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Correction Procedure for Empirical Equations for Calculating the Cosmic Microwave Background Temperature

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Abstract

We build upon previously proposed empirical equations involving the cosmic microwave background (CMB) temperature and extend the approach to include an empirical formulation for the fine-structure constant. To ensure consistency across these relationships, revised values for the CMB temperature (T_c) and the gravitational constant (G) were obtained as 2.726312 K and 6.673778 × 10^{-11} $m^3 \cdot kg^{-1} \cdot s^{-2}$, respectively. Recognizing slight deviations from the experimentally observed values, the study aims to refine these predictions. An optimized procedure yielded a recalibrated CMB temperature of 2.7256307 K, directly matching the observed value of 2.72548 ± 0.00057 K. A central claim of this work is the validity of Equation (10) independent of the MKSA unit system. The recalculated gravitational constant, 6.68917534 × 10^{-11} $m^3 \cdot kg^{-1} \cdot s^{-2}$, however, remains marginally greater than the accepted value of 6.6743 × 10^{-11}. The paper also introduces potential compensation strategies to account for this discrepancy.

Keywords

Temperature of the Cosmic Microwave Background, Minimum Mass, Ratio of Gravitational Force to Electric Force, Dimension Analysis, Fine Structure Constant

1. Introduction

The symbol list is shown in Section 2. Previously, we described Equations (1)-(3) in terms of the cosmic microwave background (CMB) temperature [1]-[5].

$$\frac{Gm_p^2}{hc} = \frac{4.5}{2} \times \frac{kT_c}{1\,\mathrm{kg} \times c^2} \tag{1}$$

$$\frac{Gm_p^2}{\left(\frac{e^2}{4\pi\varepsilon_0}\right)} = \frac{4.5}{2\pi} \times \frac{m_e}{e} \times hc \tag{2}$$

$$\frac{m_e c^2}{e} \times \left(\frac{e^2}{4\pi\varepsilon_0}\right) = \pi \times kT_c \tag{3}$$

We then derived an empirical equation for the fine-structure constant [6]. Equation (4) and Equation (5) are related to the transference number [7] [8].

$$\frac{1}{\alpha} = 137.0359991 = 136.0113077 + \frac{1}{3\times 13.5} + 1 \tag{4}$$

$$13.5 \times 136.0113077 = 1836.152654 = \frac{m_p}{m_e} \tag{5}$$

We tried to reduce the errors [9]-[14]. For this purpose, the deviations of the values of 9/2 and π have been discussed. In the Appendix in a previous report [14], the following equations were presented.

$$3.1327945\left(\mathrm{V}\cdot\mathrm{m}\right) = \frac{\left(\frac{m_p}{m_e} + 1.7927128\right) m_e c^2}{ec} \tag{6}$$

$$4.4873976\left(\frac{1}{\mathrm{A}\cdot\mathrm{m}}\right) = \frac{q_m c}{\left(\frac{m_p}{m_e} + 1.7927128\right) m_p c^2} \tag{7}$$

Then, $\left(\frac{m_p}{m_e} + 1.7927128\right)$ has units of $\left(\frac{\mathrm{m}^2}{\mathrm{s}}\right)$. By redefining the Faraday constant, these values can be adjusted back to 9/2 and π [14].

$$\pi\left(\mathrm{V}\cdot\mathrm{m}\right) = \frac{\left(\frac{m_p}{m_e} + 1.7927128\right) \times m_e c^2}{e_{new} c} \tag{8}$$

$$4.5\left(\frac{1}{\mathrm{A}\cdot\mathrm{m}}\right) = \frac{q_{m\_new} c}{\left(\frac{m_p}{m_e} + 1.7927128\right) \times m_p c^2} \tag{9}$$

Then, we introduce the following simple equation.

$$m_p c^2 \times m_e c^2 \times \frac{4.5}{\pi} hc^2 = \left(2\pi(1) \times \frac{kT_c}{\alpha}\right)^2 = 1.04985584\mathrm{E}-39 \tag{10}$$

The main problem is that Equation (10) should be mathematically proven without using MKSA units.

Quantum mechanics [15] and gravity [16] have been used to provide thermodynamic explanations for the validity of this equation. Our motivation is to use thermodynamic principles in the area of solid-state ionics, which we discovered [17].

The remainder of this paper is organized as follows. In Section 2, we present the list of symbols used in our derivations. In Section 3, we propose ensuring the consistency of Equation (10) using MKSA units. In Section 4, we attempt to verify Equation (10) without using MKSA units. Furthermore, we propose compensation methods to adjust the value of the gravitational constant. In Section 5, our conclusions are provided.

