the following parts in Nov. 2015.***)

8. Frequency-based redshift for cosmological observation

In actual cosmological observation, we compare the measured wavelength from a star with the wavelength of spectrum of the present atom of the same element but not the wavelength at the time of emission. It corresponds to the change of frequency from the time of emission. Take a case that spectral light of $\nu_0(T_E), \lambda_0(T_E)$ emitted at T_E reaches us at T_P exhibiting $\nu(T_P), \lambda(T_P)$. The spectrum of the present atom is $\nu_0(T_P)$, $\lambda_0(T_P)$. $\nu_0(T_E)$ is equal to $\nu_0(T_P)$ because the electric orbital energy gap of the atom is same for both.

$$C(T_E) = \nu_0(T_E) * \lambda_0(T_E) \quad \rightarrow \quad C(T_P) = \nu(T_P) * \lambda(T_P)$$

Present atom spectrum: $C(T_P) = \nu_0(T_P) * \lambda_0(T_P)$

$$z + 1 = \frac{\lambda(T_P)}{\lambda_0(T_P)} = \frac{\nu_0(T_P)}{\nu(T_P)} = \frac{\nu_0(T_E)}{\nu(T_P)}$$

Redshift based on wavelength is different from that based on frequency.
Wavelength-based redshift z_λ (discussed in the section 6):

$$z_\lambda + 1 \equiv \frac{\lambda(T_P)}{\lambda_0(T_E)} = n \times \frac{C(T_P)}{C(T_E)} = \frac{T_P}{T_E} \times \frac{C(T_P)}{C(T_E)} = \frac{1}{T_{ER}} \times \frac{C(T_P)}{C(T_E)} \quad .$$

Frequency-based redshift z_ν (observed redshift):

$$z_\nu + 1 \equiv \frac{\nu_0(T_E)}{\nu(T_P)} = \frac{\lambda(T_P)}{\lambda_0(T_P)} = \frac{\lambda(T_P)}{\lambda_0(T_E)} \frac{\lambda_0(T_E)}{\lambda_0(T_P)} = n \times \frac{C(T_P)}{C(T_E)} \times \frac{C(T_E)}{C(T_P)} = n = \frac{1}{T_{ER}}$$

z_ν is our observed redshift. Hereafter we use simply z for z_ν.

9. Factors affecting the brightness of a star

(i) Factor by wavelength prolongation

Along with the space expansion, the wavelength is stretched by n. While the energy of a single photon $h\nu$ decreases to $1/n$ times, the

number of photons increases to n-fold to offset and preserve the total energy. As far as we use the luminosity as energy per unit time, we do not have to consider the factor by wavelength prolongation.

(ii) Factor by scattering

$$C(x) = K * f_D * f_{EM} = K * \frac{1}{x\sqrt{1-x}} * \left(1 - \frac{T_C{}^3}{x^3}\right)$$

The Electromagnetic interaction factor f_{EM} in the above light speed equation is effect of scattering. There are plural Time Clear T_C values. One is for the Cosmic Microwave Background (CMB) radiation, about 380 thousands years after the Big Bang, when the universe cleared up after completion of atom formation from plasma. Later, hydrogen atoms started to form stars and radiate light, which re-ionized interstellar hydrogen atoms. Then, the space became opaque again. Once the number of stars reached roughly plateau, the f_{EM} immediately increased to one due to rapid decrease of the star density and the hydrogen atom density in the space. The third type of T_C-like is for light propagation in substances such as glass, water and air. T_C and the density ρ give the absorbance. If the density is constant, the transmittance becomes as follows, where x is the optical depth.

$$I(x) = I_0\left(1 - \int (T_C\rho)^3 dx\right) = I_0(1 - kx)$$

Stellar light emitted during the reionization period, said to be roughly from 150 million years to one billion years after the Big Bang, does not reach us or is darken by scattering. For stellar light emitted later, corresponding to $T_{ER} > 0.072$ or $z < 12.8$, the factor by scattering is negligible.

(iii) Factor by variation of the space energy density

The brightness is expressed as energy per unit time, that is, luminosity as energy per unit time and flux as energy per unit time per unit area. The

flux is shown as follows, where L is the luminosity and r is the distance from light source.

$$F = \frac{L}{4\pi r^2}$$

The luminosity varies depending on the light speed at the time of detection because it is a per unit-time value of energy, while the total energy from the source is invariant. It is a function of the time of detection $T = x$.

$$F(x) = \frac{L(C(x))}{4\pi r^2} = \frac{L(x)}{4\pi r^2}$$

For our observation, x is fixed to the present time T_P. $L = L(T_P)$ and $F = F(T_P)$. Therefore, we do not have to consider influence of light speed variation by space expansion for observation of brightness.

