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The Origin of Cosmic Microwave Background Radiation

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Abstract

This paper explains the Olbers paradox and the origin of cosmic microwave background radiation (CMBR) from the viewpoint of the quantum redshift effect. The derived formula dispels the Olbers paradox, confirming that the CMBR originates from the superposition of light radiated by stars in the whole universe, not the relic of the Big Bang. The dark-night sky and CMBR are all caused by Hubble redshift—the physical mechanism is the quantum redshift of the photon rather than cosmic expansion. So this theory supports the infinite and steady cosmology.

Keywords

Olbers Paradox, Cosmic Microwave Background Radiation (CMBR), Big Bang Theory, Hubble Redshift, Quantum Redshift Effect of Photon, Stefan-Boltzmann Law, Blackbody Radiation

1. Introduction

Long before the Big Bang theory, the mystery of the luminosity of the night sky appeared, that is, why the night sky is dark instead of bright. After a long debate among many astronomers, in 1826, H. Wilhelm M. Olbers summed it up as the luminosity paradox called the Olbers paradox later by the astronomical community. Historically, there have been explanations for solving this paradox, such as Olbers' belief that cosmic space dust obscures the light of distant stars. The flaw in this explanation is that dust absorption, so where does that light energy go? Moreover, dust not only absorption but also confuses the sky, making it no longer transparent. It still does not explain the paradox. In these explanations, the mainstream is the Big Bang theory. The Big Bang theory states that the universe is expanding and the lifespan of stars is finite.

In the 1920s, Edwin Hubble discovered the spectral redshift of extra-galactic galaxies, which provided observational evidence for solving the Olbers paradox. However, to establish the Big Bang theory, the Big Bang cosmologists explained the Hubble redshift as the Doppler effect produced by the light emitted by the stars when the extra-galactic galaxies are far away from the Earth and regarded Hubble redshift as evidence of the expansion of the universe.

The non-Big Bang theory has proposed many explanations for Hubble redshift, among which more famous ones are the tired-light theory, Compton scattering redshift theory, photon aging theory, elementary particle mass change theory, intrinsic redshift theory, gravitational redshift theory, new tired-light theory, and so on. These theories all have a similar problem using hypothesis to explain redshift. For example, the tired-light—Compton scattering—new tired-light does not solve the problem of the direction change of light during scattering. The photon aging theory violates the existing laws of physics—the lifespan of a photon is infinite. The elementary particle mass change—intrinsic redshift cannot find a theoretical and experimental basis for physics. Gravitational redshift theory can explain the redshift phenomenon that occurs when photons escape the gravitational pull of massive objects, but it cannot explain cosmological redshift. Therefore, the previous non-Big Bang theory failed to explain the physical mechanism of the origin of redshift.

Arno Penzias and R. W. Wilson discovered CMBR in 1965. This discovery should have been the evidence to solve the Olbers paradox and Hubble redshift. However, the Big Bang theorists took it as a relic of the Big Bang.

The non-Big Bang theory has made a variety of explanations for CMBR, the more typical of which is the cosmic dust occlusion theory. The thermodynamic theory believes that the light emitted by stars in the entire universe is absorbed and scattered by the dust of the interstellar and intergalactic medium during propagation so that the radiation and the medium reach thermodynamic equilibrium, and Planck blackbody radiation occurs in the medium, which is the CMBR. Opponents argue that if the stellar radiation and the medium reach thermodynamic equilibrium, the temperature of the medium will rise to the temperature of the star's surface. Thus, the thermodynamic interpretation leads to another new paradox similar to Olbers'. The problem with this interpretation is that it treats CMBR as the black body radiation of the medium and does not use the redshift effect of photons to explain how the visible light of stars converts into microwaves.

The previous non-Big Bang theory did not correctly explain the Olbers paradox, Hubble redshift, and CMBR, thus allowing the Big Bang theory to dominate the interpretation of these three phenomena.

So, what is the relationship between the three physical phenomena—Olbers paradox, Hubble redshift, and CMBR? How exactly do Olbers paradox and CMBR come about? Can they be explained by applying the quantum redshift effect of photons?

2. Derivation of Olbers Paradox

In 1826, German astronomer H.W.M. Olbers pointed out that a static infinite universe model with uniformly distributed stars would draw the following conclusion: the background radiant emittance of all parts of the universe is equal to the emittance of the star's surface. But the night sky is dark. This contradiction between theory and observation is called Olbers paradox by later generations [1].

2.1. The First Type of Expression

According to the cosmological principle, the universe is uniform and isotropic on a large scale in space. Assuming that if the universe is infinite, the luminous stars uniformly distribute in the universe, and the number of stars in the unit volume of the universe is certain. Suppose that the number density of luminous stars (actually, it is not uniform, but understand it as the mean density) is n_L, and the radiant power of all the luminous stars in the universe is the same (can understand it as the mean radiant power), and suppose that the value is P_0, then the irradiance on the plane at the arbitrarily selected point O of all stars in the universe with radius R is

$$I = \int_0^{2\pi}\int_0^{\frac{\pi}{2}}\int_0^{R}\frac{P_0}{4\pi r^2}n_L r^2 \sin\theta\cos\theta \mathrm{d}r\mathrm{d}\theta\mathrm{d}\varphi \tag{1-a}$$

$$= \frac{P_0}{4\pi}n_L R\int_0^{2\pi}\int_0^{\frac{\pi}{2}}\sin\theta\cos\theta\mathrm{d}\theta\mathrm{d}\varphi \tag{1-b}$$

$$= \frac{P_0}{4\pi}n_L R\cdot\frac{1}{2}\int_0^{2\pi}\mathrm{d}\varphi \tag{1-c}$$

$$= \frac{1}{4}n_L P_0 R \tag{1-d}$$

Here r, θ, and φ are shown in Figure 1.

