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# An Alternative Explanation of the Cosmological Redshift by the Tachyon Plasma Field in Intergalactic Space

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**Abstract**: From the assumption that intergalactic space is filled with tachyon plasma, it can be shown that the cosmological redshift can be explained by electromagnetic attenuation in the tachyon plasma field.

**Keywords** : tachyon, plasma, cosmological redshift, zero-point fluctuation.

## 1. Introduction

The current interpretation of observed redshift of light from distant galaxies is due to the expansion of the universe. Contrary to this interpretation, alternative explanations for the cosmological redshift were proposed by some researchers[1-3]. The author has shown that the gravitational field due to the zero-point fluctuation (ZPF) field can be cancelled by the tachyon field created out of the ZPF background and almost of all energy of the cosmic background radiation is due to the Cherenkov radiation from tachyons created from the ZPF field[4,5]. In this paper, he also presents that the cosmological redshift can be explained from the assumption that intergalactic space is filled with virtual tachyon plasma created from the ZPF field.

## 2. Tachyon Field Generated from the ZPF Background

From the wave equation for the moving elementary particle shown as

$$i\hbar\frac{\partial\psi}{\partial t}=c\sqrt{p^2+m_0^2c^2}\,\psi \quad , \tag{1}$$

which satisfies

$$\psi(x,t)=A\cdot\exp\left[-i\left(\frac{E}{\hbar}t-\frac{p}{\hbar}x\right)\right] \quad , \tag{2}$$

where $\psi$ is wave function of the moving particle, $c$ is a light speed, $\hbar$ is a Plank's constant divided by $2\pi$, $m_0$ is a proper mass of the particle, $E$ is energy of the particle and $p$ is its

momentum.

By using the proper acceleration defined by $p = m_0 \alpha t$, the solution of Eq(1) can be given by

$$\psi = C \cdot \exp\left[ -i \frac{c}{m_0 \alpha \hbar} \left( \frac{p}{2} \sqrt{p^2 + m_0^2 c^2} + \frac{m_0^2 c^2}{2} \log( p + \sqrt{p^2 + m_0^2 c^2} \right) \right] , \qquad (3)$$

where $C$ is an arbitrary constant.

From which, the probability of the highly accelerated particle which can exceed the light speed by quantum tunneling effect can be estimated as[6]

$$T \approx \exp\left[ -\frac{\pi}{2} \frac{m_0 c^3}{\alpha \hbar} \right] . \qquad (4)$$

According to the theory of quantum mechanics, the empty space is filled with virtual particles, most of which are low energy photons moving in an evanescent mode. Supposing that the virtual photon created from the ZPF field is accelerated to the light speed inside the quantum region with the size of Plank length $l_p$, we have $\alpha = c^2 / l_p$ from the uncertainty principle and $m_0 = \hbar\omega / c^2$, where $\omega$ is an angular frequency of the photon. Then we have

$$T \approx \exp\left[ -\frac{\pi}{2} \frac{l_p \omega}{c} \right] , \qquad (5)$$

which shows a possibility that the pair of a tachyon and an anti-tachyon created from the ZPF field in empty space.

By quantum electrodynamics, spectral energy density of the ZPF field in empty space is given by [7]

$$\rho(\omega) d\omega = \frac{\hbar \omega^3}{2\pi^2 c^3} d\omega . \qquad (6)$$

The mass of virtual photon created inside the quantum region with the size of Plank length yields the Plank mass $m_p$ from the uncertainty principle shown as $\Delta p \cdot l_p \approx \hbar$. From Eqs.(5) and (6), virtual tachyons created from the ZPF field can be roughly estimated as

$$N \le \int_0^{\omega_c} \frac{\hbar \omega^3}{2\pi^2 m_p c^5} \exp\left[ -\frac{\pi}{2} \frac{l_p \omega}{c} \right] d\omega , \qquad (7)$$

where $\omega_c$ is the cutoff frequency of the ZPF field given by[7]

$$\omega_c = \left( \frac{\pi c^5}{\hbar G} \right)^{1/2} , \qquad (8)$$

which has the order of the Plank frequency. By the numerical calculation, we have $N \le 3.6\times10^{102}$ from Eq.(7). Thus it is considered that empty space is filled with pairs of positive and negative charged tachyons created out from the ZPF field if the tachyon has an electric charge.

**3. Electromagnetic Wave Traveling in the Tachyon Plasma Field**

Supposing that the intergalactic space is filled with the tachyon plasma created from the ZPF field, electromagnetic waves below the plasma frequency are attenuated shown with the scattering of particles in the plasma being described as[8]

$$mv = q\vec{E}\tau \quad , \tag{9}$$

where $m$ is a mass of the particle, $v$ is the velocity of the particle, $q$ is its charge, $\vec{E}$ is an electric field and $\tau$ is the time interval between collisions.

From which, the resonant frequency of the tachyon plasma field can be estimated by[8]

$$\omega_p = \sqrt{\frac{Nq^2}{m\varepsilon_0}} \quad , \tag{10}$$

where $m$ is the mass of the tachyon defined by

$$m = \frac{m_*}{\sqrt{v^2/c^2 - 1}} \quad , \tag{11}$$

in which, $m_*$ is an absolute value of the tachyon's proper mass.

