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Variable Physical Constants and Beyond

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Abstract

We previously revealed that the speed of light in vacuum c, the gravitational constant G, the vacuum permittivity ε, and the vacuum permeability μ can be defined by the temperature T (or the expected average frequency f) of cosmic microwave background (CMB) radiation. Given that CMB is continuously cooling, that is, T is continuously decreasing, we proposed that the above "constants" are variable and their values at some space-time with CMB temperature T (c_T, G_T, ε_T, and μ_T) can be described using their values (c_0, G_0, ε_0, and μ_0) and the temperature (T_0) of CMB at present space-time. Based on the above observation, a number of physical equations related with these constants are re-described in this study, including relativity equation, mass-energy equation, and Maxwell's equations, etc.

Keywords

Speed of Light in Vacuum, Gravitational Constant, Vacuum Permittivity, Vacuum Permeability, Cosmic Microwave Background

1. Background

Constant speed of light in vacuum is the basis of relativity theory and modern physics. However, we previously revealed a possibility of variable speed of light in vacuum [1] through investigating relations of fine-structure constant and cosmic microwave background (CMB) [2].

We provided evidence for the variable speed of light in vacuum as well [1]. Moreover, for other three famous physical constants, gravitational constant G, vacuum permittivity ε, and vacuum permeability μ, we also suggested possibility of their variability as well [1]. In summary, we revealed that all of the four constants are being variable with the temperature (or expected average frequency) of CMB. As a result, we proposed Equations (1)-(4) to describe the speed of light in vacuum (c_T), the gravitational constant (G_T), the vacuum permittivity (ε_T), and the vacuum permeability (μ_T) at a space-time with CMB temperature T using the temperature (T_0) of CMB and the speed of light in vacuum (c_0), the gravitational constant (G_0), the vacuum permittivity (ε_0), and the vacuum permeability (μ_0) at present space-time.

$$c_T = \frac{T}{T_0} c_0 \tag{1}$$

$$G_T = \frac{T^2}{T_0^2} G_0 \tag{2}$$

$$\varepsilon_T = \frac{T_0}{T} \varepsilon_0 \tag{3}$$

$$\mu_T = \frac{T_0}{T} \mu_0 \tag{4}$$

where the latest value of c_0 is 299,792,458 meters/second (m/s), which was measured by National Bureau of Standards in 1983 [3]. Given the suggested possibility of variability of the above "constants", it is expected that a number of physical equations related with these constants should be re-described.

2. Physical Equations Should Be Re-Described

Given the above observations, it is expected that most of the established physical equations related with the four "constants" should be re-described. There are indeed a big number of equations including these constants should be re-described. For simplicity, we use X_0 and X_T to denote variable/constant X at present space-time and at some space-time with CMB temperature T, respectively.

2.1. Gravitational Constant *G* Related Physical Equations

The Newtonian gravitational constant is one of the most fundamental constants of our nature, which was first proposed by Isaac Newton and is used in calculating the gravitational force between two objects according to the equation of Newton's law of gravitation, as shown in Equation (5).

$$F_0 = G_0 \frac{Mm}{R^2} \tag{5}$$

where M and m are the mass of some two objects, R and F are the distance and the gravitational force between the two objects. However, we revealed that G is not a real constant but change with CMB temperature as Equation (2). Therefore, the first physical equation should be re-described is the famous Newton's universal gravitation equation, that is, Equation (5), which should be re-described as

$$F_T = \frac{T^2}{T_0^2} G_0 \frac{Mm}{R^2} = \frac{T^2}{T_0^2} F_0 \tag{6}$$

Meanwhile, the gravitational field strength or gravitational acceleration g (Equation (7)) sourced by the mass M will be re-described as Equation (8).

$$g_0 = G_0 \frac{M}{R^2} \tag{7}$$

$$g_T = \frac{T^2}{T_0^2} G_0 \frac{M}{R^2} = \frac{T^2}{T_0^2} g_0 \tag{8}$$

Then the equation (Equation (9)) of the gravitational potential energy (GPE) should be re-written as Equation (10).

$$GPE_0 = mg_0 h \tag{9}$$

$$GPE_T = mg_T h = m\frac{T^2}{T_0^2} g_0 h \tag{10}$$

Law of free fall (Equation (11)) defines the movement of an object only under the influence of uniform gravitational field, which gives the vertical velocity $v(t)$ and altitude $y(t)$ during time t for an object with initial velocity v_0 and initial altitude y_0.

