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Chapter

Tired Light Denies the Big Bang

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Abstract

More and more problems related to Big Bang have been appeared in recent years. All the problems are due to the Doppler interpretation of redshift. The "tired light" theory, proposed in 1929 by Zwicky and most recently developed by Shao in 2013, gives a new explanation for redshift. The theory has shown that the redshift is induced from the energy loss of photons by the interaction with material particles on their journey through cosmological space. The basic principles related to the energy transfer are mainly the mass-energy equivalence and the Lorentz theory. Problems, such as super velocity, the horizon problem, the cosmological microwave background radiation, and Olbers' paradox, vanish in the cosmological model of "tired light" theory. The model describes a boundless and timeless Cosmos.

Keywords: tired light, energy loss, photons, cosmological redshift, Lorentz theory, big bang, CMBR, Olbers' paradox

1. Introduction

Cosmology is as old as other branches of sciences, beginning at the ancient Greeks. But modern cosmological study started in the twentieth century, marked by Einstein's theoretical research in 1917 and Hubble's observational investigations in 1929. The Big Bang cosmological model came mainly from Hubble's work. Hubble used the Doppler Effect to interpret what came to be known as the cosmological redshift. The "tired light" hypothesis was proposed by Zwicky in 1929, after Hubble's paper, as an alternative interpretation to that of the Doppler effect for the cosmological redshift [1]. In 1929, Hubble obtained a distance-redshift relation through observations. He then obtained a new relation of distance-velocity by using the Doppler effect to interpret the redshift. About half a year later after Hubble's paper, Zwicky proposed a "tired light" hypothesis to explain the distance-redshift relation. But the nature of the "tired light" was only vaguely explained in Zwicky's work, so that the "tired light" hypothesis has not been accepted by most cosmologists and astronomers to this day. The Big Bang, after Hubble's work, became the most accepted cosmological model. In recent years, problems related to Big Bang have been more and more clearly realized by cosmologists and astronomers. Some problems are directly related to the interpretation of the Doppler effect for cosmological redshift. The Big Bang model cannot surmount these problems. Fortunately, the study of "tired light" theory has continued. In 2013, Shao developed the "tired light" hypothesis on the basis of physical principles, that is, (a) electromagnetic field theory, (b) the mass-energy equivalence, (c) the quantum light theory, and (d) the Lorentz theory [2]. Based on these physical principles, the "tired light" theory explains the cosmological

redshift as the result of photon energy loss due to the interactions with material particles as photons travel through cosmological space. By this interpretation for cosmological redshift, the Cosmos is infinite and eternal.

2. Big Bang, history and problems

Hubble derived the distance-velocity relation from observational result of the distance-redshift relation, by employing the interpretation of Doppler effect [3]. The Big Bang is popularly known in present days, but some problems accompanying it have been aroused. Furthermore, some problems result from the interpretation of Doppler effect for the cosmological redshift. Actually, all the problems are rooted in the Doppler effect interpretation of cosmological redshift. The present situation is that the Big Bang cosmology is facing some hurdles, which it seems cannot be easily overcome within the framework of the Big Bang model.

2.1 Big Bang and Doppler effect

The Big Bang model came from two sources. One source is, weakly, Einstein's finite boundless cosmological model proposed in 1917. The other one is, strongly, the interpretation of the Doppler effect for the cosmological redshift, employed by Hubble [3].

Hubble employed the Doppler effect to interpret the cosmological redshift in the distance-redshift relation he discovered in 1929. In doing this, Hubble derived the distance-velocity relation which led people to conceive of the Cosmos in the image of a Big Bang. Why did Hubble use the Doppler effect to interpret the redshift? One reason is that he had no other choice since the Doppler effect was the only interpretation for redshift at that time.

Reber had introduced the history of the Doppler effect and its application to the studies of the Sun's motion and the rotation of our galaxy [4]. The Doppler effect was enunciated in 1842. Doppler claimed that the frequency and wavelength of light or sound would change when a signal from a moving source was observed. The effect was confirmed in 1845 for sound. It was subsequently confirmed for light by observation in 1871 and by experiment in 1901.

About the year 1900, the Doppler effect was used to study the rotating of double stars. Around 1910, it was used to study the motion of the Sun in the Milky Way. And by 1920, it was used to examine the rotation of our galaxy. "All three of the above examples are correct interpretations of spectral shift caused by relative motion between the source and the observer," Reber remarked.

When Hubble had found the relation of distance-redshift, he used the Doppler effect to interpret the redshift, that is, the movements of spectral lines. He did so habitually, as previous studies had done. Whether he considered the difference between light sources within our galaxy and those in other galaxies is not known. But the problems were brewing by his doing. Hubble should have been conscious of the fact that the light sources belong to other galaxies. Then, was it suitable to use the Doppler effect for the interpretation of the redshift in the distance-redshift relation? Nevertheless, Hubble transformed the distance-redshift relation to the distance-velocity relation by using a Doppler interpretation for the redshift. In doing this, Hubble had no real choice because there was only the Doppler effect available to him for the interpretation of redshift. Regarding this, Reber remarked: "clearly, the interpretation of these spectral shifts as representing relative motion was dubious."