2. Symbol List

2.1. MKSA Units

These Values Were Obtained from Wikipedia:

G: Gravitational constant: 6.6743×10^{-11} ($m^3 \cdot kg^{-1} \cdot s^{-2}$)
(we used the compensated value $6.68917534 \times 10^{-11}$ in this study)

T_c: CMB temperature: 2.72548 ± 0.00057 (K)
(we used the compensated value 2.725630647 K in this study)

k: Boltzmann constant: 1.380649×10^{-23} ($J \cdot K^{-1}$)

c: Speed of light: 299,792,458 (m/s)

h: Planck constant: $6.62607015 \times 10^{-34}$ (J·s)

ε_0: Electric constant: $8.8541878128 \times 10^{-12}$ ($N \cdot m^2 \cdot C^{-2}$)

μ_0: Magnetic constant: $1.25663706212 \times 10^{-6}$ ($N \cdot A^{-2}$)

e: Electric charge of one electron: $-1.602176634 \times 10^{-19}$ (C)

q_m: Magnetic charge of one magnetic monopole: $4.13566770 \times 10^{-15}$ (Wb)
(this value is only a theoretical value, $q_m = h/e$)

m_p: Resting mass of a proton: $1.67262192 \times 10^{-27}$ (kg)

m_e: Resting mass of an electron: $9.1093837 \times 10^{-31}$ (kg)

R_k: Von Klitzing constant: 25812.80745 (Ω)

Z_0: Wave impedance in free space: 376.730313668 (Ω)

α: Fine-structure constant: 1/137.035999081

λ_p: Compton wavelength of a proton: 1.32141×10^{-15} (m)

λ_e: Compton wavelength of an electron: $2.4263102367 \times 10^{-12}$ (m)

2.2. Symbol List after Redefinition

$$e_{new} = e \times \frac{4.4873976}{4.5} = 1.5976897\mathrm{E}-19\left(\mathrm{C}\right) \tag{11}$$

$$q_{m\_new} = q_m \times \frac{\pi}{3.1327945} = 4.1472823\mathrm{E}-15\left(\mathrm{Wb}\right) \tag{12}$$

$$h_{new} = e_{new} \times q_{m\_new} = h \times \frac{4.4873976}{4.5} \times \frac{\pi}{3.1327945} = 6.6260702\mathrm{E}-34\left(\mathrm{J} \cdot \mathrm{s}\right) = h \tag{13}$$

$$Rk_{\_new} = \frac{q_{m\_new}}{e_{\_new}} = Rk \times \frac{4.5}{4.4873976} \times \frac{\pi}{3.1327945} = 25957.997\left(\Omega\right) \tag{14}$$

Equation (13) can be rewritten as follows:

$$Rk_{new} = 4.5\left(\frac{1}{\mathrm{A} \cdot \mathrm{m}}\right) \times \pi\left(\mathrm{V} \cdot \mathrm{m}\right) \times \frac{m_p}{m_e} = 25957.997\left(\Omega\right) \tag{15}$$

$$Z_{0\_new} = \alpha \times \frac{2h_{new}}{e_{new}{}^2} = 2\alpha \times Rk_{new} = Z_0 \times \frac{4.5}{4.4873976} \times \frac{\pi}{3.1327945} = 378.84931(\Omega) \quad (16)$$

Equation (16) can be rewritten as follows:

$$Z_{0\_new} = 4.5\left(\frac{1}{\mathrm{A \cdot m}}\right) \times \pi(\mathrm{V \cdot m}) \times 2\alpha \times \frac{m_p}{m_e} = 378.84931(\Omega) \quad (17)$$

$$\mu_{0\_new} = \frac{Z_{0\_new}}{c} = \mu_0 \times \frac{4.5}{4.4873976} \times \frac{\pi}{3.1327945} = 1.2637053\mathrm{E}-06\left(\mathrm{N \cdot A^{-2}}\right) \quad (18)$$

$$\varepsilon_{0\_new} = \frac{1}{Z_{0\_new} \times c} = \varepsilon_0 \times \frac{4.4873976}{4.5} \times \frac{3.1327945}{\pi} = 8.8046642\mathrm{E}-12\left(\mathrm{F \cdot m^{-1}}\right) \quad (19)$$

$$c_{\_new} = \frac{1}{\sqrt{\varepsilon_{0\_new}\mu_{0\_new}}} = \frac{1}{\sqrt{\varepsilon_0 \mu_0}} = c = 299792458\left(\mathrm{m \cdot s^{-1}}\right) \quad (20)$$