$$\begin{cases} v(t) = v_0 - g_0 t \\ y(t) = v_0 t + y_0 - \frac{1}{2} g_0 t^2 \end{cases} \tag{11}$$

Given Equation (8), then the above equation should be re-described as

$$\begin{cases} v(t) = v_0 - \frac{T^2}{T_0^2} g_0 t \\ y(t) = v_0 t + y_0 - \frac{1}{2}\frac{T^2}{T_0^2} g_0 t^2 \end{cases} \tag{12}$$

Another issue is buoyant force, which is an upward force exerted by fluids (for example liquids and gas) in the presence of gravity. It is known that buoyant force can be given by

$$F_{buoyant}^0 = \rho g_0 V \tag{13}$$

where ρ is the density of the fluid, V is the volume of the fluid displaced, and g is the gravitational acceleration. Naturally, buoyant force is resulted from the differences in hydrostatic gauge pressure between the bottom and the top of the object in the fluid. The pressure is given by

$$P_0 = \rho g_0 h \tag{14}$$

Then, given Equation (8), Equation of (13) and (14) at a space-time with CMB temperature T should be re-described as Equation of (15) and (16), respectively.

$$F_{buoyant}^T = \rho \frac{T^2}{T_0^2} g_0 V \tag{15}$$

$$P_T = \rho \frac{T^2}{T_0^2} g_0 h \tag{16}$$

Similarly, the famous Bernoulli's Equation (17), also called Bernoulli's principle), which connects the speed, height, and pressure of two points in a steady flowing fluid with density ρ. should be re-described as (18).

$$P_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g_0 h_2 \quad (17)$$

$$P_1 + \frac{1}{2}\rho v_1^2 + \rho \frac{T^2}{T_0^2} g_0 h_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho \frac{T^2}{T_0^2} g_0 h_2 \quad (18)$$

For the issue of gas density in the air, it is known that the density n (in the number of molecules in unit volume) of one type of gas (e.g. the oxygen) can be given by

$$n = n_0 \mathrm{e}^{-mgh/kT_{mol}} \quad (19)$$

where n_0 is the molecule density at height $h = 0$, m is the mass of each gas molecule, h is the height relative to h_0, k is the Boltzmann's constant, and T_{mol} is the average temperature of the gas molecule. Then, for a space-time with CMB T, the above equation should be re-described as

$$n_T = n_0 \mathrm{e}^{-m\frac{T^2}{T_0^2}g_0 h/kT_{mol}} \quad (20)$$

More importantly, given that some famous physical equations, for example, the Einstein's equation for general relativity, should be also re-described because it contains G, we will introduce it in the following section as it also contains speed of light in vacuum.

2.2. Speed of Light in Vacuum, Vacuum Permittivity and the Vacuum Permeability Related Physical Equations

There are a big number of physical equations that contains the speed of light in vacuum and vacuum permittivity. Some of them also include gravitational constant and vacuum permeability. One of the most famous equations is the Einstein's equation for general relativity which include both speed of light in vacuum and gravitational constant, as the following equation,

$$R_{\mu\nu} - \frac{1}{2} R g_{\mu\nu} = \frac{8\pi G_0}{c_0^4} T_{\mu\nu} \quad (21)$$

According to Equations (1) and (2), the Einstein's equation for general relativity at some space-time with CMB temperature T will be

$$R_{\mu\nu} - \frac{1}{2} R g_{\mu\nu} = \frac{8\pi \frac{T^2}{T_0^2} G_0}{\left(\frac{T}{T_0} c_0\right)^4} T_{\mu\nu} \quad (22)$$

That is,

$$R_{\mu\nu} - \frac{1}{2} R g_{\mu\nu} = \frac{8\pi T_0^2 G_0}{T^2 c_0^4} T_{\mu\nu} \quad (23)$$

Another physical equation including both speed of light in vacuum and gravitational constant is Temperature of Black holes (Equation (24)), whose new form will be Equation (25).

