Cherenkov Radiation from Faster-Than-Light Photons Created in a ZPF Background

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Abstract: Intensity of the cosmic background radiation due to the Cherenkov effect from faster-than-light virtual photons created in a ZPF background is estimated herein. The calculated result shows that spectrum and the mass density of energy due to the Cherenkov radiation almost coincides the cosmic background radiation observed.

Keywords: faster-than-light photon, zeropoint field energy, cosmic background radiation, Cherenkov effect.

Symbols

$\hbar$: Plank's constant divided by 2π
c : light speed
ψ : wave function of the moving particle
a : proper acceleration of the particle
v_* : velocity of the particle in FTL state
m_* : absolute value of the tachyon's rest mass
T_* : probability for the particle exceeding the light speed
l_p : Plank length
α : fine structure constant
k_B : Boltzman constant
T : absolute temperature of the radiation
$\rho(\omega)$: energy density of the ZPF

INTRODUCTION

Quantum electrodynamics shows that empty space is filled with the zero-point fluctuations (ZPF) of electromagnetic energy field which has spectral energy density given by [1]

$$\rho(\omega)\mathrm{d}\omega = \frac{\hbar\omega^3}{2\pi^2 c^3} d\omega \quad , \tag{1}$$

where $\rho(\omega)$ is energy density of the ZPF, ω is its angular frequency, $\hbar$ is a Plank's constant divided by 2π and *c* is the light speed.

According to the author's theory which predicts the existence of faster-than-light (FTL) photons created from the ZPF background by quantum tunneling effect [2], they have the possibility to emit electromagnetic radiation by the Cherenkov effect. In this paper, intensity of the cosmic background radiation due to the Cherenkov effect from FTL photons created in a ZPF background is estimated.

PROBABILITY OF VIRTUAL TACHYONS BEING GENERATED IN EMPTY SPACE

I. Theoretical background

The author presented the possibility of FTL phenomena in his scientific paper [3] that FTL speed can be permitted for highly accelerated elementary particles by quantum tunneling effect. For the uniformly accelerated particle, the wave equation can be given by [2]

$$\frac{d\psi}{dv} = -i\frac{m_0 c^6}{a\hbar}\frac{\psi}{(c^2 - v^2)^2} \quad , \qquad (2)$$

where ψ is a wave function for the moving particle, a is its proper acceleration, v is the velocity of the particle and m_0 is its proper mass.

From Eq.(2), the wave function of the accelerated particle can be given for the region below the light speed in Fig.1 as

$$\psi = C_0\, exp\left[-i\frac{m_0 c^6}{a\hbar}\left\{-\frac{v}{2c^2(c^2 - v^2)} + \frac{1}{4c^3}log\left(\frac{c+v}{c-v}\right)\right\}\right] \quad . \qquad (3)$$

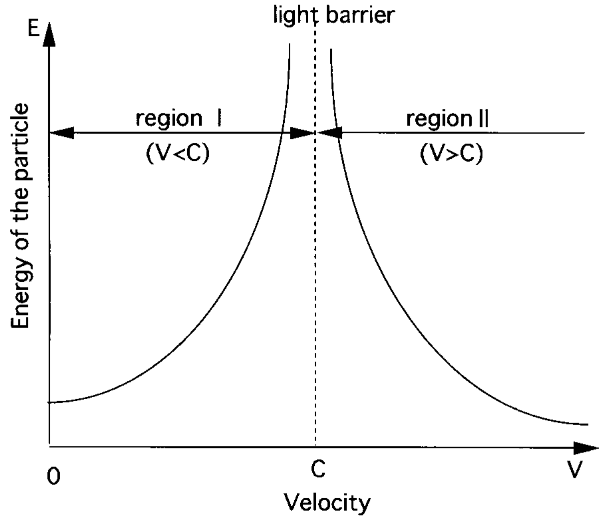

Fig.1 *Quantum tunneling of the particle through the light barrier.*

For the region above the light speed, the particle is required to have an imaginary rest mass from the theory of special relativity, the wave function ψ_* for the FTL particle can be given by replacing the term m_0 in Eq.(3) by the imaginary proper mass im_* as

$$\psi_* = C_0 \, exp\left[\frac{m_* \, c^6}{a\hbar}\left\{-\frac{v_*}{2c^2(v_*^2 - c^2)} + \frac{1}{4c^3} log\left(\frac{v_* - c}{v_* + c}\right)\right\}\right] , \qquad (4)$$

where v_* is the velocity of the FTL particle.