10. Magnitudes of flux and distance

Light of luminosity L emitted at T_E reaches us now at T_P. We observe now the flux $F(T_E)$ after correction of observational biases. $LD(T_E)$ is the light propagated distance equal to the so-called luminosity distance. Define the magnitude of the flux as follow.

$$F(T_E) = \frac{L}{4\pi \cdot LD(T_E)^2}$$

$$m(T_E) \equiv -2.5 \cdot \lg F(T_E)$$

Define the relative magnitude to the reference of the same luminosity exhibiting redshift 0.05 as the "magnitude of LD to $z = 0.05$, $DM_{0.05}$". It is a distance modulus because of the same luminosity. $z = 0.05$ corresponds to $T_{ER} = 1/(1+z) = 1/1.05$.

$$DM_{0.05}(T_{ER}) \equiv m(T_{ER}) - m(1/1.05)$$

From the equation of the flux, we get the following formula.

$$DM_{0..05}(T_{ER}) = 5 \cdot \lg LD(T_{ER}) - 5 \cdot \lg LD(1/1.05)$$

The light propagated distance LD is given as follows from light speed.

$$LD(T_E) = \int_{T_E}^{T_P} C(x)dx = \int_{T_E}^{T_P} \frac{K}{x\sqrt{1-x}}\left(1 - \frac{T_C{}^3}{x^3}\right)dx \approx \int_{T_E}^{T_P} \frac{K}{x\sqrt{1-x}}dx$$

$$= K\left(\log\left(\frac{1-\sqrt{1-T_P}}{1+\sqrt{1-T_P}}\right) - \log\left(\frac{1-\sqrt{1-T_E}}{1+\sqrt{1-T_E}}\right)\right)$$

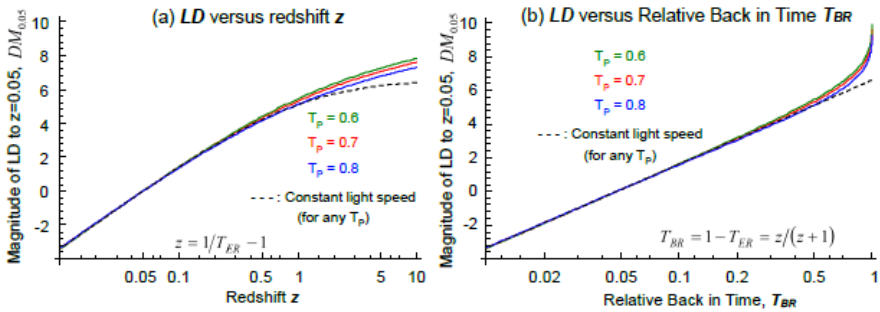
$$LD(T_{ER}) = K \cdot \log\left(\frac{1-\sqrt{1-T_P}}{1+\sqrt{1-T_P}} \cdot \frac{1+\sqrt{1-T_P T_{ER}}}{1-\sqrt{1-T_P T_{ER}}}\right)$$

Finally, we get the following equation for $DM_{0.05}(T_{ER})$.

$$DM_{0.05}(T_{ER}) = 5 \cdot \lg\left(\log\left(\frac{1-\sqrt{1-T_P}}{1+\sqrt{1-T_P}} \cdot \frac{1+\sqrt{1-T_P T_{ER}}}{1-\sqrt{1-T_P T_{ER}}}\right)\right)$$

$$- 5 \cdot \lg\left(\log\left(\frac{1-\sqrt{1-T_P}}{1+\sqrt{1-T_P}} \cdot \frac{1+\sqrt{1-T_P/1.05}}{1-\sqrt{1-T_P/1.05}}\right)\right)$$

Fig. 13 shows graphs of $DM_{0.05}(T_{ER})$ with parameter T_{ER} for plural T_P values in dual logarithmic scale. (a) is versus the frequency-based redshift $z = 1/T_{ER} - 1$. (b) is versus the Relative Back in Time $T_{BR} = 1 - T_{ER}$, which times T_P is the light travel time since the emission. The dotted line in black is a reference for constant light speed based on the distance $LD_C(T_{ER}) = c \cdot (T_P - T_E) = c \cdot T_P \cdot (1 - T_{ER})$.