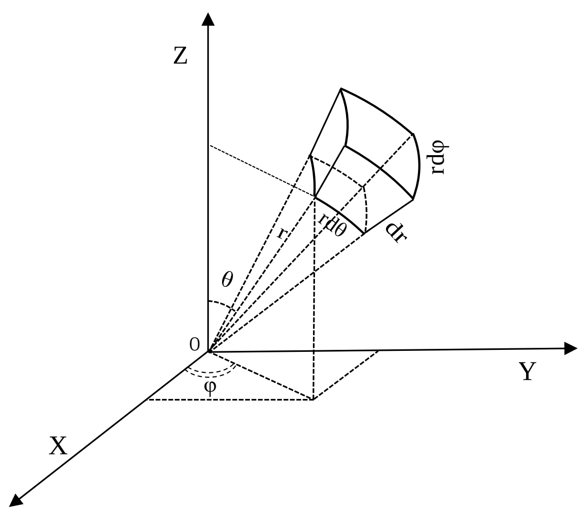

Figure 1. This diagram shows the integral calculation of the irradiance on the plane OXY from stars in the upper half of space.

If the radius of the universe is infinite, that is, $R=\infty$, then the result of the above integral is infinite, that is

$$I=\lim_{r\to\infty}\left(\frac{1}{4}n_L P_0 R\right)=\infty \tag{1-e}$$

This result means that the irradiance anywhere in space is infinite. Therefore, under the condition that the universe is infinite, the calculated value of irradiance does not conform to reality. In the 16th century, Thomas Digges, a British astronomer, first proposed this paradox.

As for this paradox, Diggs thought the above statement was inaccurate and gave a new explanation. He believed that the night sky is dark because nearby stars block the light of distant stars. J. Kepler and E. Halley also pondered this question, but neither gave a satisfactory answer.

2.2. The Second Type of Expression

According to the cosmological principle, assume that the universe is infinite and cosmic matter uniformly distributes. Suppose that the mean density of luminous stars is n_L; The total number density of the stars (including luminous and non-luminous) is n_s. Each luminous star has the same radiant power, P_0. (The above assumptions can interpret as statistical averages). With the radius R and the arbitrarily selected point O as the center of the sphere, the irradiance on the plane at point O is different from that described in Equation (1) because stars close to the observer block the light radiated by distant stars.

A star is usually a sphere, so its luminous area is spherical. If the radius of a star's sphere is r_0, the spherical area is S_L. As the nearby stars block the light of the distant stars, the blocking area is the largest cross-sectional area of the sphere, S_0, so the two expressions are as follows

$$\begin{cases} S_L=4\pi r_0^2 & (2\text{-}1)\\ S_0=\pi r_0^2 & (2\text{-}2)\end{cases}$$

Let the surface radiant emittance of the star,that is, the radiant power per unit area of a luminous star, be R_e, and the radiant power of the star is given by

$$P_0=S_L R_e=4\pi r_0^2 R_e \tag{3}$$

If distant stars emit N_0 photons, the number of photons, N, varies in the propagation abiding by the following equation:

$$\begin{cases} \dfrac{\mathrm{d}N}{\mathrm{d}t}+cn_s S_0 N=0 & (4)\\ N_{t=0}=N_0 & (5)\end{cases}$$

The solution is given by

$$N=N_0\mathrm{e}^{-cn_s S_0 t}=N_0\mathrm{e}^{-n_s S_0 r} \tag{6}$$

where c is the speed of light, t is the time for light to travel on the way, and $r=ct$ is the distance the light travels. Equation (6) shows that the photon number N attenuates negatively exponentially with propagation time t or distance *r*.

The irradiance passing through the unit area at any point O in the universe is

$$I = \int_0^{2\pi}\int_0^{\frac{\pi}{2}}\int_0^{R} \frac{P_0}{4\pi r^2} \mathrm{e}^{-n_s S_0 r} n_L r^2 \sin\theta\cos\theta \mathrm{d}r\mathrm{d}\theta\mathrm{d}\varphi \tag{7-a}$$

$$= \frac{n_L P_0}{4}\int_0^{R} \mathrm{e}^{-n_s S_0 r}\mathrm{d}r \tag{7-b}$$

$$= \frac{n_L P_0}{4 n_s S_0}\left(1-\mathrm{e}^{-n_s S_0 R}\right) \tag{7-c}$$

This formula shows that if the universe is infinite, $R \to \infty$, then $\lim\limits_{R\to\infty} \mathrm{e}^{-n_s S_0 R} = 0$. Applying Equations (2-1) (2-2) and (3), the above formula becomes

$$I = \frac{n_L P_0}{4 n_s S_0} = \frac{n_L}{n_s} R_e \tag{8}$$

where n_L/n_s is the ratio of the number density of luminous stars to the total number density of stars. Because there are always stars that don't emit light or are dim, that is $n_L/n_s \le 1$. Suppose that $n_L = n_s$, then $n_L/n_s = 1$, the Equation (8) becomes

$$I = R_e \tag{9}$$

Equation (9) means: For whatever direction we look in the sky, our line of sight eventually intercepts a star, and the whole sky should therefore be ablaze with light as bright as the Sun [2]. But the sky at night is dark. This disagreement between theoretical inference and observation is now called the Olbers paradox.