2.2 The problems related to Big Bang

As a cosmological model, the Big Bang presents some difficult problems. There are some phenomena that the Doppler effect cannot explain and others that Big Bang cannot resolve, due to its Doppler effect interpretation for cosmological redshift.

Some of the phenomena and problems are:

1. The solar limb effect, that is, the variation of redshift on solar disc,

2. The signal redshift of Pioneer 6,

3. The large redshift of quasars,

4. Super velocity of light,

5. The horizon problem,

6. The age of the Cosmos.

3. The history of "tired light" theory

Hubble employed the Doppler effect to interpret the cosmological redshift in his study. It was a bold move which he might not have made if he had considered the issue deeply. Zwicky however did not think the Doppler effect was suitable for the interpretation of the cosmological redshift. The Doppler effect says nothing about the nature of matter. It is only a problem in kinematics. The redshift induced by the Doppler effect is caused by relative motion between the light source and the observer. Zwicky thought the things are not so simple. He proposed the "tired light" hypothesis that the cosmological redshift is caused by the interaction of the light with a latent feature of the Cosmos. The tired light hypothesis claims that while the light propagates, it must be affected by all matters of the Cosmos. The idea came from Mach who thought that all of the matter in the Cosmos is related, so that any part of the matter is affected by all the other parts. Although Zwicky objected to the Doppler effect interpretation of cosmological redshift, the tired light hypothesis was vague on physical mechanics, so few people took the hypothesis seriously. But there have been a few people contemplating tired light, keenly working to find the physical mechanics thereof, without success [5–11]. The physical mechanics of tired light was not clearly described until 2013 when M. Shao published his paper. Shao pointed out that the physical mechanics of tired light should be the Lorentz electric force produced by the electromagnetic field of photons acting on material particles.

The phenomena and problems related to Big Bang listed in Section 2.2 can now be explained by the renewed tired light theory (thereafter referred as TLT).

4. The TLT: basic thoughts

The Cosmos is composed of matters and fields. A material aggregation produces two kinds of field, the gravitational field and the electromagnetic field, with the forces of the fields; the gravitational and the electromagnetic forces; and different matter aggregations interact with one another. They attract for or repel each other, which changes or keeps the conditions of matter distribution of various regions, in large or small scales, of the Cosmos.

With the principle of matter-energy equivalence, the electromagnetic field and material particles can be considered the same thing. Then, their densities and sizes can be calculated. A hydrogen atom and a photon of visible light are presented in the simplest case.

The mass of a hydrogen atom is 1.67×10^{-27} kg, and its diameter is 2.4×10^{-10}m. Then, the density of the hydrogen atom is 231 kgm^{-3}.

The average wavelength of the visible light is 5.5×10^{-7} m, being the diameter of a photon. For the simplicity, we assume that the photon has spherical symmetry. From $E = h\nu$, here h is the Plank constant, and ν is the frequency of the light, and $E = Mc^2$, the mass of the photon is 4×10^{-36} kg. Then, the density of the photon is $4.6 \times 10^{-17}\text{kgm}^{-3}$.

From the above data, the ratio of the size of the photon to that of the hydrogen atom is 2292, and the ratio of the density of the photon to that of the hydrogen atom is 2×10^{-19}. The two ratios reveal that the hydrogen atom is very hard and small compared to the photon. The photon, relatively, is extremely low in density and more than 2000 times larger than the hydrogen atom. We now consider a hydrogen atom encountering a photon. The photon is traveling at a light speed, 3×10^8 ms^{-1}, in cosmological space. The hydrogen atom is more or less stable. Since the motion is relative between the photon and the hydrogen atom, the photon could be supposed in a stable mode, and the hydrogen atom penetrates the photon at the speed of light. The diameter of the photon being 5.5×10^{-7} m, then the hydrogen atom should penetrate the photon in 1.8×10^{-15} s. In such a short time, the hydrogen atom should not show electronic neutrality but present in the mode of electric dipole. A photon is actually a section of moving electromagnetic field. During the time of hydrogen atom penetration of the photon, the electromagnetic field of the photon should interact with the hydrogen atom. The electromagnetic field of the photon acts on the hydrogen atom and does some work on the hydrogen atom, given by the Lorentz electric force. A little bit of the energy of the electromagnetic field is transferred from the electromagnetic field to the hydrogen atom. Although the photon loses a very small amount of energy in meeting with a hydrogen atom, it will, traveling a long distance in the cosmological space, show a detectable effect for a photon meeting a large number of hydrogen atoms (and other kinds of atoms and molecules), that is, the photon undergoes a cosmological redshift.