Magnitude of *LD* to *z* = 0.05 versus (a) redshift or (b) Relative Back in Time

Figure 13

11. Hubble diagram

According to the 4-D spherical model, the expansion speed of the 3-D space by the Observed Time is constant for a given angle θ as shown by

$$\frac{dr}{dT} = \frac{dr}{dx} = \frac{d(x\theta)}{dx} = \theta$$

, in which *r* is the distance of any two points in the 3-D space and θ is the angle between the two positions from the center of 4-D sphere. For variable θ at a given *x*, the recessional velocity is in proportion to θ and the distance $r = \theta \cdot x$. This is the Hubble's law. The said velocity is of the so-called "proper distance", which is the real distance from the target to the observer at a given time point and changes over time. Refer the proper distance at present to as the "present distance, PD". The observed brightness primarily gives the luminosity distance, which is equal to the light propagated distance LD.

(i) LD-PD conversion

Take a case shown in Fig. 14. Light emitted at location A_E and time T_E reaches us at B_P and T_P. The light propagated distance LD is the 3-D space component of the line A_E-B_P, equal to the line C-B_P. *n* is the space expansion ratio given by $n = T_P / T_E = 1/T_{ER}$. As see in Fig. 14, the ratio of

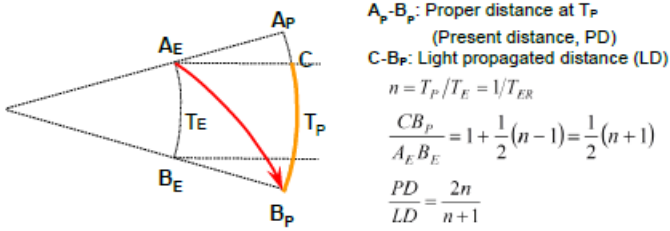
C-B_P to A_E-B_E is

$$\frac{CB_P}{A_E B_E} = 1 + \frac{1}{2}(n-1) = \frac{1}{2}(n+1)$$

.

Because the ratio A_P-B_P to A_E-B_E is n, the conversion ratio of the light propagated distance LD to the present distance PD becomes as follows.

$$\frac{PD}{LD} = \frac{2n}{n+1} = \frac{2(z+1)}{z+2} = \frac{2}{1+T_{ER}}$$



Light propagated distance (LD) - Present distance (PD) conversion

Figure 14

(ii) Time dilation

Provide tentatively that the light speed has been constant from the emission to the present. The light propagated distance LD_C from T_E to T_P becomes as follows.

$$LD_C = c \cdot (T_P - T_E) = c \cdot T_P \cdot (1 - T_{ER}) = c \cdot T_P \frac{z}{z+1}$$

Multiply the both sides by $1+z$, we get the following equation.

$$(1+z) \cdot LD_C = c \cdot T_P \cdot z \equiv k \cdot z$$

The left side becomes proportional to the redshift z. The modification by $1+z$ is generally called "time dilation". Any model of universe including space expansion requires the time dilation by $1+z$. Time interval Δt of two events of light emission at the emission becomes $(1+z)\Delta t$ at the

observer with redshift *z*. This dilation has been observed in individual light-curve widths of supernovae Ia. They exhibited a uniform light-curve width after divided by $1+z$ along with normalization of maximum fluxes. Strictly speaking, it is not a real time dilation but the distance $c\Delta t$ at the emission expanded to $c\Delta t' = c(1+z)\Delta t$ at the present observation.

(iii) K-correction

In actual cosmological observation, so called the K-correction is made to the observed flux (brightness) in addition to the time dilation. The K-correction converts a measurement of an object at a redshift *z* to an equivalent measurement in the rest frame of the object at $z=0$. Virtually consider a stationary universe without expansion. m_x^0 is the apparent magnitude when one observes an object in the rest frame in band *x*. DM^0 is the distance modulus defined by $DM^0 = 5\lg\left(D_L^0/10\mathrm{pc}\right)$, where D_L^0 is the luminosity distance. m_y is the magnitude in band *y* with redshift *z* of the same flux density function and distance. The difference of the magnitudes is the K-correction.

$$K_{xy} \equiv m_y - m_x^0 \quad \text{or} \quad m_y \equiv M_x + DM^0 + K_{xy}$$

In the observed frame of m_y with *z*, the absolute magnitude and distance modulus accord with

$$m_y = M_y + DM(z) \quad .$$

We get the following relation for the K-correction.

$$K_{xy} = M_y - M_x + DM(z) - DM^0$$

The K-correction is also the sum of difference in absolute magnitude and that in distance modulus between the redshifted and rest frames. $M_y - M_x$ is the cross-filter adjustment on absolute magnitude between *x* and *y* bands. The luminosity distance $D_L(z)$ in the observed frame is equal to the light

propagated distance $LD(z)$. The luminosity distance D_L^0 in the rest frame corresponds to the present distance PD of the source. We can conclude that the K-correction deducted by the cross-filter adjustment exactly expresses the LD-PD conversion.