Although known that stars do not uniformly distribute in space, from the Mach principle, if galaxies or galaxy clusters replace stars, this conclusion can remain unchanged.

The two expressions of the Olbers paradox imply that: 1) If the universe is infinite, without considering the light blocking of the stars, the irradiance anywhere in the universe is infinite; 2) If the universe is infinite, with considering the light blocking of the stars, the irradiance anywhere in the universe does not exceed the radiant emittance of the surface of the stars.

In both cases, the light energy absorbed by the stars' surface balances with the light energy radiated. Either way of expression is unrealistic since the night sky is dark. The problem is to find out what is wrong with these logical calculations.

3. The Resolution to Olbers Paradox

3.1. Debates about the Olbers Paradox in History

In history, there has been a long-term debate on the Olbers paradox. Many explanations emerged. Now, summarizing them can get four controversial conclusions [2] [3]:

1) Stars don't shine long enough: Stars don't shine long enough, so the light from distant stars is still on the way to the Earth, and the observers on the Earth can only receive the light from stars in a finite range. (It implies that the night

sky will brighten as time goes on.)

2) The universe is expanding: Because the universe is expanding and the stars are moving away from the Earth, the Doppler effect causes the photon to redshift, which reduces the frequency of light and makes part of the light observable by the human eye invisible.

3) The light energy density of stars is too scarce: The total energy density of light radiated by stars in the observable range (due to the product $n_L P_0$) is too little to reach the irradiance perceived by human eyes.

4) There is a medium in space: Space is not an absolute vacuum, but a medium exists which can absorb and block light.

In the above four conclusions, in the author's opinion, point 1) involves the theory of the finite universe, and point 2) involves the theory of the expanding universe. The two points have low reliability. Point 3) is flawed but does not involve whether the universe is finite. Point 4) indicates that there is a medium in space, and there is no doubt that the medium can absorb and block light.

All the existing explanations of the Olbers paradox can only explain one phenomenon, and there are loopholes, mainly because they are not coherent theories.

3.2. A New Explanation of the Olbers Paradox

This paper accepts the two points: 3) and 4) in 3.1. The following explains the Olbers paradox mathematically.

On the one hand, due to the block of stars, the number of photons attenuates negatively exponentially with distance. Equation (6) expresses this relation. On the other hand, as pointed out in the paper "*The Quantum Redshift Effect of Photon*" [4], due to the existence of a medium in intergalactic space, the main component of the medium is atomic hydrogen. When photons propagate in the medium, the quantum redshift effect occurs, and the frequency of each photon attenuates negatively exponentially with the propagation time t or distance r. The following formula can express this relation:

$$\nu = \nu_0 \mathrm{e}^{-H_0 t} = \nu_0 \mathrm{e}^{-\frac{H_0}{c} r} \tag{10}$$

The wavelength increases exponentially with the propagation time t or distance r. The following formula can express this relation:

$$\lambda = \lambda_0 \mathrm{e}^{H_0 t} = \lambda_0 \mathrm{e}^{\frac{H_0}{c} r} \tag{11}$$

So, a beam of light with energy E_0 emitted from the stars, its energy E attenuates in a negatively exponential law with the propagation distance r. When it reaches the observer, it becomes

$$E = E_0 \mathrm{e}^{-\left(n_s S_0 + \frac{H_0}{c}\right) r} \tag{12}$$

If the universe is infinite, the energy limit above is given by

$$E_\infty = E_0 \lim_{r \to \infty} \mathrm{e}^{-\left(n_s S_0 + \frac{H_0}{c}\right) r} = 0 \tag{13}$$

Thus, as the propagation distance increases, the number of photons decreases and finally tends to zero, as stars continuously block photons. At the same time, the frequency of photons gradually decreases and eventually equals zero. Both work at the same time. When the propagation distance of a beam of light tends to infinity, its light energy tends to zero. It means that space gradually converts to a black body from a transparent body. Therefore, the infinite universe is a three-dimensional blackbody, which differs from the familiar surface blackbody.

It is speculated from Equation (12) that the irradiance at any point in the space of the universe changes from Equation (1) to

$$I = \int_0^{2\pi}\int_0^{\frac{\pi}{2}}\int_0^R \frac{P_0}{4\pi r^2} \mathrm{e}^{-\left(n_s S_0+\frac{H_0}{c}\right)r} n_L r^2 \sin\theta\cos\theta \mathrm{d}r\mathrm{d}\theta\mathrm{d}\varphi \tag{14-a}$$

$$= \frac{n_L P_0}{4\left(n_s S_0 + \frac{H_0}{c}\right)}\left[1-\mathrm{e}^{-\left(n_s S_0+\frac{H_0}{c}\right)R}\right] \tag{14-b}$$

The derivation of Equations (14-a) and (14-b) implies that if the distance traveled by light in space is small enough, that is, $R \ll 1\Big/\left(n_s S_0 + \frac{H_0}{c}\right)$, there is $\mathrm{e}^{-\left(n_s S_0+\frac{H_0}{c}\right)R} \approx 1-\left(n_s S_0 + \frac{H_0}{c}\right)R$. Thus

$$I \approx \frac{1}{4} n_L P_0 R \tag{15}$$

It is the same as (1-d). It suggests that light travels through space at a distance short enough to see space as a transparent body and that the blocking effect of stars and media does not work. In other words, if the universe is finite, the space can regard as a three-dimensional transparency body.