$$T_{BH0} = \frac{hc_0^3}{8\pi k G_0 m} \tag{24}$$

$$T_{BHT} = \frac{hT^2 T T_0^2 c_0^3}{8\pi k G_0 m} \tag{25}$$

The most famous equation contains both physical constants of vacuum permittivity and vacuum permeability could be the Maxwell's Equations whose forms in vacuum are as follows

$$\nabla \cdot \boldsymbol{E} = \frac{\rho}{\varepsilon_0} \tag{26}$$

$$\nabla \cdot \boldsymbol{H} = 0 \tag{27}$$

$$\nabla \times \boldsymbol{E} = -\mu_0 \frac{\partial H}{\partial t} \tag{28}$$

$$\nabla \times \boldsymbol{H} = \boldsymbol{J} + \varepsilon_0 \frac{\partial \boldsymbol{E}}{\partial t} \tag{29}$$

Then the re-described Maxwell's Equations in vacuum will be as follows

$$\nabla \cdot \boldsymbol{E} = \frac{T\rho}{T_0 \varepsilon_0} \tag{30}$$

$$\nabla \cdot \boldsymbol{H} = 0 \tag{31}$$

$$\nabla \times \boldsymbol{E} = -\frac{T_0 \mu_0}{T} \frac{\partial H}{\partial t} \tag{32}$$

$$\nabla \times \boldsymbol{H} = \boldsymbol{J} + \frac{T_0 \varepsilon_0}{T} \frac{\partial \boldsymbol{E}}{\partial t} \tag{33}$$

Some other famous physical equations should be re-described including Mass-Energy equation from Equations (34) to (35), and Coulomb Equation from Equations (36) to (37).

$$\begin{cases} E_0 = mc_0^2 & (34) \\ E_T = m\dfrac{T^2}{T_0^2} c_0^2 & (35) \end{cases}$$

$$\begin{cases} F_{e0} = \dfrac{q_1 q_2}{4\pi \varepsilon_0 r^2} & (36) \\ F_{eT} = \dfrac{q_1 q_2}{4\pi \varepsilon_0 r^2} \dfrac{T}{T_0} & (37) \end{cases}$$

Because the number of physical equations including these constants is very big, we will not re-describe them one by one here but give a list for part of these physical equations. Table 1 list some equations including the original ones and the new ones. Which constant(s) included are also introduced as well.

3. Equations Do Not Need to Be Re-Described

Besides the above four constants, some equations including these constants may not need to be re-described. Here, we summarize some of these equations in Table 2.

Table 1. List of the original equations and corresponding new equations re-described by the temperature (T_0) and speed of light in vacuum (c_0), gravitational constant (G_0), vacuum permittivity (ε_0), and vacuum permeability (μ_0) at present space-time, and the temperature T at some space-time.

Equation (which constant)	Original Equation (T_0)	New Equation (T)
Einstein's Equation for Special Relativity (c_0)	$\Delta t_B = \frac{\Delta t_A}{\sqrt{1-\frac{v^2}{c^2}}}$ $u(v_r, v') = \frac{v_r + v'}{1+\frac{v_r v'}{c^2}}$	$\Delta t_{BT} = \frac{\Delta t_{AT}}{\sqrt{1-\frac{T_0^2 v^2}{T^2 c_0^2}}}$ $u(v_r, v')_T = \frac{v_r + v'}{1+\frac{T_0^2 v_r v'}{T^2 c_0^2}}$
Dirac Equation (c_0)	$\left(\beta mc^2 + c\int_{n=1}^{3}\alpha_n p_n\right)\varphi(x,t) = ih\frac{\partial\varphi(x,t)}{\partial t}$	$\left(\beta m\frac{T^2}{T_0^2}c_0^2 + \frac{T}{T_0}c_0\int_{n=1}^{3}\alpha_n p_n\right)\varphi(x,t) = ih\frac{\partial\varphi(x,t)}{\partial t}$
Planck's Equation for Blackbody Radiation (c_0)	$\frac{N(v)}{V}\mathrm{d}v = \frac{8\pi}{c_0^3}v^2\frac{1}{\mathrm{e}^{hv/kT_{bd}}-1}\mathrm{d}v$	$\frac{N(v)}{V}\mathrm{d}v = \frac{8\pi T_0^3}{T^3 c_0^3}v^2\frac{1}{\mathrm{e}^{hv/kT_{bd}}-1}\mathrm{d}v$
plasma frequency (ε_0)	$w_p^2 = \frac{n_0 q_e^2}{\varepsilon_0 m_e}$	$w_{pT}^2 = \frac{T n_0 q_e^2}{T_0 \varepsilon_0 m_e}$
Ampere's law (ε_0, c_0)	$\oint B\cdot\mathrm{d}s = \frac{I}{\varepsilon_0 c_0^2}$	$\oint B\cdot\mathrm{d}s = \frac{T_0 I}{T\varepsilon_0 c_0^2}$

Table 2. List of the equations do not need to be re-described.

