Light speed and the expansion of the universe

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Abstract. Based on the formerly proposed model of the time and universe, a time-course of the light speed along with the expansion of the universe is discussed. Formulas of light propagated distance of a supernova are derived, whose graphs showed an excellent consistency to the observed supernovae data. This outcome verifies that the universe has been expanding at a constant speed by our observed time as the model predicts.

1. Introduction

There is a big mystery that the supernova data seem to imply the universe is expanding in an accelerating manner [1] - [5], for which successful explanation is missing. On the other hand, we unintentionally perceive the time without a clear definition. The author of this article proposed before a model for the development of the universe as well as the definition of a time dimension and what the time we observe passing at a constant speed is [6] [7].

Key aspects of the model are as follows:

- Energy is a vibration in multiple dimensions.
- In order to express a vibration, which is a movement, a dimension tracing values in other dimensions is essential.
- A vibration of energy in an additional space dimension vests an additional energy.
- If a vibration of energy in a certain dimension reaches a steady state for a minimum duration of observation, showing a stationary wave, it can be treated as a particle exhibiting the mass corresponding to the energy of the vibration. We can define that the vibration in the dimension is "quantized" and the dimension is "compactified" for the vibration.
- The gravitational force is given by the Newtonian equation provided that the mass is not the rest mass but is corresponding to the total energy.
- The space of universe is the area where energy is spread.
- At the Big Bang, the energy distribution transformed to be spread with expansion in 3-dimensional surface of a 4-dimensional sphere in tracing by the original time dimension. A reference image for the expansion is illustrated in Fig. 1.
- Vibrations in other hidden dimensions remain being quantized and the dimensions are compactified for the expansion of the universe.

1 This paper is a private work independent from the company.
2 Business Development and Licensing, Nippon Boehringer Ingelheim Co., Ltd.
Vibrations in the hidden dimensions render intrinsic energy (referred to as the “Spacia”) to the space.

A vibration of the intrinsic energy (Spacia) in the 3-D space dimensions vests additional energy, which is our observable energy as light or other quantum particles.

The time we observe passing constantly (referred to as the “Time”) is the movement of the space energy in the radius dimension of the 4-D sphere.

The gravitational attraction of an object from the space energy or the whole universe is equal to all directions and is offset each other. What we observe as a mass of an object is not for the whole energy of the space occupied by the object but is the additional energy vested by the vibration of the space energy in the 3-D space.

The mass for gravitational interaction for the expansion of the universe is different from the mass for gravitational interaction between particles in the 3-D space.

According to this model, the space of the universe should expand at a constant speed with tracing by our observed Time ($T$) as shown by the equation

$$\frac{dr}{dT} = \frac{dr}{dx} = \theta,$$

where $r$ denotes an arc vector in the 3-D surface, $x$ denotes the radius of the 4-D sphere, and $\theta$ is the angle from the center of universe corresponding to $r$ [7].

2. Light speed

This model implies the presence of the medium for light, which contradicts with the two propositions of the special relativity [8]; the principle of relativity and the principle of invariant light speed. The special relativity requires a constant speed of light even when the observer is moving. If there is a medium for light as I propose, light speed is independent from the light emitter’s speed but is variable if the observer is moving toward the medium.

In this model, all quantum particles including photon are vibrations of the Spacia in the 3-D space. The propagating speed of the light should depend on the energy density or temperature of the medium, the Spacia. Along with the expansion of the universe, the energy density of the Spacia is getting lower. The light speed would be getting slower either by the time or the Time passing, I expect. A simulation of the light speed by analogy with the speed of sound in air [9] was given in my previous article [6]. Currently, the traveled time period of the light of supernovae is calculated to divide the luminosity distance (fainter) by the constant light speed throughout the whole time period. Therefore, the traveled time of the light of a distant supernova should be calculated longer than the real value. For getting Hubble Plots, the Time back from present when light was emitted should be adjusted by the change of the light speed by the Time. There is a possibility that the real expansion by the Time would be at a constant speed as expected from this model.
If the light is a wave of the Spacia, the Spacia should be equal to the light medium "luminiferous aether", which had been introduced before Einstein released the Special theory of relativity. It is well accepted that the Michelson-Morley experiment did not detect the relative speed of the observer to the aether but it became the most successful experiment having proved the absence of the aether and the constant speed of the light independent from observer’s movement [10] - [12]. However, there is a critical mistake in the experimental design itself. Let’s check key aspects subjected the presence of the aether (or Spacia).