The Compton wavelength (λ) is as follows:

$$\lambda = \frac{h}{mc} \quad (21)$$

The value (λ) should be unchanged since the unit for 1 m is unchanged. In this report, in Equation (13), Planck's constant is unchanged. However, the units for the masses of one electron and one proton can be redefined.

$$m_{e\_new} = m_e \times \frac{4.4873976}{4.5} \times \frac{\pi}{3.1327945} = m_e = 9.1093837\mathrm{E}-31(\mathrm{kg}) \quad (22)$$

$$m_{p\_new} = m_p \times \frac{4.4873976}{4.5} \times \frac{\pi}{3.1327945} = m_p = 1.6726219\mathrm{E}-27(\mathrm{kg}) \quad (23)$$

From the dimensional analysis in a previous report [9], the following expression is obtained:

$$kT_{c\_new} = kT_c \times \frac{4.4873976}{4.5} \times \frac{\pi}{3.1327945} = kT_c = 3.7631393\mathrm{E}-23(\mathrm{J}) \quad (24)$$

To simplify the calculation, G_N is defined as follows:

$$G_N = G \times 1\,\mathrm{kg}\left(\mathrm{m^3 \cdot s^{-2}}\right) = 6.68917521\mathrm{E}-11\left(\mathrm{m^3 \cdot s^{-2}}\right) \quad (25)$$

In this report, we propose the following compensation relation.

$$G_{N\_new} = G_N \times \frac{1}{(1.001113745)^2}\left(\frac{\mathrm{m^3}}{\mathrm{s^2}}\right) = 6.6743\mathrm{E}-11\left(\frac{\mathrm{m^3}}{\mathrm{s^2}}\right) \quad (26)$$

2.3. Symbol List in Terms of the Compton Length of an Electron (λ_e), the Compton Length of a Proton (λ_p) and α

The following equations were proposed in a previous study [10]:

$$m_{e\_new}c^2 \times \left(\frac{m_p}{m_e} + 1.7927128\right)^2 \left(\frac{\mathrm{J \cdot m^4}}{\mathrm{s^2}}\right) = \frac{\pi}{4.5}(\mathrm{V \cdot m \times A \cdot m}) \times \lambda_p c\left(\frac{\mathrm{m^2}}{\mathrm{s}}\right) = 2.76564\mathrm{E}-07\left(\frac{\mathrm{J \cdot m^4}}{\mathrm{s^2}}\right) \quad (27)$$

$$e_{new}c\times\left(\frac{m_p}{m_e}+1.7927128\right)\left(\frac{\text{A}\cdot\text{m}^3}{\text{s}}\right)$$
$$=\frac{1}{4.5}(\text{A}\cdot\text{m})\times\lambda_p c\left(\frac{\text{m}^2}{\text{s}}\right)=8.80330\text{E}-08\left(\frac{\text{A}\cdot\text{m}^3}{\text{s}}\right) \quad (28)$$

$$m_{p\_new}c^2\times\left(\frac{m_p}{m_e}+1.7927128\right)^2\left(\frac{\text{J}\cdot\text{m}^4}{\text{s}^2}\right)$$
$$=\frac{\pi}{4.5}\left(\frac{\text{J}\cdot\text{m}^2}{\text{s}}\right)\times\lambda_e c\left(\frac{\text{m}^2}{\text{s}}\right)=5.07814\text{E}-04\left(\frac{\text{J}\cdot\text{m}^4}{\text{s}^2}\right) \quad (29)$$

$$q_{m\_new}c\times\left(\frac{m_p}{m_e}+1.7927128\right)\left(\frac{\text{V}\cdot\text{m}^3}{\text{s}}\right)$$
$$=\pi(\text{V}\cdot\text{m})\times\lambda_e c\left(\frac{\text{m}^2}{\text{s}}\right)=2.28516\text{E}-03\left(\frac{\text{V}\cdot\text{m}^3}{\text{s}}\right) \quad (30)$$

$$kT_{c\_new}\times\frac{2\pi}{\alpha}\times\left(\frac{m_p}{m_e}+1.7927128\right)^3\left(\frac{\text{J}\cdot\text{m}^6}{\text{s}^3}\right)$$
$$=\frac{\pi}{4.5}\left(\frac{\text{J}\cdot\text{m}^2}{\text{s}}\right)\times\lambda_p c\times\lambda_e c=2.011697\text{E}-10\left(\frac{\text{J}\cdot\text{m}^6}{\text{s}^3}\right) \quad (31)$$

$$G_{N\_new}\left(\frac{\text{m}^3}{\text{s}^2}\right)\times\left(\frac{m_p}{m_e}+1.7927128\right)\left(\frac{\text{m}^2}{\text{s}}\right)$$
$$=\left(\lambda_p c\right)^2\left(\frac{\text{m}^4}{\text{s}^2}\right)\times c\left(\frac{\text{m}}{\text{s}}\right)\times\frac{9\alpha}{8\pi}=1.22943\text{E}-07\left(\frac{\text{m}^5}{\text{s}^3}\right) \quad (32)$$