The expression for the cosmological redshift, based on the tired light theory, obtained by Shao in 2013, is, $Z = \exp(kN\lambda_0 + u) - 1$, where k is a coefficient, N is the number of material particles that a photon interacts with in its course from emitter to observer, λ_0 is the original wavelength of the light, and u is the change of the wavelength induced by the gravitational effect [2].

5. Reasoning: the energy loss of a photon, the electromagnetic field of a photon, etc.

5.1 Polarization of atoms and molecules

A hydrogen atom is electrically neutrality in a common time scale. But in a very short instant, for example, about the period of an electron revolving around the nucleus, the hydrogen atom appears to be polarized. A polarized atom must be affected by an electromagnetic field. The hydrogen atom is the simplest atom. It is believed that many kinds of atoms are similarly polarized in a very short time interval.

A small molecule is not always oscillating, deviating from the mode of electromagnetic equilibration. Hence, in a very short time interval, a molecule may be affected by an electromagnetic field. Based on this reasoning, it may be said that many kinds of atoms and molecules should be affected by electromagnetic fields.

5.2 The electromagnetic field of a photon

Light has been considered from two different viewpoints, the wave theory and the particle theory. To explain the photoelectron effect, Einstein suggested that light energy propagates in packets, that is, photons. This is the particle viewpoint of light. The energy of a photon is $E = h\nu$. Contrarily, from the viewpoint of wave theory, light is looked upon as a propagating series of electromagnetic wave.

The two different viewpoints describe the same objective thing but they express different features of light. For the purpose of understanding the energy transfer process from photons to material particles, both viewpoints need to be combined. What is a photon? Einstein and Plank defined a photon by the frequency of the light. They were talking about the effects of energy emission and absorption. For the special case under discussion here, a photon is looked upon as a section of the electromagnetic field of the traveling light. The length of the section is the wavelength of the light. In the corresponding period, the electromagnetic field completes an oscillation. A thread of traveling light can be imaged as a series of photons, and a photon is a section of moving electromagnetic field.

Consider the case of a photon interacting with a hydrogen atom. Since the average size of a photon of visible light is more than 2000 times larger than a hydrogen atom, as mentioned above, the situation of a photon interacting with a hydrogen atom can be viewed as the hydrogen atom penetrating the photon. The photon is viewed as a stable electromagnetic field, and the hydrogen atom is moving through the electromagnetic field of the photon.

5.3 The Lorentz force of the electromagnetic field of a photon

The size of the electromagnetic field is the wavelength of the light. That is to say that a photon is a section of electromagnetic field which, in a period, oscillates along its length. Image moving together with an electromagnetic field is within the cosmological space. We will see some hydrogen atoms passing through the electromagnetic field, that is, they are penetrating the photon.

The electromagnetic field of the photon will affect a charged particle with a Lorentz force. In the short time of 1.8×10^{-15} second, the hydrogen atom is polarized, and it should be forced to change its motion mode by the Lorentz force. The Lorentz magnetic force changes the moving direction of the hydrogen atom, and the Lorentz electric force does some work on the hydrogen atom. Thus, some energy, although small, is transferred from the photon to the hydrogen atom. In the tremendous long journey from emitter to receiver, a photon has to encounter a large number of material particles, so the sum of the energy loss of the photon should show up. The energy loss of the photon is the redshift of the light.

5.4 The ISM and IGM

The Cosmos is the only objective existence and is composed of all the matter and fields produced by the matter. Since it is the only existent thing, it is eternal and infinite. Since it is eternal and infinite, matter can exist in all possible forms, of which there are galaxies, stars, planetary systems, planets and others. All the above

are aggregations of atoms, except that there are roaming atoms, molecules, and dusts, which are the components of the interstellar medium (ISM) and intergalactic medium (IGM). By the way, since the Cosmos possesses infinite possibilities for matter, all kinds of living things, including the human, are here on Earth.

5.5 Matter and fields

There are four kinds of forces related to matter. The strong force and the weak force, which manifest within atoms, are not discussed here. The electromagnetic force and the gravitation are the forces controlling the material distribution of the Cosmos. Generally speaking, all forms of material aggregation and the two kinds of field, the electromagnetic field and the gravitational field, are the elements composing the Cosmos. Matter forms galaxies, stars and planets, and still more smaller celestial objects. The concern here is the atoms and molecules which roam in the interstellar space and intergalactic space, that is, the ISM and the IGM. The greater part of the ISM and IGM is composed of the simplest atom, hydrogen. Kant first talked about the formation process of planetary system. Generally, he is right, and, his reasoning is applicable to the formation of galaxies. These processes are condensing processes. The question is what is the inverse process by which matter is exiled? Roughly, the supernova is a means of material dispersion. Another way is the evaporation of black holes. The Cosmos is in an equilibrium state by these two processes: condensing and dispersing. Nevertheless, we are especially interested here in the interaction between photons and material particles, atoms and molecules.