As the light is a vibration of the medium, its propagation speed is a constant independent from the relative speed of the light emitter to the medium. However, if the observer moves to the medium, it detects the light speed depending on its own speed. In the Michelson-Morley 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 end of arms respectively, return to a half-mirror and are combined for detection.

The round traveled time $t_a$, from the half-mirror light splitter to the mirror and return, for the light beam parallel to the aether wind is given as

$$t_a = \frac{L}{c + v} + \frac{L}{c - v} = \frac{2cL}{c^2 - v^2},$$

(2)

where $c$ is the light speed to the aether, $v$ is the speed of the apparatus toward the aether, and $L$ is the distance from the splitter to the mirror. On the other hand, the round traveled time $t_b$ for the light beam perpendicular to the aether wind is given as

$$t_b = \frac{2L}{\sqrt{c^2 - v^2}}.$$

(3)

The difference of the traveled time among the two beams, $\Delta t$, becomes as follows.

$$\Delta t = t_a - t_b = \frac{2L}{c^2 - v^2} \left( c - \sqrt{c^2 - v^2} \right)$$

(4)

Unless $v = 0$, $\Delta t$ is greater than 0 and the two beams make an interference fringe. By rotating the apparatus, $v$ varies and a change in the interference fringe should be observed. This was the expectation for the experiment.

In case two beams are split from the identical coherent light, the two beams have the same phase when they are split.

$$\varphi_a(t_0) = \varphi_b(t_0)$$

(5)

If there is a difference in time, $\Delta t$, to return to the detector, the pair of the respective phases of the beams, which separated at the same instant, can not be combined simultaneously to interfere. In a real experiment, continuous light beam is used. Because the fringe of the two split beams is detected, it is an essential requirement that the respective phases of the two beams should be combined for detector simultaneously. However, the phases, which are combined for interference, should have left the splitter at different time points. One should split $\Delta t$ earlier than the other.

The parallel beam A takes $\Delta t$ longer time than the right-angle beam B.

$$t_a = t_b + \Delta t$$

(6)

On the other hand, the phase of the beam B combined with the beam A should be released at the splitter $\Delta t$ earlier than the phase of the beam A is released.

$$t_{0,b} = t_{0,a} + \Delta t$$

(7)
The phase of the beam A is equal to that of the beam B when they are combined for detection, independent from the value of \( v \) as shown below.

\[
\phi_a = \phi(t_{0,a} + t_a) = \phi(t_{0,a} + t_b + \Delta t) \quad (8)
\]

\[
\phi_b = \phi(t_{0,b} + t_b) = \phi(t_{0,a} + \Delta t + t_b) = \phi_a \quad (9)
\]

As another possibility, if \( \Delta t \) is zero but the traveled distances are different among the two beams, such fringe would be expected. However, the light speed is constant in the medium independent from light emitter’s speed. Therefore the traveled distance is identical for both beams because their traveled time periods are equal.

In conclusion, any change in the interference fringes can not be expected theoretically by the Michelson-Morley experiment.