Equation (14-b) means that no matter whether the universe is finite or infinite, the irradiance of any point in space cannot be infinite. Assuming that the universe is infinite, then $R \to \infty$ in Equation (14-b), thus $\lim_{R\to\infty} \mathrm{e}^{-\left(n_s S_0+\frac{H_0}{c}\right)R} = 0$, and Equation (14-b) becomes

$$I = I_{\max} = \frac{n_L P_0}{4\left(n_s S_0 + \frac{H_0}{c}\right)} = \frac{c n_L P_0}{4\left(c n_s S_0 + H_0\right)} \tag{16}$$

It means that if the universe is infinite, the irradiance of any point in space is finite. In other words, the irradiance of starlight on the ground is not infinitive.

Equation (16) means that if there is no factor H_0/c, or if there is no redshift effect, only the light-blocking of the stars exists, then Equation (16) returns to Equation (8). Equation (8) shows that if there is no medium in space, the irradiance of any point is close to the radiant emittance of the star's surface.

Comparing Equation (16) with (1-d) can see that $c\big/\left(H_0 + c n_0 S_0\right)$ in Equation (16) plays the role of "cosmic radius" R in Equation (1-d).

Ignoring $c n_s S_0$ in Equation (16), the factor c/H_0 acts as the radius of the universe. It is the so-called Hubble Radius, which is finite.

According to the paper *the Quantum Redshift Effect of Photon* [4], the Hubble constant should take as

$$H_0 = \frac{3\pi}{8\alpha} c\sigma_T n_e \tag{17-a}$$

$$= 2.27\times10^{-18}/\text{s} = 70\ \text{km/s}\cdot\text{Mpc} \tag{17-b}$$

where α is the fine structure constant, $\sigma_T = 8\pi r_e^2/3$ is the Thomson scattering cross-sectional area of the electron, and $n_e \approx 0.7/\text{m}^3$ is the electron density bound in the atom in the intergalactic medium.

According to reference [5] and **Table 1**, if the mean light-blocking radius of the star is $r_0 = 4.0\times10^8\ \text{m}$, take the approximation $n_s \approx n_L$, then the light-blocking area of a star is given by

$$S_0 = \pi r_0^2 = 5.03\times10^{17}\ \text{m}^2 \tag{18}$$

Hence

$$cn_s S_0 \approx cn_L S_0 = 3\times10^8\ \text{m/s}\times 2.17\times10^{-58}/\text{m}^3\times 5.03\times10^{17}/\text{m}^2 \tag{19-a}$$

$$= 3.27\times10^{-32}/\text{s} \tag{19-b}$$

Comparing the two factors in Equation (17) and Equation (19) in the denominator of Equation (16) can obtain a relationship

$$cn_s S_0/H_0 = \left(3.27\times10^{-32}\right)/\left(2.27\times10^{-18}\right) = 1.44\times10^{-14} \tag{20}$$

Because $cn_s S_0 \ll H_0$ in the denominator in Equation (16), $cn_s S_0$ is negligible. So Equation (16) becomes

$$I = I_{\max} = \frac{cn_L P_0}{4H_0} \tag{21}$$

This formula shows that the irradiance at any point in the universe is finite, and the value is inversely proportional to the Hubble constant.

Equations (8) and (9) show that stars in the universe emit enough light to make any point as bright as the surface of the Sun. However, according to Equation (21), the irradiance at any point in the universe is little. Moreover, from Equation (20) can know that $cn_s S_0/H_0 = 1.44\times10^{-14}$ so that $I \ll R_e$, that is, the irradiance of the night sky is 14 orders of magnitude lower than the radiant emittance of the star's surface. By comparing Equations (21) and (8) can know in the two factors of the star's light-blocking effect and the redshift effect, the former is negligible while the latter plays a dominant role. The redshift is the main reason why the night sky is so dark.

Even if the universe is infinite, due to the redshift effect of photons propagating in the medium of the universe, the irradiance of light radiated by all stars in the whole universe is very dim at any point, so the Olbers paradox does not exist. The infinite universe becomes a three-dimensional black body.

Table 1. Cosmic stellar parameters.

The radiant power of a star	$\bar{P}_0 = 6.35 \times 10^{26}$ W
The number density of stars	$\bar{n}_L = 2.17 \times 10^{-58}/\text{m}^3$
The light-blocking radius of a star	$\bar{r}_0 = 4 \times 10^8$ m
The radiant emittance of the star's surface	$\bar{R}_e = 3.16 \times 10^8\ \text{W/m}^2$
The temperature of the star's surface	$\bar{T}_0 = 8640$ K

4. The Origin of CMBR

4.1. Discovery and Explanation of CMBR

In 1964, engineers A.A. Penzias and R.W. Wilson of Bell Laboratory stumbled upon the presence of microwave radiation with a wavelength of 7.35 cm in space during an experiment to test the noise performance of the antenna and that the radiation is isotropic. This radiation has neither diurnal nor seasonal changes. This additional radiation is the CMBR, which corresponds to the black body radiation of about 3 K in space. They published this result in 1965 [6]. CMBR is one of the significant discoveries in astrophysics in the 1960s.