Most of the ISM and IGM are hydrogen atoms, and most of the others are helium. The rest are heavier elements, molecules, etc. As discussed previously, when a photon meets a material particle, the photon can be looked upon as a section of moving electromagnetic field, and the atom or molecule is passing through the electromagnetic field. While the atom or molecule travels through the electromagnetic field of the photon, a little bit of energy is transferred from the photon to the particle through the effect of the Lorentz electric force. Within the tremendously long journey of a photon from emitter to observer, a vast number of atoms and molecules are encountered and interacted with the photon. With the interactions, a part of the energy of the photon is consumed, and the photon is redshifted.

5.6 Equilibrium of energy matter and energy transfer

As a whole, the cosmos is in an equilibrium state of the matter and energy. But in a local area, there are stars forming and extinguishing. On the larger scale, there are galaxies forming and extinguishing (dispersing). All the processes relate to energy absorption or emission. Consider again the energy transfer process from a photon to a material particle. As said before, when a photon meets a material particle, it can be looked upon as a material particle moving through an electromagnetic field. The material particle may be an atom or a molecule. The particle may be charged. If not, the electrically neutral particle may display polarity in the very short interval as it moves through the electromagnetic field of the photon. When the charged or polarized material particle moves through the electromagnetic field, the Lorentz magnetic force of the electromagnetic field changes the direction of the path of the material particle, and the Lorentz electric force does some work on the material particle, changing the motion of the particle. Then some energy is transferred from the electromagnetic field, that is, the photon, to the material particle. In the long journey of the photon from emitter to observer, a massive number of material particles have interacted with the photon, producing an observable effect, that is, the redshift.

6. The equation of the cosmological redshift

6.1 The energy loss of a photon

A larger photon will transfer more energy to a material particle since it has a longer interaction time with the material particle. So a larger photon transfers a larger part of its energy to the material particle than a smaller one. Thus, the energy loss of a photon is proportional to its size. A photon, on its journey after emission, meets a number of material particles before being received by an observer. The greater the number of material particles it meets, the more energy it loses. So, the energy loss of the photon is also proportional to the number of material particles it meets.

6.2 Equations for the cosmological redshift

When a photon of size λ and energy E meets a material particle, the material particle runs through the electromagnetic field of the photon in a time $t = \lambda/c$, where c is the speed of light. In the interaction, the material particle can be viewed as stationary compared to the speed of the photon. During the interaction, the photon transfers a tiny amount of energy $\delta(E)$ to the material particle. A coefficient $k = \delta(E)/E\lambda$ is defined here, denoting the rate of energy loss of the photon per unit length. The coefficient k is denoted conceptually at this stage. Further theoretical or experimental studies are needed to determine its value.

If a photon of size λ_0 and energy E when emitted meets N material particles in its path and transfers a part of its energy to the material particles, supposing all the material particles interact equally with the photon, a differential equation for the energy of the photon is obtained with coefficient k as follows:

$$\frac{dE}{dN} = -k\lambda_0 E. \tag{1}$$

The solution, from the condition $E = E_0$ when $N = 0$, is

$$E = \frac{E_0}{\exp(kN\lambda_0)} \tag{2}$$

The energy loss of the photon is $\Delta E = E_0 - E$. Thus, there is

$$\Delta E = E_0\left(1 - \frac{1}{\exp(kN\lambda_0)}\right). \tag{3}$$

The expression for the redshift is $Z = \frac{\lambda-\lambda_0}{\lambda_0}$. It can be written as $Z = \frac{\nu_0-\nu}{\nu} = \frac{E_0-E}{E}$. Then, it obtains,

$$Z = \frac{\Delta E}{E}. \tag{4}$$

From Eqs. (2)–(4),

$$Z = \exp(kN\lambda_0) - 1. \tag{5}$$

6.3 The gravitational redshift

The redshift described above is induced by the process of energy loss of photons. It can be called tired light redshift, referred to as "TR" thereafter. The cosmological redshift (CR) is not simply induced by a single effect. In addition to TR, the gravitational redshift (GR), that is, the redshift induced by the gravitational field of the source star, must be considered in the analysis and evaluation of CR.

The GR is different from TR in nature. It has no relation to the interaction of photons with material particles. So, Eq. (5) should have the form

$$Z = \exp\left(kN\lambda_0 + \lambda_g\right) - 1, \tag{6}$$

where λ_g denotes the part of the wavelength change induced by the gravitational effect. (GR equals GM/c^2R. Here, it is also expressed as λ_g/λ_0.) For simplicity, set $u = \lambda_g$. Eq. (6) is rewritten as,

$$Z = \exp\left(kN\lambda_0 + u\right) - 1. \tag{7}$$

Now, there are two expressions, Eqs. (5) and (7), for the cosmological redshift. Eq. (5), comparatively simpler, considers only the effect of TR, whereas Eq. (7) considers the effects of TR and GR.

