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Corona Heating Problem from the Standpoint of ZPF Radiation from Vacuum

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Abstract

The corona heating problem in solar physics relates to the question of why the temperature of the Sun's corona is millions of Kelvin higher than that of the surface. The author proposed in his paper that cosmic background radiation might be due to Cherenkov radiation from superluminal particle pairs created in a ZPF field of the vacuum. By using this theory, it can be shown that that the corona heating problem can be explained by Cherenkov radiation from superluminal particles created from the ZPF field in the hot plasma of the Sun

Keywords: Cherenkov radiation, Superluminal particle, ZPF field, Corona heating problem.

1. Introduction

The corona is the furthest layer from the sun's core, but it's still incredibly hot – and the reasons for this strange 'layering' of our nearest star are still a mystery.

Conventionally, the Sun is considered to be a natural nuclear fusion reactor, which is powered by a proton-proton chain reaction which converts four hydrogen nuclei into helium, neutrinos and energy. The excess energy is released as gamma rays and as kinetic energy of the particles, including the neutrinos, which travel from the Sun's core to the Earth without any appreciable absorption by the Sun's outer layers.

The corona heating problem in solar physics relates to the question of why the temperature of the Sun's corona is millions of Kelvin higher than that of the surface. The high temperatures require energy to be carried from the solar interior to the corona by non-thermal processes, because the second law of thermodynamics prevents heat from flowing directly from the solar photosphere, or surface, at about 5800 $°K$, to the much hotter corona at about 1,000,000 $°K$ (Erdelyi, Ballai, 2007). Many coronal heating theories have been proposed, but two theories have remained as the most likely candidates: wave heating and magnetic reconnection (or nanoflares) (Malara, Velli, 2001). Through most of the past fifty years, neither theory has been able to account for the extreme coronal temperatures.

The author presented the possibility in his article that cosmic background radiation (CBR) might be due to the Chrenkov radiation from faster-than-light virtual photons created in a zero-point-fluctuation (ZPF) of vacuum (Musha, Hayman, 2013). By applying this theory, the author has proposed another possibility to explain that the corona heating problem can be explained from Cherenkov radiation from the ZPF field.

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2. Discussion

Chrenkov Radiation from Superluminal Particles Created inside ZPF Vacuum

The author has shown in his paper that faster-than-light phenomena can be permitted for highly accelerated elementary particles if they have a very small mass compared to that of the electron (Musha, 1998). By using this theory, Cherenkov radiation from pairs of superluminal virtual particles created from the ZPF field can be estimated shown as follows (Musha, 2005).

From the wave equation taking account of the special relativity (i.e. Klein-Gordon equation) given by

$$i\hbar\frac{\partial\psi}{\partial t}=H\psi\,, \tag{1}$$

where $H=\sqrt{p^2c^2+M^2c^4}$ (p : momentum of the particle, M : effective mass) and ψ is a wave function for the particle, the following equation can be obtained for the accelerated particle;

$$\frac{\partial\psi}{\partial p}=-\frac{i}{Ma\hbar}\sqrt{p^2c^2+M^2c^4}\psi\ , \tag{2}$$

where a is a proper acceleration of the virtual elementary particle created from ZPF field.

If virtual particles are created inside the quantum region, which size is l, the proper acceleration of them becomes

$$a=\frac{1}{m}\frac{\Delta p}{\Delta t}\approx\frac{c^2}{l}\ , \tag{3}$$

from the uncertainty of momentum and energy given by $\Delta p\cdot l\approx\hbar$ and $\Delta E=\Delta p\cdot c$ respectively, when we let $\Delta E=mc^2$ and $\Delta t=l/c$.

From these equations, the probability of the accelerated particle to tunnel through the light barrier can be given by (Musha, 2009).

$$T(\omega)\approx\exp(-\gamma\cdot l_p\omega)\ , \tag{4}$$

where l_p is a Plank length and

$$\gamma=-\frac{3\log 3-2+3\log(\hbar/c)}{\sqrt{3c}}\approx 5.62\times10^{-7}\ . \tag{5}$$

If a pair of superluminal particles created from the ZPF background have an electric charge, they radiate photons at the angle of $\theta_c=\cos^{-1}(1/\beta n)$ as shown in Fig. 1, where θ_c is a half-angle of Chrenkov radiation from the particle moving at the speed of $\beta\ (=v/c)$ and n is the index of refraction, which equals to unity in a vacuum.