The equation for the light propagation speed by the Time proposed in my previous article [6] is derived as follows. The speed of light should depend on the density of the medium, the Spacia. The sound speed in the air is given as

\[
c_{\text{air}} = 331.3 \ m \cdot s^{-1} \sqrt{\frac{T}{273.15}}, \quad (10)
\]

in which \( T \) denotes the absolute temperature in kelvins [9, 13]. Speculated by analogy with the speed of sound, the light propagating velocity in the Spacia would be proportional to square root of the energy density or temperature of the Spacia. The energy density is inversely proportional to cube of the size of the space. The light speed by the original tracing time dimension would be given as follows.

\[
\frac{dL}{dt} = \frac{K_1}{\sqrt{x^3}} \quad (11)
\]

\( L \) is the light propagated distance, and \( x \) is the radius of the universe. The expansion speed of the radius by the time is shown as follows from energy preservation of potential and kinetic energies based on the Newtonian theory of gravity [6].

\[
\frac{dx}{dt} = \pm \sqrt{2GM \left( \frac{1}{x} - K_2 \right)} \quad (12)
\]

\( M \) denotes the mass of the whole universe. The light speed by the Time is accordingly given as

\[
\frac{dL}{dT} = \frac{dL}{dt} \cdot \frac{dt}{dT} = \frac{dL}{dx} \cdot \frac{dx}{dt} = \frac{K_1}{\sqrt{2GMx^3 \left( \frac{1}{x} - K_2 \right)}} = \frac{K}{x^\sqrt{1 - K_2x}}. \quad (13)
\]

**Figure 2.** Time-course of light speed by the Time

If we use the unit of Time as 1 for the maximum radius of the universe, the space expansion speed by \( t \) at \( T = 1 \) is zero. Therefore \( K_2 = 1 \) from the equation (12), and the formula (13) becomes as follows.

\[
\frac{dL}{dT} = \frac{K}{x^\sqrt{1 - x}} \quad (14)
\]

The graph of the Time-course of light speed by the Time is shown in Fig. 2. It has the minimum at \( x = 0.75 \).
3. Light propagated distance of a supernova

The light speed expected by this model is expressed as the equation (14). Let’s see a light propagated distance of a supernova. Let the Time at present be $T_P$, and the back in Time from $T_P$ when the light was emitted be $T_B$. The propagated distance $L$ is given as follows from the equation (14).

\[
L = \int_{T_P-T_B}^{T_P} \frac{K}{x\sqrt{1-x}} dT = \int_{T_P-T_B}^{T_P} \frac{K}{x\sqrt{1-x}} dx
\]  

\[
\int \frac{1}{x\sqrt{1-x}} dx = \log \left| \frac{1 - \sqrt{1 - x}}{1 + \sqrt{1 - x}} \right|
\]  

\[
L = K \left( \log \left| \frac{1 - \sqrt{1 - T_P}}{1 + \sqrt{1 - T_P}} \right| - \log \left| \frac{1 - \sqrt{1 - T_P + T_B}}{1 + \sqrt{1 - T_P + T_B}} \right| \right)
\]

\[
= K \cdot \log \left| \frac{1 - \sqrt{1 - T_P}}{1 + \sqrt{1 - T_P}} \cdot \frac{1 + \sqrt{1 - T_P + T_B}}{1 - \sqrt{1 - T_P + T_B}} \right|
\]  

We don’t know yet $T_P$ or $K$. The graphs of $L$ for various $T_P$ values are shown in Fig. 3.

![Figure 3. Light propagated distance ($L$) versus Back in Time ($T_B$)](image)

Fig. 4 is the Hubble plots from the Supernova Cosmology Project [14]. In order to verify if there is a set of $T_P$ and $K$ values, which nicely matches the supernova observation in Fig. 4, let’s modify the axes of Fig. 3. The value 1.0 of the redshift $Z$ corresponds to a half of the present Time $T_P$ as the back in Time $T_B$ because the size of universe is expanded to two fold since the light was emitted. The equation (17) is alternatively expressed by the relative back in Time, which is defined as $T_{BR} = T_B/T_P$, instead of $T_B$, as follows.

\[
L(T_{BR}) = K \cdot \log \left| \frac{1 - \sqrt{1 - T_P}}{1 + \sqrt{1 - T_P}} \cdot \frac{1 + \sqrt{1 - T_P + T_B}}{1 - \sqrt{1 - T_P + T_B}} \cdot \frac{1 - \sqrt{1 - T_B}}{1 + \sqrt{1 - T_B}} \right|
\]  