7. Features of TLT and evidence: part I

7.1 Redshift vs. wavelength

A photon emitted from a star undergoes a continuous process of energy loss on its journey by interacting with material particles before it reaches an observer on Earth. It encounters material particles within the corresponding spaces of: (1) the atmosphere around the star, (2) the ISM in the galaxy the star belongs to, (3) the IGM, (4) the ISM of our galaxy, and (5) the atmosphere of the Earth. In the five parts, the IGM is the main one which CR is induced by. Although, the IGMs are sparsely distributed in the intergalactic space, the space is vast compared with the other spaces. Therefore, the tired light redshift (TR), the main part of the cosmological redshift (CR), is mainly induced by the interaction of photons with material particles of IGM. It may then be supposed that the photons of different wavelengths emitted from a certain source meet the same number of material particles in the intergalactic space along the line of sight of an observer on the Earth. Furthermore, roughly speaking, it may be supposed that the photons meet the same number of material particles on their entire journey from an emitter to an observer. So, N, the number of material particles the photons met can be considered as a constant. Thus, N can be included in the coefficient k, and Eq. (7) takes the form,

$$Z = \exp\left(k\lambda_0 + u\right) - 1. \tag{8}$$

The first-order approximation to Eq. (8) is

$$Z = k\lambda_0 + u. \tag{9}$$

Eq. (7) shows the characters that a larger λ_0 is related to a larger Z, and a larger N is related to a larger Z too.

7.2 Evidence for TLT

7.2.1 Early evidence

As early as 1929, Zwicky had noticed the relation between redshift and wavelength. "Some exceptions have been found, suggesting that $\Delta\nu/\nu$ for H_β is somewhat greater than for H_γ" [1]. Here, $\Delta\nu/\nu = \Delta\lambda/\lambda_0$ is the redshift, and the value of λ_0 for H_β is greater than that for H_γ. This is the earliest description for the relation between redshift and wavelength, whereby a longer wavelength is related to a larger redshift. Eq. (7) shows this character; a larger λ_0 is corresponding to a larger Z.

Wilson reported an observational result for the Seyfert galaxy NGC4151 [12]. He noticed a "slight apparent trend of velocity with wavelength." In that study, redshift is interpreted in terms of the Doppler effect and expressed as a recession velocity, that is, $V = cZ$. Then, from Eq. (9),

$$V = k'\lambda_0 + u'. \tag{10}$$

The fitting result for the relation between the velocity V and wavelength λ_0 to Eq. (10) in Eq. (2) is,

$$V = 0.003959\lambda_0 + 948.09. \tag{11}$$

Comparatively, the mean radial velocity obtained by Wilson is 967 km s^{-1}.

Espey et al. presented a set of data for redshifts in a range of about 1–3, of six emission lines from 18 quasars, with mean values of velocity for five lines relative to H_α [13]. The fitted result for the data is,

$$V_{relative\ to\ H_\alpha} = 0.21739\lambda_0 - 1275.8. \tag{12}$$

7.2.2 More evidence

Schmidt and Matthews presented observational results of emission lines for quasars 3C47 and 3C147. Seven lines were observed for 3C47 and five lines for 3C147 [14]. After necessary treatment for the data, relations between redshift Z and wavelength λ_0 have been fitted to Eq. (8) as follows [2]. For 3C47, the relation is,

$$Z = \exp\left(2.67 \times 10^{-7}\lambda_0 + 0.353\right) - 1. \tag{13}$$

For 3C147, the relation is,

$$Z = \exp\left(7.11 \times 10^{-7}\lambda_0 + 0.432\right) - 1. \tag{14}$$

Nishihara et al. presented redshifts of the emission lines H_α, H_β, OIII, M_gII, CIII, CIV, and OI for five quasars, Q1634 + 706, Q1630 + 377, Q0117 + 213, Q1011 + 250, and Q1331 + 170 [15]. The relations between redshift Z and wavelength λ_0 to Eq. (8) for each quasar in Eq. (2) are:

$$\text{For Q1634} + 706,\ Z = \exp\left(5.33 \times 10^{-7}\lambda_0 + 0.847\right) - 1, \tag{15}$$

$$\text{For Q1630} + 377,\ Z = \exp\left(6.41 \times 10^{-7}\lambda_0 + 0.904\right) - 1, \tag{16}$$

$$\text{For Q0117} + 213,\ Z = \exp\left(8.84 \times 10^{-7}\lambda_0 + 0.912\right) - 1, \tag{17}$$

$$\text{For Q1011} + 250,\ Z = \exp\left(3.64 \times 10^{-7}\lambda_0 + 0.968\right) - 1, \tag{18}$$

$$\text{For Q1331} + 170,\ Z = \exp\left(9.18 \times 10^{-7}\lambda_0 + 1.126\right) - 1. \tag{19}$$