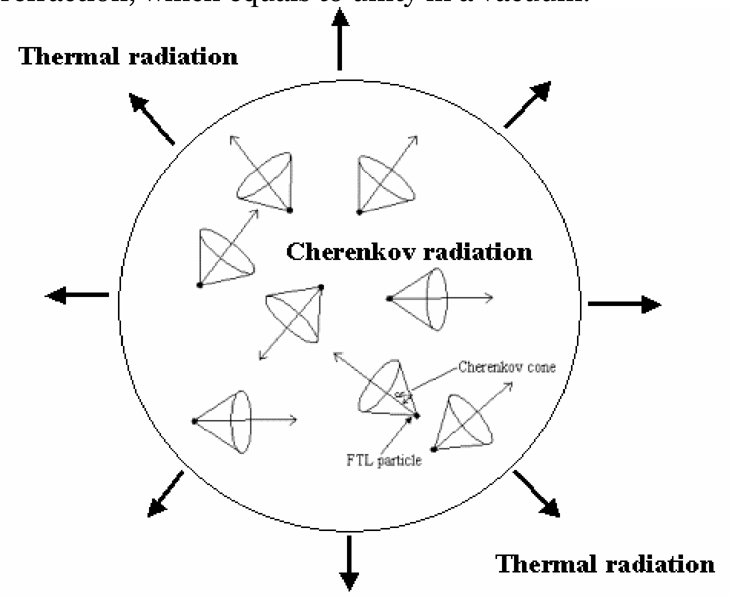

Fig. 1. Cherenkov radiation from tachyon pars created from ZPF field

According to the SED theory, small fraction of energy from electromagnetic field generated by Cherenkov radiation from pairs of virtual superluminal particles can be emitted as blackbody radiation shown as (Musha, 2009).

$$\rho(\omega)=\frac{\hbar\omega^3}{2\pi c^3}T(\omega)\frac{\sum_{k=0}^{\infty}ke^{-k\hbar\omega/k_BT}}{\sum_{k=0}^{\infty}e^{-k\hbar\omega/k_BT}}=\frac{\hbar\omega^3}{2\pi^2c^3}\exp\left(-\gamma\, l_p\omega\right)\cdot\left[\exp\left(\frac{\hbar\omega}{k_BT}\right)-1\right]^{-1}, \qquad (6)$$

where k_B is a Boltzman constant and T is a temperature of radiation.

Then the energy density of Cherenkov radiation generated from pairs of superluminal particles can be given by (Musha, 2009).

$$\rho_C=2\int_0^{\infty}\rho(\omega)d\omega=\frac{\hbar}{\pi^2c^3}\int_0^{\infty}\omega^3\exp\left(-\gamma\, l_p\omega\right)\cdot\left[\exp\left(\frac{\hbar\omega}{k_BT}\right)-1\right]^{-1}d\omega$$

$$=\frac{k_B^4T^4}{\pi^2c^3\hbar^3}\int_0^{\infty}x^3\exp(-\alpha x)/[\exp(x)-1]dx=\frac{6}{\pi^2}\frac{k_B^4T^4}{\hbar^3c^3}\zeta(4,1+\alpha)\ , \qquad (7)$$

where $\zeta(m,n)$ is a Hurwitz zeta function and $\alpha=\gamma\, l_pk_BT/\hbar$.

From which, the energy density of Cherenkov radiation from pairs of superluminal particles created from the ZPF field can be estimated.

Light Speed inside the Plasma Field

Inside the medium of electromagnetic field such as inside the plasma, the wave propagation can be described by (Drummond, 2013)

$$rotB=-\varepsilon_0\mu_0\left(1+\frac{e^2N}{\varepsilon_0m(\omega_e^2-\omega^2)}\right)\omega E_0\sin\omega t\ , \qquad (8)$$

where m is a mass of electron, e is its charge, N is a density of electrons and ω_e is a resonant frequency of electrons given by $\omega_e=\sqrt{Ze^2/\alpha_em}$ (α_e: electron polarizability) which satisfies $\omega_e\geq$ (upper frequency of visible light).