In history, astronomers have long predicted the temperature of interstellar space and intergalactic space [7]. As early as 1926, astronomer A.S. Eddington predicted 3.2 K; In 1933, E. Regener predicted 2.8 K; In 1937, W. Ernst predicted 2.8 K; In 1941, Stephen G. Brush estimated 2.3 K; in 1954, E. Finlay Freundlich predicted a temperature of $1.9\ \text{K} \le T \le 6.0\ \text{K}$. These numerical predictions of temperature did not base on the Big Bang. The temperatures predicted by these non-Big Bang theorists are close to the currently recognized value of 2.725 K.

In 1948, George Gamow put forward the Big Bang theory. The theory points out that the Big Bang sent out intense light at the moment, but at the beginning of the Big Bang, the whole universe was hot and dense, just like the core of a star, and the universe was opaque to electromagnetic waves. The temperature dropped to 3100 K about 380,000 years after the Big Bang. The electrons and atomic nuclei began to combine to form atoms. Then atoms repeatedly scattered the photons. This period, known as final scattering, was long before the formation of galaxies (the formation of galaxies was about 1 billion years after the explosion). Because galaxies have not yet formed, the universe is a homogeneous and highly bright cluster. During this period, the intense light radiation made the whole universe bright. The light radiation during the "final scattering" period has been redshifted due to the expanding of the universe, and these ancient light waves have now been redshifted to the microwave wavelength range. They are no longer visible light and cannot illuminate the night sky. The redshift effect not only converts light waves during "final scattering" into microwave background radiation but also shifts all spectral lines propagating from distant galaxies to Earth toward the lower-frequency, enhancing the effect of night dark.

Since the standard model of the universe created in the Big Bang theory has become mainstream, the theorists naturally connect the discovery by A.A. Penzias and R. W. Wilson to Gamow's hypothesis. The 3K microwave background radiation became evidence of the Big Bang.

Several Big Bang theorists have predicted the temperature of space [7]. In 1949, Ralph A. Alpher and Robert C. Herman predicted $T \geq 5\text{ K}$. In 1953, G. Gamow predicted 7 K; In 1961, G. Gamow predicted 50 K. The predicted data of Big Bang theorists vary widely, proving that Big Bang predictions are far less accurate than those of non-Big Bang theories.

As for the CMBR, though Big Bang theorists can't predict its exact value, they certainly need it as evidence for the Big Bang.

4.2. A Unified Explanation of Three Phenomena

Leaving aside the Big Bang theory explanation of CMBR, this section unifies the Hubble redshift (the law of attenuation of photon frequencies) and the CMBR phenomenon in the infinite and steady-state universe.

Equation (21) represents the superposition of the light radiated by stars on the plane of any point after redshift. The selected point, whether it is the vacuum or the location of the medium, is unnecessary to be the surface of the black body.

That is to say, the radiation at any point is not the sudden transformation of the light emitted by the star through the surface of the black body, but because the light of stars is originally blackbody radiation, which has conformed to the Planck blackbody radiation formula. On the way of propagation, the frequency of each photon attenuates and shifts to the band of microwave frequency. Therefore, CMBR must be black body radiation.

Universe space is almost close to a vacuum, and there is no temperature. To describe the temperature of molecular motion can find the wavelength corresponding to the peak intensity of blackbody radiation. Applying this wavelength can calculate the temperature of molecular motion in space according to the Stefan-Boltzmann formula. Thus, the radiation emitted at any point in space equals the radiation received by this point. Both conform to the blackbody radiation spectrum and obey the Planck blackbody radiation formula, which differential form is given by

$$\rho_{\lambda'} \mathrm{d}\lambda' = \frac{8\pi}{c^3 \lambda'^5} \frac{h}{\mathrm{e}^{\frac{hc}{\lambda' k T'}} - 1} \mathrm{d}\lambda' \tag{22}$$

Since the irradiance is the superposition of photons of various wavelengths, as the wavelength of each photon increases according to Equation (11), the wavelength corresponding to the peak also increases. According to Wien's law of displacement

$$\lambda'_m T' = \lambda_m T \tag{23}$$

redshift lowers the temperature of the radiant emittance in space. Here an increase in λ'_m means a decrease in T'. The radiation temperature T' here plays the role of space temperature in the universe, corresponding to the wavelength of the peak of radiant emittance, λ'_m.

Here T' may be misinterpreted as the thermal radiation temperature of the thermal motion of molecules when the medium of space reaches thermal equilibrium with radiation. In fact that it represents the superposition of the radiation of all celestial bodies in the universe at the investigation point. It is not molecular thermal radiation in space, so the temperature T' does not represent the intensity of the thermal movement of molecules. Therefore, no matter how long the exposure time is, the temperature at the investigation point will not rise.