12. Comparison with Hubble diagrams from the Supernova Cosmology Project

The reported graphs of Hubble diagram by the Supernova Cosmology Project (SCP) applied the time dilation by $z+1$ and K-corrections. In order to superimpose the expected curves from the model on their reported graphs, take the following value.

$$(1+z)\cdot PD = (1+z)\cdot \frac{2(z+1)}{z+2}\cdot LD$$

$$\frac{1}{T_{ER}}\cdot PD = \frac{1}{T_{ER}}\cdot \frac{2}{1+T_{ER}}\cdot LD$$

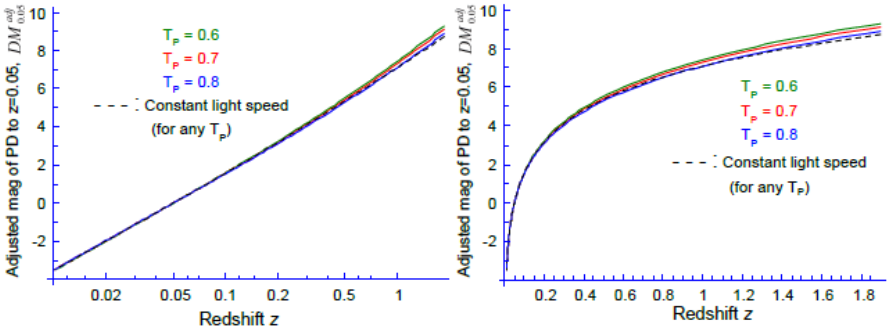
LD is converted to *PD* and multiplied by $1+z$ corresponding to the time dilation. Refer its magnitude to as the "adjusted magnitude of PD to z=0.05, $DM_{0.05}^{adj}$".

$$\begin{aligned} DM_{0.05}^{adj}(T_{ER}) &= 5\cdot(\lg LD(T_{ER}) + \lg(1/T_{ER}) + \lg(2/(1+T_{ER})) - \lg LD(1/1.05) - \lg 1.05 - \lg(2*1.05/2.05)) \\ &= 5\cdot(\lg LD(T_{ER}) - \lg(T_{ER}) - \lg(1+T_{ER}) - \lg LD(1/1.05) - 2\cdot\lg 1.05 + \lg 2.05) \end{aligned}$$

We get the following final equation for comparison with observed data.

$$\begin{aligned} M_{0.05}^{adj}(T_{ER}) = {} & 5\cdot\lg\left(\log\left(\frac{1-\sqrt{1-T_P}}{1+\sqrt{1-T_P}}\cdot\frac{1+\sqrt{1-T_P T_{ER}}}{1-\sqrt{1-T_P T_{ER}}}\right)\right) - 5\cdot\lg\left(\log\left(\frac{1-\sqrt{1-T_P}}{1+\sqrt{1-T_P}}\cdot\frac{1+\sqrt{1-T_P/1.05}}{1-\sqrt{1-T_P/1.05}}\right)\right) \\ & -5\cdot\lg T_{ER} - 5\cdot\lg(1+T_{ER}) - 10\cdot\lg 1.05 + 5\cdot\lg 2.05 \end{aligned}$$

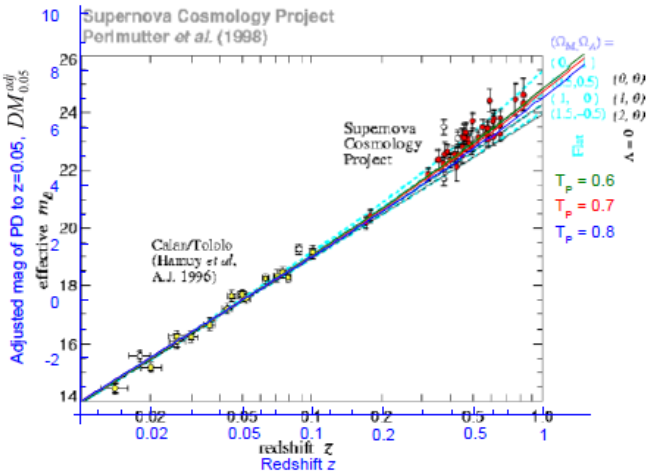
Fig. 15 shows the graphs of $DM_{0.05}^{adj}$ versus the redshift *z*, in a logarithmic scale and a uniform scale for *z*, respectively. The dotted line in black is a reference for constant light speed for any T_P value.