7.2.3 The data of redshifts

In an ordinary redshift observation, usually some emission lines or absorption lines are detected. In most cases, the values of redshift of the lines are slightly different from each other. Early observers had published the original results. But afterwards, the deviations between the redshifts of the lines in most cases were moved out by averaging the values of redshift, the reason being that the redshifts for lines from a certain source should be the same according to the Big Bang model. Hence, all that is required is an average value. Subsequently, most observers gave only the average value of redshifts and did not mention the deviations, as if they do not exist, since they cannot be explained by Big Bang. But the difference between redshifts for lines from a certain source reveals a flaw in the Big Bang model. Nishihara et al. have remarked: "however, the physical mechanisms producing these velocity deviations are not well understood" [15].

The cosmological model of Big Bang is mainly inferred from the Doppler interpretation to CR following Hubble's lead. The main reason of Hubble used it is that the Doppler effect was the only interpretation for redshift at that time. Zwicky advanced an alternative, that is, the tired light hypothesis, which led to TLT (tired light theory) [1, 2]. TLT developed the tired light hypothesis on the foundations of physics, that is, electromagnetic field theory and the Lorentz force. It revealed the redshift-wavelength relation, substantiated by observational results as shown above.

8. Features of TLT and evidence: part II

8.1 Redshift vs. the number of material particles

For a given λ_0 included in the coefficient k, Eq. (7) becomes,

$$Z = \exp\left(kN + u\right) - 1, \tag{20}$$

showing the relation between redshift and the number of material particles a photon interacts with on its journey. If the material particles are assumed to be distributed evenly in intergalactic space or the other respective spaces, the redshift should be proportional to the distance of the photon's journey. Some redshift phenomena that cannot be explained by the Doppler effect can be explained by TLT.

The Limber effect of the Sun, the signal redshift of Pioneer 6, and the large redshift of quasars are the examples of some overt phenomena that cannot be explained by the Doppler effect. Eq. (11) explicitly shows the relation of the redshift to the number of material particles by which the three foregoing puzzles can be accounted for.

8.2 The limb effect (variation of redshift on the solar disc)

8.2.1 The Cosmos, Sun, Earth, and human beings

The Sun is a special star for human beings. It is the only star we can observe in detail since it is near the Earth. Actually, the Earth and we human beings and all the

living things on the Earth are entwined with the Sun. We are a part of the solar system. We belong to the solar system, which belongs to our galaxy, which in turn belongs to the Cosmos. We human beings are simply a particular form of matter in the Cosmos. We observe the Cosmos and try to understand it with our peculiar intelligence that is self-understanding of the Cosmos from a viewpoint of philosophical significance.

8.2.2 Limb effect

The limb effect is a phenomenon involving redshift on the solar disc, that is, the redshift changing from the center to the limb of the solar disc. On the edge of the solar disc, the redshift is larger than that near the center. Although the limb effect was discovered more than a century ago, it could not be adequately explained [3]. Assis discussed the limb effect and concluded that the tired light theory provides a satisfactory explanation. He suggested that the redshift was due to the interaction of light with the atmosphere of the Sun while passing through it [16].

TLT gives a clear explanation of the Limber effect—the largest redshift on the limb of the solar disc is due to the fact that the light emitted from the edge of the surface of the Sun encounters more material particles while traveling to Earth and therefore loses more energy than that from the inner part of the solar disc, since the atmosphere of the Sun at the edge of the solar disc has the deepest length along the line of sight of an observer on Earth [2].

Adam, as early as in 1948, observed the redshift on the solar disc and presented a set of 14 redshifted lines at seven positions on solar disc. The redshifts vary from the center to the limb [17]. In 1991, LoPresto et al. observed the infrared oxygen triplet absorption lines at seven positions on the solar disc along the limb effect [18].

According to Eq. (11), redshift is related to the number of material particles that the photons met on their journey. Considering the depth of the atmosphere of the Sun along the line of sight of an observer on the Earth, Shao showed that Adam's data fit Eq. (11). The redshift curve coincides with the data points satisfactorily. Similarly, the data from LoPresto et al. were found to fit Eq. (11) very well too [2].

8.3 The signal redshift of Pioneer 6

When Pioneer 6 on its orbit at the far side of the Sun was approaching the Sun in November 1968, the signal it sent to Earth gave an additional frequency shift, or redshifted. The shift changed day by day. The phenomena could not be well explained. Chastel and Heyvaerts introduced the frequency shift [19]. Merat et al. reported that the data "strongly favor the existence of a new redshift cause at work in the Sun's vicinity" [20].