The radiant emittance on a plane at any point in space is given by

$$R_e' = \frac{c}{4}\int_0^\infty \rho_{\nu'} \mathrm{d}\nu' = \int_0^\infty \frac{2\pi}{c^2}\frac{h\nu'^3}{\mathrm{e}^{\frac{h\nu'}{kT}}-1}\mathrm{d}\nu' \tag{24}$$

where h is Planck constant , $k = 1.380649\times10^{-23}\ \mathrm{J/K}$ is the Boltzmann constant.

The result of the integral above is the Stefan-Boltzmann law of blackbody radiation

$$R_e' = \sigma T'^4 \tag{25}$$

where σ is the Stefan-Boltzmann constant, whose value is given by

$$\sigma = \frac{2\pi^5 k^4}{15c^2h^3} = 5.67\times10^{-8}\ \mathrm{W/m^2\cdot K^4} \tag{26}$$

The point arbitrarily selected in space is not a luminous body or a blackbody surface, so this point does not produce radiation. Its radiation is from a superposition of that emitted by luminous celestial bodies throughout the universe.

As shown in **Figure 2**, a plane at the location of an arbitrarily selected point O in space, and the radiant emittance of this point towards the upper half-space angle 2π range is equal to the irradiance from the lower half-space angle 2π range.

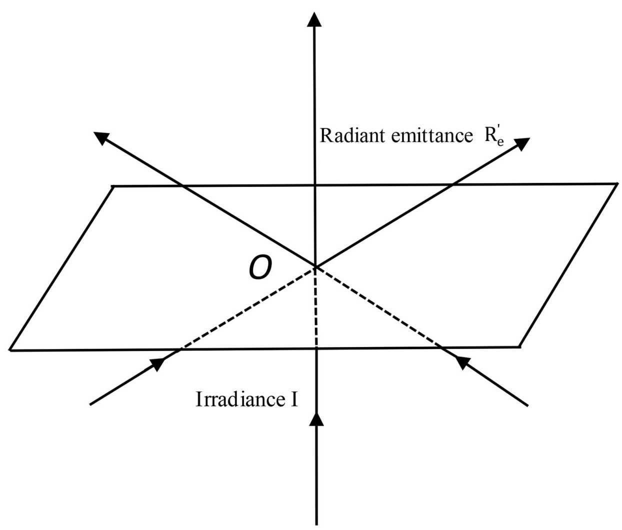

Figure 2. At an arbitrarily selected point O in cosmic space, the radiant emittance toward the upper half-space of the plane at point O is equal to the irradiance of all luminous objects from the lower half-space of this plane.

Vice versa, the emittance towards the lower half-space angle 2π equals the irradiance from the upper half-space angle 2π. (As shown in **Figure 2**, reverse the direction of the arrow. Illustration omitted.)

It implies that R_e' in Equation (25) equals I in Equation (21), *i.e.*, $R_e' = I$. Combining (21) and (25) can obtain

$$R_e' = I = \frac{cn_L P_0}{4H_0} = \sigma T'^4 \tag{27}$$

Solving it can obtain

$$T' = \left(\frac{cn_L P_0}{4\sigma H_0}\right)^{\frac{1}{4}} \tag{28}$$

Applying Equation (28) can find the temperature T' corresponding to the CMBR under the known conditions n_L, P_0, and H_0.It implies that as long as the parameters n_L, P_0, and H_0 are stable, the temperature T' at any point in space will not change with time.

The radiant power P_0 of a star can express as the product of the radiance R_e per unit area of the star's surface and the area S_L of the star's surface, as shown in Equation (3).

Since the surface radiation of a star is blackbody radiation, the radiant emittance R_e can express as Stephan-Boltzmann's law

$$R_e = \frac{c}{4}\int_0^\infty \rho_\nu \mathrm{d}\nu \tag{29-a}$$

$$= \frac{c}{4}\int_0^\infty \frac{8\pi h}{c^3}\frac{\nu^3}{\mathrm{e}^{\frac{h\nu}{kT}} - 1}\mathrm{d}\nu \tag{29-b}$$

$$= \sigma T^4 \tag{29-c}$$

Substituting (3) and (29) into (27) obtain

$$\sigma T'^4 = \frac{\pi c n_L r_0^2}{H_0}\sigma T^4 \tag{30}$$

Solving it can obtain

$$T' = \left(\frac{\pi c n_L r_0^2}{H_0}\right)^{\frac{1}{4}} T \tag{31}$$

Using the Hubble constant Equation (17-a) and Thomson's electron cross-sectional area $\sigma_T = 8\pi r_e^2/3$, Equation (31) can express as

$$T' = \left(\frac{\alpha}{\pi}\cdot\frac{n_L}{n_e}\cdot\frac{r_0^2}{r_e^2}\right)^{\frac{1}{4}} T \tag{32}$$

This formula establishes the relationship between the radiation temperature at any point in the universe and the mean surface temperature of stars.

4.3. Verification by Numerical Calculations

The distribution of luminous stars in the universe is non-uniform. So, n_L varies everywhere; Stars vary in radius r_0, and surface temperature T. According to the rough statistical estimation of the Chinese scholar G. Pan [5] can obtain three parameters in Equations (28) (31) for stars in the universe: 1) The mean radiant power of stars in the universe, $\overline{P}_0$; 2) The mean number density of stars in the universe, $\overline{n}_L$; 3) The mean light-blocking radius of stars in the universe, $\overline{r}_0$. Using this set of data and according to Equations (3) and (29) can calculate 4) The mean radiant emittance of the surface of stars in the universe, R_e; 5) The mean temperature of the surface of a luminous star in the space, $\overline{T}_0$. In this way can obtain **Table 1**.