Term	Original form
Schwarzschild radius	$R_s = \frac{2G_0M}{c_0^2}$
Gravitational redshift	$\frac{\Delta f}{f} = \frac{g_0 h}{c_0^2}$
Precession of Mercury's perihelion	$\Delta\theta = \frac{6\pi G_0 M}{a_0 c_0^2(1-\varepsilon^2)}$
Vacuum impedance	$Z_0 = 1/\varepsilon_0 c_0$

*ε in this table is the eccentricity rate of the Mercury's orbit.

4. Question on Planet's Ellipses Orbits

Given the variable physical constants addressed above, it is expected that some physical rules should be also re-visited besides a big number of physical equations. One example is that the planet's orbits. It is well known that planets run on ellipses orbits, which is then closed orbits. Meanwhile, it is widely accepted that the reasons the orbits are elliptical but not circle are resulted from gravitational forces from other planets or meteor collision. However, as we addressed above, the gravitational constant is variable and is decreasing along the present space-time. The gravitational force between the planets and their stars will decrease and then the orbits could be not elliptical although they looks very similar to be elliptical as gravitational force decreases very slowly. Moreover, their orbits are not closed but should be logarithmic spiral which can be described by

$$\rho = \frac{r}{k}\left(e^{k\theta} - 1\right) \quad (38)$$

where θ is some degree (relative position) of the planet and its star, r is the original/basic radius between them, ρ is the length of the logarithmic spiral from the original point and the current position (or the degree of θ), and $k > 0$. When k is close to zero, the above equation will be lose to that of a circle with radius of r, as described by the following equation,

$$\lim_{k \to 0} \frac{r}{k}\left(e^{k\theta} - 1\right) = r\theta \quad (39)$$

Given that the gravitational constant is continuously decreasing, not only the planet-star systems but also all celestial body systems are moving away with each other and the orbit eccentricity is then becoming bigger and bigger. One example is the Earth-Moon system. If we assume that the orbit is perfectly circle when it was born, that is originally orbit eccentricity = 0, we then may estimate the age of the Earth-Moon system based on their recession rate, Perigee distance, and Apogee distance. We previously calculated the recession rate of Earth-Moon is ~0.92 cm/year [1]. It is known that currently the Perigee distance and Apogee distance of Earth-Moon are 3.633×10^5 km and 4.055×10^5 km [4], respectively. If we assume the orbit eccentricity is mainly resulted from the decreasing gravitational constant induced recession, we may estimate the age of the Earth-Moon will be

$$\text{AGE}_{\text{Moon-Earth}} = \frac{4.055 \times 10^{10} - 3.633 \times 10^{10}}{0.92} = 4.577 \text{ billion years} \quad (40)$$

This estimated age is quite close to the estimated age (~4.51 billion years) of Moon by rocks [5] and that (~4.6 billion years) of Earth using a single-stage model based on the evolution of lead isotopes in the Earth [6]. Meanwhile, this prediction of Earth-Moon age (4.577 billion years) supports that Moon and Earth have the same origin or Moon is originally from Earth.

5. Conclusion and Discussion

In summary, using the variable four physical "constants" including speed of light in vacuum, gravitational constant, vacuum permittivity, and vacuum permeability, we re-described several important equations, for example the relativity equations and the Maxwell's equations. In addition, we also find some equations keep unchanged with the CMB temperature, for example gravitational red shift and Schwarzschild radius. Moreover, it is known that there are a big number of physical equations including the four constants and most of them may need to be re-described. In addition, the variable constant can predict the planets' orbits are logarithmic spiral, which is quite similar with ellipses orbits as the gravitation constant is decreasing very slowly. This further gives a totally different interpretation for the reason why planets' orbits are elliptical but not circle. Finally, given the above "variable" constants, we suggest that some standard international (SI) base units (e.g. Length—meter (m); Electric current—ampere (A)) should be also re-defined.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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