From which, the light speed in the plasma becomes

$$c'=c\Big/\sqrt{1+\frac{e^2N}{\varepsilon_0m(\omega_e^2-\omega^2)}}\ . \qquad (9)$$

Then the energy density generated by Cherenkov radiation from virtual superluminal particles created from ZPF vacuum can be given from Eqs. (7) and (9) as

$$\rho'(\omega)=\frac{\hbar\omega^3}{2\pi c^3}\exp\left(-\gamma\cdot l_p\omega\sqrt{1+\frac{\omega_{pe}^2}{(\omega_e^2-\omega^2)}}\right)\cdot\left[\exp\left(-\frac{\hbar\omega}{k_BT}\right)-1\right]^{-1}\left(1+\frac{\omega_{pe}^2}{(\omega_e^2-\omega^2)}\right)^{3/2}, \qquad (10)$$

where $\omega_{pe}=\sqrt{e^2N/\varepsilon_0m}$.

For the case when satisfying $\omega_e>>\omega$, we have

$$\sqrt{1+\frac{\omega_{pe}^2}{\omega_e^2-\omega^2}}\approx\sqrt{1+\varepsilon^2}\ , \qquad (11)$$

where $\varepsilon=\omega_{pe}/\omega_e$.

If the effects of the electron thermal speed are taken into account, the electron pressure acts as a restoring force as well as the electric field and the oscillations propagate with frequency and wave number, then the plasma frequency can be given by (Andreev, 2000)

$$\omega_p^2=\omega_{pe}^2+3k^2v^2, \qquad (12)$$

where k is a wave number and v is a velocity of electrons.

In the medium where the speed of light is reduced, it is still possible that other high energy particles, such as electrons, move faster than the speed of light and hence Cherenkov radiation is produced.

In the hot plasma, the speed of light can be given by

$$c' = c/\sqrt{1+\varepsilon'^2}\,, \tag{13}$$

where c' is the light speed in plasma, c is the speed in a vacuum and ε' is

$$\varepsilon' = \sqrt{\omega_{pe}^2 + 3k^2v^2}\,/\,\omega_e\,, \tag{14}$$

then the calculation result of c'/c can be shown as Fig. 2, when we let $\omega_e = 8\times10^{14}$ and $\omega_{pe} = 1.78\times10^9$.

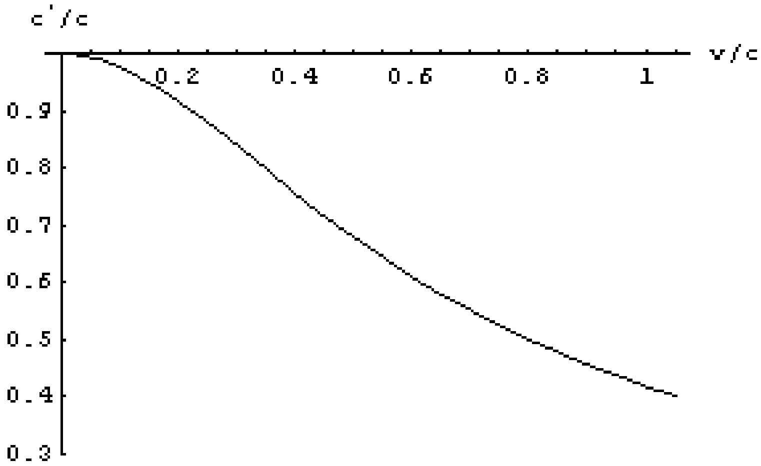

Fig. 2. Calculation result of the value v/c vs. c'/c

From this figure, it can be seen that the speed of light decreases when the speed of electrons inside plasma approaches the light speed in vacuum.

Energy Generation by Chrenkov Radiation from the Plasma Field inside Corona

The core of the Sun is considered to extend from the center to about 0.2 to 0.25 solar radii, which has a temperature of close to 13,600,000 $°K$. This is hot enough to create conditions nuclear fusion, where atoms of hydrogen are fused together to create helium.