The signal redshift of Pioneer 6 can be explained by TLT. Like the explanation to the limb effect of the Sun, the signal redshift of Pioneer 6 is due to the energy loss in the signal while traveling through the atmosphere of the Sun. The atmosphere of the Sun is at a certain depth around the Sun. While the signal path from Pioneer 6 to Earth was getting closer to the edge of the Sun, the signal passed through a longer distance, day by day, through the atmosphere of the Sun. Consequently, more energy was lost and so the stronger the redshift caused, day by day, until Pioneer 6 went behind the Sun.

8.4 The large redshift of the quasars

The large redshifts of the quasars are rather queer, as their nature is not clear. TLT may give some insight into the quasars. The quasars might have

much thicker and denser layers of atmosphere, that is, gaseous material particles, compared to normal stars. On this assumption, TLT provides a possible explanation for the large redshifts of the quasars. The main part of CR is TR, which is induced by the interaction of photons with material particles. The greater the number of material particles that the photons encounter the larger the redshift that should result. The light emitted from a quasar has to penetrate through the dense and thick layer of atmosphere around it, so that the light is redshifted much more than that from a normal star at the same distance from Earth. Thus, the quasars do not need to be located so far away as the Doppler effect interpretation of redshift supposes.

9. Considerations about the problems related to Big Bang

9.1 The problems of Big Bang

Hubble's work had led to the Big Bang model by using the Doppler effect to interpret the cosmological redshift. Of the two possible alternatives to Hubble for the observed redshift, either employing the Doppler interpretation or giving no interpretation, Hubble selected the former, to some extent beyond the traditional usage of the Doppler effect. In so doing, Hubble had triggered the Big Bang, although he harbored doubts as to its legitimacy. In 1937, he remarked: "thus the familiar interpretation of redshift as velocity shifts leads to strange and dubious conclusions." In contrast, as to the tired light interpretation for redshift, Hubble remarked, "while the unknown, alternative interpretation leads to conclusions that seem plausible and even familiar" [21].

Because the Big Bang is rooted in the Doppler interpretation for cosmological redshift, many problems are produced thereof, puzzling cosmologists to this day. These problems are insoluble by Big Bang cosmology because they are largely characteristic of the Doppler effect, from which researchers cannot exculpate themselves. Among the problems loom the super velocity problem, the horizon effect, and most importantly, the problem of the beginning of the Cosmos. There are other problems also related to the cosmological model of Big Bang, famously the cosmic microwave background radiation (CMBR) and the old paradox of Olbers. Comparatively, all these problems do not arise in the tired light theory (TLT).

9.2 Super velocity

The super velocity problem is the direct consequence of invoking the Doppler interpretation of cosmological redshift to obtain $V = H_0 D$. Recalling history, Hubble and Humason had adduced a distance-redshift relation (DRR) through observations. Following traditional lines, Hubble transformed DRR to a distance-velocity relation (DVR) by replacing redshift with velocity, from which it has been concluded that the galaxies are moving away from the Milky Way. Hubble accepted the idea of runaway galaxies as a fact. But is it really a fact? The answer must be "no." The supposed "fact" simply lends support to the Big Bang model, hence its raison d'être. In the treatment from DRR to DVR, there is no physical meaningful content about the nature of matter at all. Zwicky, therefore, objected and proposed his "tired light" hypothesis, which, afterwards, Hubble said is "plausible" and "familiar."

Zwicky's hypothesis has not been accepted by most astronomers and cosmologists because it is vague on physical meaning. But things are changing. It is

especially important at present because more and more people have realized the problems related to Big Bang entanglement. After 84 years, the tired light hypothesis has been reset in accord with the foundations of physical principles [2]. The basic principles that TLT is based on are: (a) electromagnetic field theory, (b) the matter-energy equivalence, (c) the quantum theory of light, and (d) the Lorentz theory. According to TLT, since redshift is produced by energy transfer from photons to material particles, it concludes that there is no systematic motion of galaxies on large scale of the Cosmos. Hence, there is no super velocity problem. The Cosmos is boundless and timeless.

9.3 Horizon problem

The horizon problem (also known as the homogeneity problem) is a characteristic problem of the Big Bang model. It arises from the homogeneity of regions in the Cosmos, which cannot be explained by the Big Bang model. According to Big Bang, the history of the Cosmos is finite, and in a finite time, the Cosmos could not evolve to the present homogeneity. Because the Big Bang model is based on the Doppler interpretation for cosmological redshift, the problem is, then, inherited from the Doppler interpretation. If the Doppler interpretation of cosmological redshift is abandoned, the problem disappears. The cosmological model based on TLT does not produce the problem. Based on TLT, the Cosmos is infinite and eternal, so that the homogeneity of the Cosmos is natural.