Then the probability of the virtual photon that exceeds the light speed becomes [4]

$$T_* \approx \frac{|\psi_*|^2}{|\psi|^2} = exp\left[\frac{m_* \, c^3}{a\hbar}\left\{\frac{1}{2} log\left(\frac{v_* - c}{v_* + c}\right) - \frac{c v_*}{v_*^2 - c^2}\right\}\right] . \qquad (5)$$

II. Probability of virtual photons being transformed into a tachyonic state.

In empty space, virtual particles, most of which are low energy photons, are created from the ZPF background. From Eq.(5), the probability of the pair of a tachyon and an anti-tachyon created from the ZPF field by quantum tunneling effect can be estimated.

From the energy conservation law, we have

$$\Delta E = \frac{2 m_* c^2}{\sqrt{v_*^2 / c^2 - 1}} = \hbar\omega \ , \qquad (6)$$

where $\hbar\omega$ is the energy of the virtual photon created in a ZPF background. From which we have

$$2m_* = \frac{\hbar\omega}{c^2}\sqrt{v_*^2 / c^2 - 1} \quad . \tag{7}$$

Since the FTL particle follows the uncertainty principle for the tachyon given by [5]

$$\Delta p \cdot \Delta t \approx \frac{\hbar}{v_* - c} \quad , \tag{8}$$

where Δp is the difference of the momentum and $\Delta\, t$ is the time interval of the virtual photon moving in a FTL state. Then the following equation can be derived.

$$\Delta p = \frac{2m_* v_*}{\sqrt{{v_*}^2 / c^2 - 1}} - \frac{\hbar\omega}{c} \approx \frac{\hbar}{(v_* - c)\Delta\, t} \quad . \tag{9}$$

From which FTL velocity of the photon can be roughly estimated as

$$v_* \approx c\left(1 + \sqrt{\frac{1}{\omega\Delta\, t}}\right) \quad . \tag{10}$$

According to the uncertainty relation $\Delta E \cdot \Delta t \approx \hbar$, we obtain $\Delta t \approx \omega^{-1}$ for the virtual photon, which has the energy $\Delta E = \hbar\omega$. Then the velocity of it can be approximated as

$$v_* \approx 2c \quad . \tag{11}$$

Substituting this value into Eq.(7), the absolute mass of the FTL photon becomes

$$m_* \approx \frac{\sqrt{3}\hbar\omega}{2c^2} \quad . \tag{12}$$

Supposing that the virtual photon is created inside the region, which size almost equals the Plank length l_p, the acceleration of the virtual photon which has the mass $m = \hbar\omega / c^2$ is roughly estimated by the uncertainty principle as

$$a \approx \frac{1}{m}\frac{\Delta p}{\Delta t} \approx \frac{c^2}{l_p} \quad . \tag{13}$$

From which the probability of the photon transformed into tachyonic state becomes

$$T_* \approx exp\left(-\frac{\gamma\, l_p}{c}\omega\right) \quad . \tag{14}$$

where $\gamma = \frac{\sqrt{3}}{2}\left(\frac{log\,3}{2} + \frac{2}{3}\right)$.

CHERENKOV RADIATION FROM FTL PHOTONS

If a tachyon pair created from the ZPF background have electric charge, it radiates a photon at the angle of[6]

$$\theta_c = cos^{-1}\left(\frac{1}{\beta n}\right) \quad , \qquad (15)$$

by the Cherenkov effect as shown in Fig.2, where θ_c is half-angle of the Cherenkov cone and n is the index of refraction which equals to unity in a vacuum.