As for the vertical axis, $L(T_{BR})/L(0.1)$ is used to superimpose the lines for various $T_P$ values in a way that its values fit the observed supernova data in the range of $T_{BR}$ from 0 to 0.1. The relative light propagated distance to $L(0.1)$ versus the relative Back in Time is expressed by the formula (19) and shown in Fig. 5.
\[ \frac{L(T_{BR})}{L(0.1)} = \log \left( \frac{1 - \sqrt{1 - T_P}}{1 + \sqrt{1 - T_P}} \cdot \frac{1 + \sqrt{1 - T_P + T_P \cdot T_{BR}}}{1 - \sqrt{1 - T_P + T_P \cdot T_{BR}}} \right) \times \left( \log \frac{1 - \sqrt{1 - T_P}}{1 + \sqrt{1 - T_P \cdot 0.9 \cdot T_P}} \right)^{-1} \] (19)

Figure 4. Hubble plots from the Supernova Cosmology Project

Figure 5. Relative light propagated distance, \( L(T_{BR})/L(0.1) \), versus Relative Back in Time, \( T_{BR} = T_B/T_P \)

Fig. 6 is superimposed graphs of Fig. 5 to Fig. 4 for \( T_P = 0.6, 0.7 \) and 0.8, respectively. The superimposed line of the light propagated distance for \( T_P = 0.7 \) gives an excellent consistency to the real observation. If we can find a \( T_P \) value, whose graph in Fig. 5 meets the observed supernova data in Fig. 4 for the whole range of the back in Time, we can conclude that the back in Time \( T_B \) and the space expansion show a perfect linearity, that is, the universe has been expanding at a constant speed by our observed Time.

Provided that the current Time \( T_P \) is roughly 0.7, then the \( K \) value is given as follows from the equation (14), where \( c \) denotes the current light speed.

\[ K \approx \left( 0.7 \times \sqrt{0.3} \right) \cdot c \approx 0.3834 \times c \approx 1.15 \times 10^8 \text{ m} \cdot \text{s}^{-1} \] (20)
Why I insist that the time we observe passing at a constant speed is not the original tracing dimension but the radius dimension of the universe is mainly based on this linearity of the space expansion.

4. Discussion

Many evidences for claiming the constant speed of light propagation are in fact supporting the independence from the speed of the light emitter. Although the special relativity is based on the invariance of the light speed even if the observer of light is moving [8], there might be no evidence that has proven it other than the Michelson-Morley type experiment. As I argued in this article, the experimental design of the Michelson-Morley experiment is theoretically impossible to detect the change of phases between the two split beams.

Most of evidences supporting the general relativity, e.g. the gravitational lensing, should be explained also by the Newton’s gravity theory provided that the working mass is not the rest mass but the mass corresponding to the total energy including kinetic and potential energies.

The model of the universe discussed in this and former articles [6] [7] is based on classical physics on gravity with modified interpretation of working mass. It would be rather hypothetical. On the other hand, the definition of a time dimension by analyzing vectors, which is discussed in my preceding article [7], should be theoretical. The combination of the 4-D sphere model with the new interpretation of our observed Time led consequences that meet so beautifully our real observations of the space expansion from supernova data.

As shown in this article, I strongly insist that the universe has been expanding at a constant speed by our observed Time. Consequently, the dark energy should not exist but was introduced due to the lack of adjustment of the Time in back when light was emitted from supernovae, while the adjustment is required from the changing speed of light.

As a testable effect predicted from this model of the time and the universe, I wish professional physicists would investigate in more detail the adjustment line of the back in Time from the light propagated distance for supernovae.

Lastly, it is rather natural to expect that the Dark Matter would be the space energy referred to as the Spacia in this article. Verifying this possibility would be also highly appreciated.
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