Using the Hubble constant Equation (17-a) and replacing n_L, r_0, and T in Equation (28) with $\overline{n}_L$, $\overline{r}_0$, and $\overline{T}_0$ can obtain

$$T' = \left(\frac{\pi c \overline{n}_L \overline{r}_0^2}{H_0}\right)^{\frac{1}{4}} \overline{T}_0 \tag{33-a}$$

$$= \left[\frac{\pi \times 3\times10^8\ \text{m/s} \times 2.17\times10^{-58}/\text{m}^3 \times \left(4\times10^8\ \text{m}\right)^2}{2.27\times10^{-18}/\text{s}}\right]^{\frac{1}{4}} \times 8640\ \text{K} \tag{33-b}$$

$$= 2.994\ \text{K} \tag{33-c}$$

This result is 0.269 K or 9.87% higher than the accepted CMBR temperature of 2.725 K.

The Sun is a medium star among the stars. The total radiant power of the Sun is P_s, the radius of the Sun is r_s, the mean radiant emittance of the surface of the Sun is R_s, and the surface temperature of the Sun is T_s [8]. In this way can obtain **Table 2**.

The number density of stars in the universe is still $\overline{n}_L$, and the Hubble constant is Equation (17-a). Substituting them into Equation (31) can obtain

$$T_s' = \left(\frac{\pi c n_L r_s^2}{H_0}\right)^{\frac{1}{4}} T_s \tag{34-a}$$

$$= \left[\frac{\pi \times 3\times10^8\ \text{m/s} \times 2.17\times10^{-58}/\text{m}^3 \times \left(6.96\times10^8\ \text{m}\right)^2}{2.27\times10^{-18}/\text{s}}\right]^{\frac{1}{4}} \times 5800\ \text{K} \tag{34-b}$$

$$= 2.651\ \text{K} \tag{34-c}$$

This result is 0.074 K or 2.71% lower than the accepted CMBR temperature of 2.725 K.

Table 2. Solar parameters.

The radiant power of the sun	$P_s = 3.83\times10^{26}$ W
The radius of the sun	$r_s = 6.96\times10^8$ m
The radiant emittance of the sun's surface	$R_s = 6.29\times10^7$ W/m^2
The temperature of the sun's surface	$T_s = 5800$ K

Although obtained different calculated values using various data, these values deviate very little from acceptable measurements. How can the cosmic background temperature, which spans such orders of magnitude and is composed of so many physical quantities, coincidentally makes up such a precise physical quantity?

The deviation can attribute to four factors: the density n_L of luminous stars in the universe, the mean radius r_0 of stars, the mean temperature T of stars, and the Hubble constant H_0. Any deviation between any one factor and the actual value will cause the calculation result to deviate from the actual one, not to mention that T' is affected by a combination of 4 factors.

Since the stars' radiation conforms to the blackbody radiation spectrum, the quantity expressed by Equation (21) is the superposition of light of various frequencies radiated by all celestial bodies on the plane of any point after redshift. Thus, Equation (21) expresses the intensity of blackbody radiation without the blackbody surface.

Equation (28) contains the mean radiant power P_0 of stars and the Hubble constant. It proves that CMBR is the light radiated by luminous stars that undergoes redshift. In other words, CMBR is not a relic of the Big Bang. Thus, both the night sky darkness and CMBR originate from the quantum redshift of photons.

The above calculations show that the radiation of luminous stars, through quantum redshift, is converted into CMBR.

5. Discussion

5.1. The Explanations Required for the Big Bang Theory

The Big Bang theory explains the Olbers paradox as the age of the stars, the finite space-time of the universe, the expansion of space, and the sparseness of the luminescent energy density of stars. It regards the CMBR as the relic of the Big Bang and Hubble redshift as the Doppler effect of photons caused by the galaxies' recession.

Proponents of the Big Bang theory believe that if the medium absorbs the energy of the light can cause the temperature of the medium to continue to rise so that it can emit visible light and the entire sky is bright. It is one reason for Big Bang theorists to oppose the idea that the medium causes darkness in the night sky.

The Big Bang Theory explains Hubble redshift, Olbers paradox, and CMBR as the following:

1) Attribute Hubble redshift to the Doppler effect caused by the expanding universe.

2) Attribute the Olbers paradox to the finite age of stars in the universe, the energy radiated by all-stars too scarce, and the expanding universe.

3) Attribute CMBR to the relic of the Big Bang.

In a word, attribute all three phenomena to the finite universe and the expansion of the universe.

5.2. Explanations Based on the Quantum Redshift Effect

Through theoretical derivation and numerical calculations can affirm that the energy radiated by stars throughout space is converted into CMBR, making the sky dark, and the Olbers paradox is solved together with the CMBR.

The quantum redshift effect theory explains Hubble redshift, Olbers paradox, and CMBR as the following:

1) Attribute Hubble redshift to the quantum redshift effect of photons caused by the cosmic medium.