From the uncertainty relation for the tachyon given by[9]

$$\Delta p \cdot \Delta t \approx \frac{\hbar}{v - c} \quad , \tag{12}$$

the velocity of the tachyon moving in empty space can be estimated as $v \approx 2c$ [5]. Then the mass of the tachyon becomes

$$m \approx \frac{\hbar}{cl_p} \quad , \tag{13}$$

by using relations that $m \approx \Delta p / 2c$ and $\Delta t \approx l_p / 2c$.

Supposing that an assumed charge of the tachyon equals that of the electron[10], the resonant angular frequency of tachyon plasma can be evaluated as $\omega_p \approx 6.93\times10^{41}$ (rad/s) at most by using $N = 3.6\times10^{102}$.

**4. Redshift of the Light from the Distant Galaxies due to the Tachyon Plasma Field**

According to the electromagnetic theory, electromagnetic waves in the plasma can be described by

$$\frac{\partial^2 \vec{E}}{\partial x^2} - \left(\frac{\omega_p}{u}\right)^2 \vec{E} = \frac{1}{u^2}\frac{\partial^2 \vec{E}}{\partial t^2} \quad , \tag{14}$$

where $u$ is the electromagnetic wave speed inside the plasma.

By substituting $E = A \cdot \exp[i(kx - \omega t)]$ into Eq.(14), we have

$$k = \pm i\sqrt{\omega_p^2 - \omega}\,/\,u \quad . \tag{15}$$

As the electric field can be described as $\vec{E} = -\nabla\phi - \partial A/\partial t$ by using the scalar potential $\phi$ and the vector potential $\vec{A}$, the wave equation for the electromagnetic field in terms of the velocity gauge as[11]

$$\nabla^2 \phi - \frac{1}{u^2}\frac{\partial^2}{\partial t^2}\phi = -\frac{\rho}{\varepsilon_0} \quad , \tag{16.1}$$

$$\nabla^2 \vec{\mathbf{A}} - \frac{1}{c^2}\frac{\partial^2}{\partial t^2}\vec{A} = -\mu_0 \vec{J} + \left(\frac{1}{c^2} - \frac{1}{u^2}\right)\frac{\partial \nabla \phi}{\partial t} \quad , \tag{16.2}$$

where $\rho$ is a charge density, $\vec{J}$ is a current density $\varepsilon_0$ is permittivity and $\mu_0$ is permeability of free space. For the case when $\omega_p >> \omega$, the vector potential, the velocity of which equals the light speed, is rapidly attenuated and finally becomes zero from Eq.(15) and only longitudinal waves can propagate in the plasma field as shown by following equations, if the speed of the scalar potential is much higher than the light speed (see Fig.1).

$$\nabla^2 \phi - \frac{1}{c_L^2}\frac{\partial^2}{\partial t^2}\phi = -\frac{\rho}{\varepsilon_0} \quad , \tag{17.1}$$

$$\left(\frac{1}{c^2} - \frac{1}{c_L^2}\right)\frac{\partial \nabla \phi}{\partial t} = \mu_0 \vec{J} \quad , \tag{17.2}$$

where $c_L$ is the velocity of longitudinal waves.

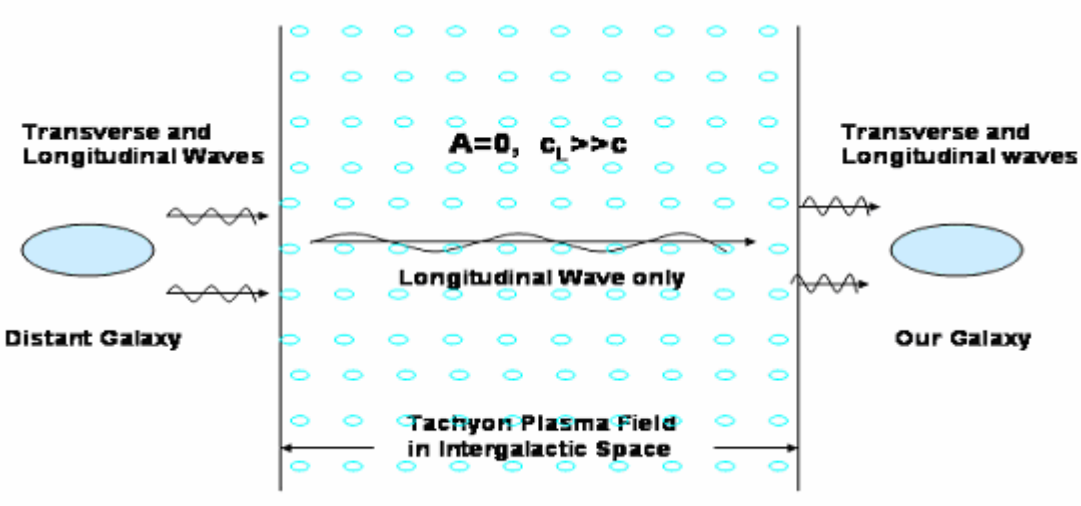


**Figure 1.** Wave propagation in intergalactic space.

Supposing that there is no tachyon plasma field in the space near the Earth, where $c_L = c$, $\rho = 0$ and $\vec{J} = 0$, the scalar wave is transformed into transverse and longitudinal waves from Eqs.(16.1) and (16.2) shown as