Adjusted magnitude of present distance PD to z = 0.05 versus redshift

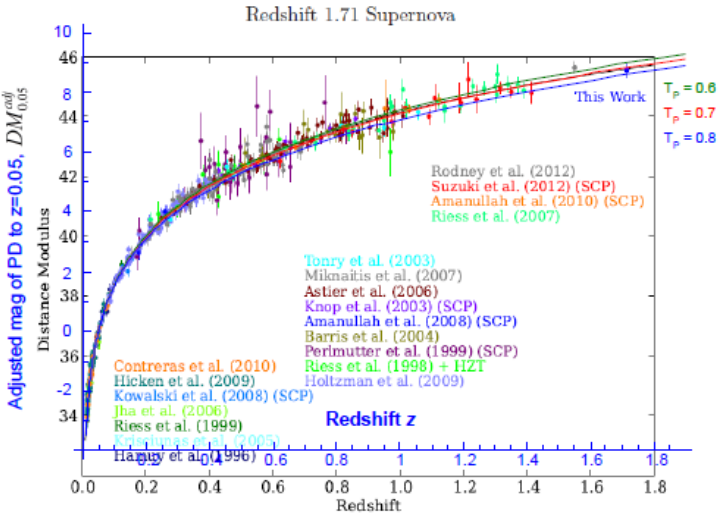
Figure 15

Fig. 16 is the superimposed results of the equation on the Hubble diagram with z in a logarithmic scale, which Perlmutter et al reported. Fig. 17 is the superimposition on the latest Hubble diagram from the SCP with z in a uniform scale. In the both comparisons, we see excellent fits to the observed data of supernovae for T_P value around 0.7.



Superimposition of adjusted mag of present distance PD to z = 0.05 versus redshift graphs on the reported Hubble diagram from SCP (1999): redshift in a logarithmic scale

Figure 16



Superimposition of adjusted mag of present distance PD to z = 0.05 versus redshift graphs on the reported Hubble diagram from SCP (2013): redshift in a uniform scale

Figure 17

13. Conclusion as verification of the universe model

As shown here, the 4-D spherical model of the universe, which I am proposing, exhibited an excellent fit to the observed data from the Supernova Cosmology Project. This fact itself does not signify that it has proved the model, but it has fulfilled the most important requirement that we have to test. We can say that the fact has at least showed a big possibility of the model. In the present state that there is yet no one fully satisfied while many attempts are underway to interpret the SCP data, it should be very valuable to examine at least the possibility of the 4-D spherical model. For a newly proposed model in general, it is required to present a measurable evidence, which the model projects, and then verify it by an experiment. What the 4-D spherical model of the universe projects is that the space expansion by the Observed Time should be in a uniform velocity. Furthermore, the model has given the concrete equation on the relationship between the luminosity and the redshift. The actual data from the

supernova survey have exhibited an excellent fit to the equation while they were obtained prior to the release of the model.

If there is a fatal mistake or a point experimentally disproved in a model, the model is denied. Against the model I proposed, most of professional physicists argue that there is no room to doubt the light speed invariance because it has been experimentally proved. However, I have theoretically demonstrated that the Michelson-Morley type experiments, which are said to have proved the light speed invariance, are incapable to detect a change in location of the interference fringe. What this claim predicts for its validation is a variation of the brightness of the fringe. It projects that the brightness should alter by circadian change or a rotation of the apparatus while there should be no change of location or patter of the fringe. I hope someone would carry out an experiment for verifying the expectation some day.

< Postscript >

I would like to thank all of you very much for having read this book up to here. Even those, who read various prospects on the time interestingly, might feel that it has got harder to read this piece since the contents turned to be exclusive of physical descriptions in the Part-2. I wrote this book expecting that I can share with other people those like romances or imaginations surrounding the time and the universe if a non-professional in physics like me explains the content by my own words in the order of the actual sequence of my thinking processes. I would like to ask your pardon for too insistent expressions in the book, which is due to setting a high value on the logicality. It would be my great pleasure if you would consent to any contents in this book and think over them. I have to do my best to ask the validity of the model in the professional society of physics. Although I am continuing my effort of it, it is a fact that I stand alone between the public people and the astrophysicists. Trying to write an explanatory book for non-professionals this time has blown out my feeling of isolation to some extent and is giving me a power for further challenge from now. In the course of writing this piece with a hope to think about the time jointly with you readers, I became to recognize the time more deeply and discovered new findings. I would highly appreciate receiving your reading impression or your own opinion on an individual subject of the time or the universe.

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