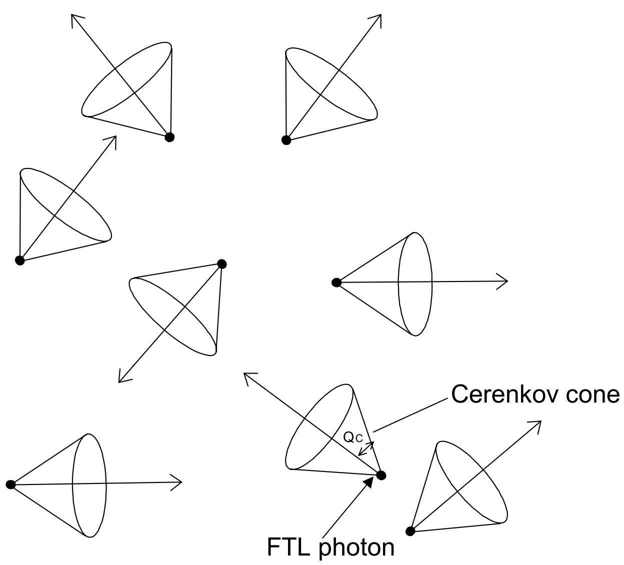

Fig.2 *Cerenkov radiation in the ZPF background*

If the FTL particle moving at the speed of $\beta = v_* / c$, number of photons at an angular frequency ω created in a space can be roughly estimated by[6]

$$\frac{dN}{dl} = 2\pi\alpha\left(1 - \frac{1}{\beta^2 n^2}\right)\int\frac{d\lambda}{\lambda^2} = \frac{2\pi\alpha}{c} sin^2\,\theta_c \Delta\nu \, , \qquad (16)$$

where α is a fine structure constant and $\Delta\nu$ is a band width of the radiation. By the uncertainty of energy and momentum, the traveling distance of the FTL photon becomes $l = c/\omega$, then the number of the photons at a single frequency band created by the Cherenkov effect becomes

$$N = \frac{3\pi\alpha}{2c} \ , \qquad (17)$$

which is negligible small compared to unity.

By statistical dynamics, the light quanta radiated which number is k has the probability shown as $exp(-k\hbar\omega / k_B T)$, where T is the absolute temperature of radiation and k_B is the Boltzman constant [7]. Then the mean of energy density of photons created from the ZPF field at an angular frequency ω becomes

$$\langle \rho_E \rangle = \frac{\hbar\omega^3}{2\pi c^3} T_*(\omega) \frac{\sum_{k=0}^{\infty} n e^{-k\tau\hbar\omega}}{\sum_{k=0}^{\infty} e^{-k\tau\hbar\omega}} = \frac{\hbar\omega^3}{2\pi c^3} exp\left(-\frac{\gamma\ l_p}{c}\omega\right)\left[exp\left(-\frac{\hbar\omega}{k_B T}\right) - 1\right]^{-1} \ , \qquad (18)$$

where $\tau = 1/k_B T$. Taking $T = 2.73°$ K, spectrum of $\langle \rho_E \rangle$ can be calculated by Eq.(18) as shown in Fig.3, which coincides well with the observed spectrum of the cosmic background radiation [8].