$$\nabla^2\phi - \frac{1}{c_L^2}\frac{\partial^2}{\partial t^2}\phi = 0 \quad , \tag{18.1}$$

$$\nabla^2\vec{A} - \frac{1}{c^2}\frac{\partial^2}{\partial t^2}\vec{A} = 0 \quad . \tag{18.2}$$

From Eq.(15), we have $k \approx \pm i\omega_p / c_L$ for the photon traveling in a longitudinal mode inside the plasma, which frequency is much lower that the plasma resonant frequency. Then the energy of the photon traveling inside the plasma field is given by

$$\mathrm{E}(x) = \mathrm{E}_0 \exp(-\beta x) = \mathrm{E}_0 \exp\left(-\frac{2\omega_p}{c_L}x\right) \quad , \tag{19}$$

where $\mathrm{E}$ is energy of the photon, $\beta$ is an attenuation constant and $x$ is a traveling distance of the photon. By the relation of energy of the wave shown as $\mathrm{E} = 2\pi\hbar c / \lambda$, the wavelength of the photon becomes

$$\lambda(x) = \lambda_0 \exp\left(\frac{2\omega_p}{c_L}x\right) \quad , \tag{20}$$

where $\lambda_0$ is the wavelength of the photon at the time of emission and $\lambda$ is the wavelength of the photon which is observed. When the value of $2\omega_p / c_L$ is negligibly small compared with unity, the relation of the redshift of photon and the distance $x$ can be given by

$$\frac{\lambda-\lambda_0}{\lambda_0}=\exp\left(\frac{2\omega_p}{c_L}x\right)-1\approx\frac{2\omega_p}{c_L}x \quad . \tag{21}$$

From which, the receding velocity of distant galaxies can be obtained as

$$v/c\approx\frac{2\omega_p}{c_L}x \quad , \tag{22}$$

where the speed of the longitudinal wave in intergalactic space can be estimated from the Hubble constant $H_0$ as

$$c_L\approx\frac{2\omega_p}{H_0}c\le 2.1\times10^{68} \ \text{(m/s)} \tag{23}$$

by making the substitution $v\approx H_0x$ [12]. Considering higher terms of $\exp(x)$, the velocity of expansion becomes

$$v/c=\frac{2\omega_p}{c_L}x+\frac{1}{2}\left(\frac{2\omega_p}{c_L}\right)^2x^2+\frac{1}{6}\left(\frac{2\omega_p}{c_L}\right)^3x^3+\cdots \quad . \tag{24}$$

If we let $c_L=2.1\times10^{68}$ (m/s), velocity curves calculated by Eqs.(22) and (24) is shown in Fig.2, where a horizontal line is for a distance from us in billion light years and a vertical line is for the receding speed of the galaxy in km/s. From this figure, the calculation result considering higher terms shows that the receding speed of galaxies is accelerated with increased distance from us.

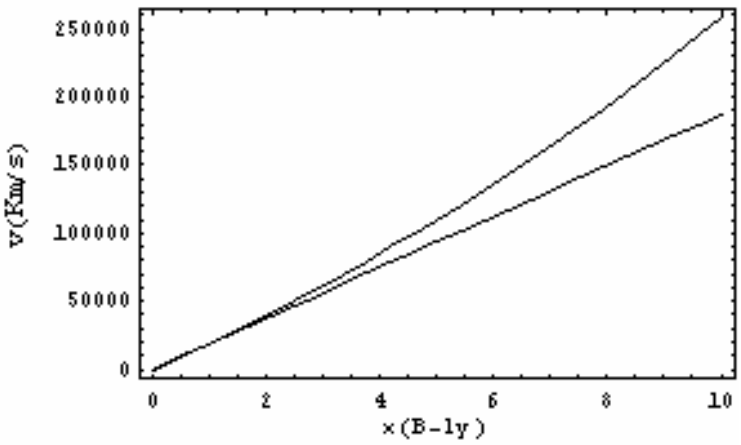


**Figure 2.** Speed of the distant galaxy predicted by the theory.

Recently astronomer groups have revealed that cosmic expansion is speeding up from the observation of very distant supernovae[13]. They concluded that their observation result is due to the repulsive cosmological constant, but it might also be explained by the attenuation of

electromagnetic waves traveling in the intergalactic tachyon plasma field as shown in this paper.

## 5. Conclusion

In this paper, it is shown that the cosmic redshift of light can be explained by the attenuation of electromagnetic waves in the intergalactic tachyon plasma field. From which, the recent observation result that cosmic expansion is speeding up can also be explained by the exponential attenuation of electromagnetic waves in the intergalactic tachyon plasma field.

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