As solar radiation can be regarded as blackbody radiation, the energy density of thermal radiation from the core can be obtained by (McMahon, 2006).

$$\rho_E = \frac{\hbar}{\pi^2c^3}\int_0^\infty \frac{\omega^3 d\omega}{\exp(\hbar\omega/k_BT)-1} = \frac{\pi^2}{15}\frac{k_B^4T^4}{\hbar^3c^3}\,. \tag{15}$$

From Eq.(10), the total energy density by Cherenkov radiation ρ'_C can be given by

$$\rho'_C \approx 2\int_0^\infty (1+\varepsilon'^2)^{3/2}\frac{\hbar\omega^3}{2\pi^2c^3}\exp\left(-\sqrt{1+\varepsilon'^2}\,\gamma\, l_p\omega\right)\cdot\left[\exp\left(\frac{\hbar\omega}{k_BT}\right)-1\right]^{-1} d\omega\,, \tag{16}$$

From which, we have

$$\rho'_C \approx 6\frac{(1+\varepsilon'^2)^{3/2}}{\pi^2c^3\hbar^3}\zeta(4{,}1+\alpha')\,, \tag{17}$$

where $\alpha' = \sqrt{1+\varepsilon'^2}\,\alpha$

As the vacuum can have a temperature due to electromagnetic waves inside of it, then the ratio of the energy density radiated by Cherenkov effect from the ZPF field and the energy density of blackbody heat radiation of the Sun becomes

$$R \approx \rho_C' / \rho_E > \frac{90}{\pi^4}(1+\varepsilon^2)^{3/2}\zeta(4,1+\alpha'), \qquad (18)$$

The electrons accelerated in solar flares have very high velocities as a 30 keV electron has a speed of about 100,000 km per second, one-third the speed of light. The highest energy electrons accelerated in many flares travel at nearly the speed of light.

From Eq.(18), the ratio R considering the effects of the electron thermal speed can be estimated as shown in Fig. 3 inside the hot plasma where $T = 20000°K$.

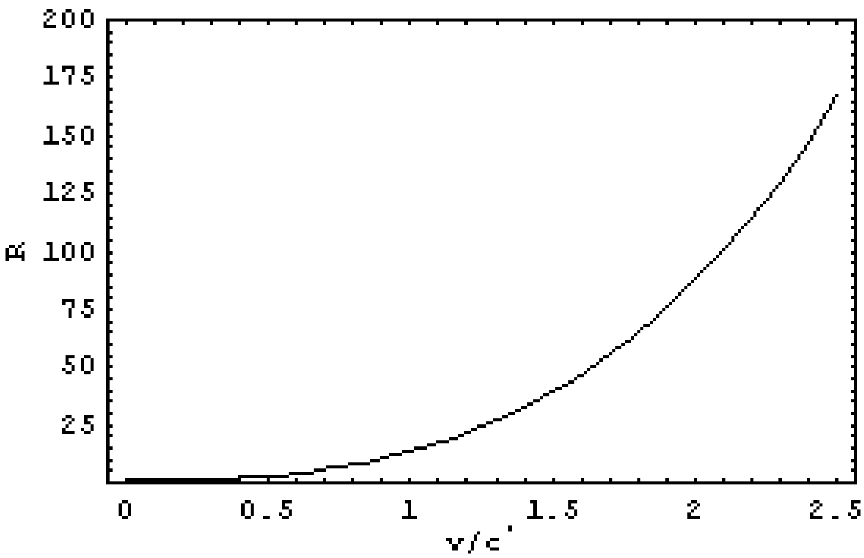

Fig. 3. The calculation result of v/c' vs. R

In media where the speed of light is reduced, it is still possible that other high energy particles, e.g. electrons, move faster than the speed of light in this medium.

From Fig. 2, it can be seen that the electron can move more than about 2.5 times the light speed in hot plasma of the Sun. Then the radiation energy reaches over 150 times the radiation energy of heat from the Sun as shown in Fig. 3.

This might explain that the corona is heated by the energy source except for the heat energy from the surface of the Sun and the temperature increased for the far-side from the surface of the Sun because the electron speed may be accelerated to the light speed in the plasma of outer space.

Hence we can consider that the heat by thermonuclear reaction of the core can induce the thermal radiation at the furthest layer from the sun's core by Cherenkov radiation from ZPF field of the vacuum and high temperature can be observed inside the corona outside of the Sun.

3. Conclusion

From the theoretical analysis, we can see that the heat by thermonuclear reaction of the core can induce the thermal radiation at the furthest layer from the sun's core by Cherenkov radiation from ZPF field of the vacuum and high temperature can be observed as the corona outside of the Sun. By the astronomical observation, the solar corona above the optical surface of the Sun has a temperature of 1,000,000 $°K$, which shows that the corona is heated by something other than the high-energy photons released in fusion reactions inside the Sun. For the explanation of these observation results, we need to reconsider the present solar model and another explanation of the solar energy source must be studied including Cherenkov radiation from the ZPF field.

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