2) Attribute the Olbers paradox to the fact that the energy radiated by stars is too scarce, and the photons collide with atoms of the medium, which causes photons to undergo quantum redshift, reducing the brightness of the sky and frequency of photons.

3) Attribute the CMBR to the quantum redshift of photons of light radiated by the stars colliding with atoms of the medium, making the light become blackbody radiation of the temperature of 3 K.

In a word, unify all three phenomena by the quantum redshift effect of photons.

The energy of CMBR converts from luminous stars in the universe. The photons emitted by stars collide with the atoms of cosmic medium and undergo a quantum redshift. This effect makes the photon frequency lower and the light intensity weaker. The light becomes invisible and makes the night sky dark. After the stellar radiation is redshifted, it is superimposed at any point in space to become CMBR. The CMBR originates from stellar blackbody radiation, so the CMBR presents a blackbody spectrum.

5.3. Distinction in Observation

As can be seen from Equations (21) and (31), both the sky irradiance and CMBR temperature depend on the Hubble constant. So, the key to explaining the Olbers paradox and CMBR is the Hubble constant, which relates to the origin of photon redshift.

There are different explanations of the origin of photon redshift in the Big Bang theory and non-Big Bang theory:

In the 1920s, E. Hubble discovered a systematic redshift in the spectrum of extragalactic galaxies. Interpreting it as the Doppler effect by luminous stars moving away from Earth with galaxies, the photon frequency decreases according to the following formula:

$$\nu = \nu_0 \sqrt{\frac{1-\frac{V}{c}}{1+\frac{V}{c}}} \tag{35}$$

where ν_0 is the initial frequency of the photon, and V is the receding velocity of the luminous celestial body.

Redshift z is defined by

$$z = \frac{\lambda - \lambda_0}{\lambda_0} = \frac{\nu_0 - \nu}{\nu} \tag{36}$$

Hubble found that the redshift z is proportional to the distance r, so substituting Equation (35) to Equation (36) gives the approximate formula:

$$V = H_0 r \tag{37}$$

where H_0 is the Hubble constant.

Equation (37) is Hubble's Law, which expresses the relationship between the receding speed and distance of the celestial bodies. Therefore, the Hubble redshift becomes the direct evidence of the Big Bang.

In history, astronomers have never independently measured the receding speed of distant galaxies. Its calculation is dependent on the photon redshift. Therefore, Hubble's law is very dubious.

The physical meaning of the Hubble constant in the paper "*The Quantum Redshift Effect of Photon*" is well defined.

In the process of photon propagation in space, energy loses due to collision with the atoms in the medium. On average, the lost portion every time it collides with a bound electron is given by

$$\Delta\varepsilon = \frac{\pi^2}{4} \frac{(h\nu)^3}{(m_e c^2)^2} = \frac{3\pi}{8\alpha} \frac{\sigma_T}{\sigma_p} \cdot h\nu \tag{38}$$

In Equation (38), α is the fine structure constant, σ_T is the classical electron cross-sectional area—Thomson electron cross-sectional area, and $\sigma_p = \alpha\lambda^2 / \pi^2$ is the photon cross-sectional area.

Photons propagate in space, causing frequency reductions such as in Equation (10) or wavelength elongation as in Equation (11). The Hubble constant H_0 is the damping coefficient of photon motion. It is also the attenuation rate of photon frequency, which is proportional to the density of bound electrons in space, as in Equation (17-a). Therefore, the theory of the quantum redshift effect of the photon negates that of cosmic expansion.

So, is there any distinction in the aspect of observation between the cosmic expansion and the quantum redshift effect?

The redshift caused by the Doppler effect does not produce secondary waves, while the quantum redshift effect necessarily generates secondary waves. In the quantum redshift effect, each time a photon collides with a hydrogen atom, it loses energy, as in Equation (38). The atom can't always absorb energy, but it has to store the gained energy and radiate it into space after the collision to maintain the stability of the atom.

The radiated energy corresponding to Equation (38) is an electromagnetic wave lower than that of microwaves. Therefore, radio radiation necessarily occurs after the quantum redshift effect. So, it is hard to observe secondary photons due to the low frequency and weak intensity of secondary waves after a single collision. But if the hydrogen atom density is high and the radiance of the incident light is powerful, photons will collide with atoms frequently. In this way, the secondary waves will be strong, and it will be possible to observe with instruments. It is how the radio phenomenon of certain quasars arises.

As Max Born famously predicted in 1954, "The redshift is linked to radio astronomy." [7]

In addition, the quantum redshift effect of photons accompanies phenomena such as 21 cm hydrogen lines, Lyα, and Lyβ forests.

6. Conclusion

The light radiated by stars in the universe is collided by the atoms in the medium to produce a quantum redshift effect, which is the physical mechanism of Hubble redshift. It causes the frequency of photons to attenuate negatively exponentially with the propagation distance. It unifies the explanation of two seemingly unrelated phenomena. On the one hand, the irradiance of the night sky becomes very low, showing darkness. On the other hand, the light emitted by the stars becomes CMBR. The quantum redshift effect generates radio background radiation. This effect explains where the light energy radiated by stars in the universe goes and dispels the Olbers paradox. It explains the origin of CMBR at the same time. The Hubble redshift, Olbers paradox, and CMBR are all caused by the quantum redshift effect of photons and cannot use to be the basis for the Big Bang theory.

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Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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