9.4 The age of the Cosmos

The age of the Cosmos is another feature of the Big Bang model, again due to the Doppler interpretation of redshift. By using the Doppler effect for redshift, Hubble obtained the relation $V = H_0 D$. Since H_0, the Hubble constant, has the dimension v/d, then $1/H_0 = S$. Thus, S has been labeled the age of the Cosmos. But Hubble took the wrong direction when he interpreted the cosmological redshift by the Doppler effect. Everything derived from this wrong direction is also wrong. In the Big Bang model of the Cosmos, the cause is the result, and the result is the cause. Actually, the Doppler effect used in the interpretation of cosmological redshift and the Big Bang model describe the same thing, that is, recession of the celestial objects being observed. There is, between the two, nothing related to the material nature or physical process except kinematics. The TLT model of the Cosmos does not possess this problem.

9.5 The cosmic microwave background radiation (CMBR)

The CMBR was discovered in the 1960s, and it has been thought to be proof of the Big Bang. Just as Hubble had used the Doppler effect to interpret the redshift in the relation of redshift-distance because he had no alternative choice at his disposal, proponents of CMBR had no other explanation for it except Big Bang, at the time of the discovery. Now, the situation has changed. TLT interprets the redshift on a profound basis of physical principles and, at the same time, gives a plausible explanation for CMBR. The CMBR is tired light in the microwave band. The photons from all directions emitted by the faraway sources are redshifted after a long journey. Photons then, from all the other galaxies in the background of the Cosmos, around the Earth, theoretically around the Milky Way, have been redshifted to form the CMBR. Tired light does not only form CMBR, but it also forms CRBR (cosmological radio background radiation) [4].

9.6 Olbers' paradox

Olbers' paradox is a historical problem as old as natural science itself, that is, from the time of the ancient Greeks. Olbers described the paradox in 1823. After the Big Bang became a popular cosmological model, Olbers' paradox was explained by Big Bang because the history of the Cosmos was finite. But if Big Bang is not assured, then the explanation by it is not reliable. A new explanation could be given by the principle of TLT. By TLT, light from the stars in faraway galaxies should be redshifted such that visible light would be lengthened outside the waveband of visible light, then the night sky should be dark. As mentioned above, visible light has been redshifted into CMBR and CRBR. Since the energy lost by photons is transferred to material particles, the Cosmos may not be heavily heated. Material particles that have gained the energy have more ability to form new stars and galaxies.

10. Some thoughts on cosmology

Zwicky first proposed TLT because application of the Doppler effect to interpret cosmological redshift leads to a strange idea, that is, Big Bang. The etiology of the logical reasoning of TLT presented here is also uncomfortable feelings by the dizzy image of Big Bang.

We human beings have been living on the Earth for several million years. Our system of knowledge began in the Neolithic Age, not more than 10,000 years. The beginning of the sciences dates back to the age of ancient Greeks, about 2500 years ago. The beginning of modern sciences is marked by the work of Copernicus, not more than 500 years ago. As a branch of modern science, the history of modern cosmology is not more than 100 years. But the history of the knowledge of the Cosmos is as old as the beginning of science. On the one hand, cosmology is old since it began from and needs only reasoning on the whole nature. On the other hand, it is young because the detailed and elaborate observation methods and technology for the study of the Cosmos emerged at the start of the twentieth century. Thus, paradoxically, cosmology is the oldest and also the youngest branch of science.

Big Bang cosmology is only the beginning of modern cosmology. The tired light theory described herein, began with Zwicky's hypothesis, has been reset on the basis of physical principles. It may be the next forward step of modern cosmology.

11. Conclusions

The tired light theory, proposed by Zwicky in 1929 and recently developed by Shao in 2013, explains the cosmological redshift as the result of energy loss of photons due to the interactions with material particles as photons travel through cosmological space. A differential equation is established through the analysis of a photon's energy loss based on the mass-energy equivalence and the Lorentz theory. A redshift expression is achieved by expanding the solution of the equation. The redshift expression shows that the redshift is related to the wavelength of light and the number of material particles that photons interact with on their traveling journey in the cosmological space. The relationship of redshift to wavelength of light is in accordance with the observational data in the cited literatures. And the relationship of redshift to the number of material particles that interact with photons explains the limb effect of the Sun, the signal redshift of Pioneer 6, and the large redshifts of quasars. The cosmological model based on the tired light theory gets rid

of the problems that are related to Big Bang, that is, the super velocity problem, the horizon effect, and the problem of the beginning of the Cosmos. Moreover, the model explains the cosmic microwave background radiation as a natural result of the tired light effect, and therefore, Olbers' paradox is disappeared. Based on the tired light theory and together from the cosmological principle, the Cosmos is infinite and eternal.

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