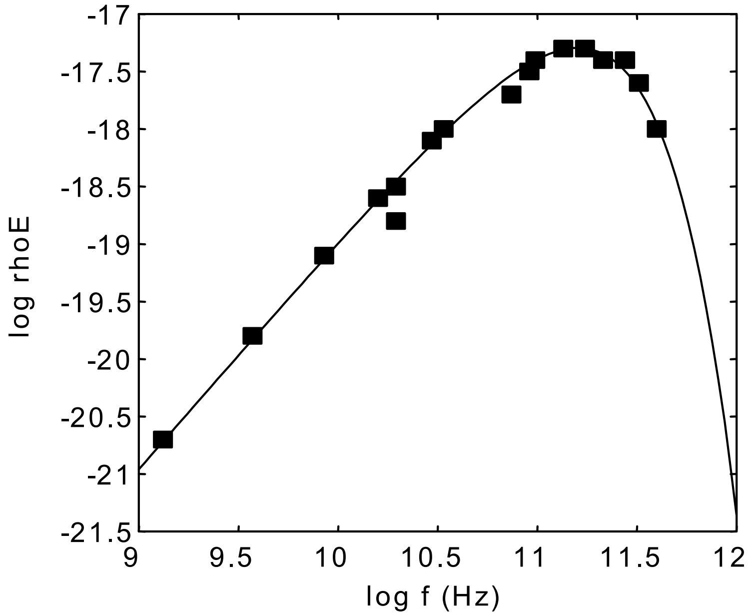

Fig.3 *Spectrum of $\langle \rho_E \rangle$ compared with the observed cosmic microwave background radiation denoted as* ■.

By integrating Eq.(18) over the microwave frequency $\omega_1 = 10^{11} \sim \omega_2 = 2 \times 10^{14}$, the equivalent mass density of radiation due to the Cherenkov effect can be given by

$$\rho_r = \frac{1}{c^2}\int_{\omega_1}^{\omega_2} \langle \rho_E \rangle d\omega \approx \frac{\hbar}{2\pi c^5}\int_{\omega_1}^{\omega_2} \omega^3\, exp\left(-\frac{\gamma\ l_p}{c}\omega\right)\left[exp\left(-\frac{\hbar\omega}{k_B T}\right) - 1\right]^{-1} d\omega \qquad (19)$$

$$\approx 7.28\times 10^{-31}\,(\mathrm{kg/m^3})\ .$$

The observation equivalent mass density of the cosmic background radiation is estimated as

$$\rho_r \approx 4.4\times 10^{-31}\ \ (\mathrm{kg/m^3})\ . \tag{20}$$

according to the work by Fang Li Zhi [9]. From this result, it is considered that almost of all energy of the cosmic background radiation is due to the Cherenkov radiation from the FTL photons created in a ZPF background.

CONCLUSION AND DISCUSSION

In this paper, the author evaluates the cosmic background radiation due to the Cherenkov effect from FTL virtual photons created in a ZPF background. The calculated result shows that the spectrum and the mass density of energy due to the Cherenkov radiation almost coincides the cosmic background radiation and it is considered that almost of all energy of the cosmic background radiation is due to the Cherenkov radiation from the FTL photons created in a ZPF background. Generally the cosmic background radiation is considered to be the remnants of the Big Bang of the Universe. However the Big Bang theory must be reconsidered if the cosmic background radiation is created from the ZPF field as the author presented in this article.

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REFERENCES

1. Puthoff,H.E.(1989) Gravity as a zero-point-fluctuation force,Physical Review A,vol.39, No.5,2333-2342.
2. Musha,T.(2000) Possible Existence on Tachyon Field Cancellation of ZPF Induced Gravitational Field in Empty Space, Journal of Theoretics, Vol.2,No.4(2000).
3. Musha,T.(1998) Possible existence of faster-than-light phenomena for highly accelerated elementary particles, Speculations in Science and Technology,21,29-36.
4. French,A.P. and Taylor.E.F.(1978) An Introduction to Quantum Physics, The MIT Introducing Physics series, MIT Press.
5. Park,M. and Park,Y.(1996) On the foundation of the relativistic dynamics with the tachyon, Vol.111B,N.11,Nuovo Cimento,1333-1368.
6. Anderson,L.H. (1989) A Physicist's Desk Reference, The Second Edition of Physics Vade Mecum,American Institute of Physics, New York.
7. Menzel,D.H.(1960) Fundamental Formulas of Physics, Volume One,Dover Publications,Inc.,New York.
8. Davis,P.C.W. (1982) The Accidental Universe, Cambridge University Press, Cambridge.
9. Fang Li Zhi and Li Shu Xian (1989) Creation of the Universe, World Scientific Co. Pte. Ltd.

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