2.4. Symbol List for the Advanced Expressions for kT_c and G_N

Furthermore, we propose the following equations [11]:

$$kT_{c\_new}(\text{J})=\frac{\alpha}{2\pi(1)}\times\frac{1}{\pi}\left(\frac{1}{\text{V}\cdot\text{m}}\right)\times q_{m\_new}c\times m_{e\_new}c^2=3.7631393\text{E}-23 \quad (33)$$

$$kT_{c\_new}(\text{J})=\frac{\alpha}{2\pi(1)}\times4.5\left(\frac{1}{\text{A}\cdot\text{m}}\right)\times e_{new}c\times m_{p\_new}c^2=3.7631393\text{E}-23 \quad (34)$$

In Equation (33) and Equation (34), $2\pi(1)$ is dimensionless. For G, two equations exist, as follows:

$$G_{N\_new}\left(\frac{\text{m}^3}{\text{s}^2}\right)=\alpha c\frac{4.5(1)}{4\pi(1)}\times(4.5\times e_{new}c)\times e_{new}c\times\frac{q_{m\_new}c}{m_{p\_new}c^2}$$
$$=6.68917521\text{E}-11\left(\frac{\text{m}^3}{\text{s}^2}\right) \quad (35)$$

$$G_{N\_new}\left(\frac{\text{m}^3}{\text{s}^2}\right)=\alpha c\frac{4.5(1)}{4\pi(1)}\times(4.5\times e_{new}c)^2\times e_{new}c\times\frac{\pi(\text{V}\cdot\text{m})}{m_{e\_new}c^2}$$
$$=6.68917521\text{E}-11\left(\frac{\text{m}^3}{\text{s}^2}\right) \quad (36)$$

In Equation (35) and Equation (36), $4\pi(1)$ and $4.5(1)$ are dimensionless.

2.5. Symbol List for the Algorithms Used to Explain Our Empirical Equations

2.5.1. Equations for Establishing the First Symbol List

Equation (37) and Equation (38) are important for establishing the first symbol list. The following expressions can be obtained on the basis of Equations (27)-(32) [13].

$$\frac{h}{m_p} = \frac{h_{new}}{m_{p\_new}} = 3.9614871\text{E}-07 = \text{experimental result} \tag{37}$$

$$\frac{h}{m_e} = \frac{h_{new}}{m_{e\_new}} = 7.2738951\text{E}-04 = \text{experimental result} \tag{38}$$

$$\begin{aligned} e_{new}c(\text{A}\cdot\text{m}) &= \frac{1}{4.5}\times\frac{h}{m_p}\times\left(\frac{m_p}{m_e}+1.7927128\right)^{-1}(\text{A}\cdot\text{m}) \\ &= 4.78975317\text{E}-11(\text{A}\cdot\text{m}) \end{aligned} \tag{39}$$

$$\begin{aligned} q_{m\_new}c(\text{V}\cdot\text{m}) &= \pi\times\frac{h}{m_e}\times\left(\frac{m_p}{m_e}+1.7927128\right)^{-1}(\text{V}\cdot\text{m}) \\ &= 1.24332398\text{E}-06(\text{V}\cdot\text{m}) \end{aligned} \tag{40}$$

$$\begin{aligned} m_{e\_new}c^2(\text{J}) &= \frac{\pi}{4.5}\times\frac{h}{m_p}\times\left(\frac{m_p}{m_e}+1.7927128\right)^{-2}(\text{J}) = m_e c^2(\text{J}) \\ &= 8.18710591\text{E}-14(\text{J}) \end{aligned} \tag{41}$$

$$\begin{aligned} m_{p\_new}c^2(\text{J}) &= \frac{\pi}{4.5}\times\frac{h}{m_e}\times\left(\frac{m_p}{m_e}+1.7927128\right)^{-2}(\text{J}) = m_p c^2 \\ &= 1.50327764\text{E}-10(\text{J}) \end{aligned} \tag{42}$$

$$\begin{aligned} h_{new}c^2\left(\frac{\text{J}\cdot\text{m}^2}{\text{s}}\right) &= \frac{\pi}{4.5}\times\frac{h}{m_p}\times\frac{h}{m_e}\times\left(\frac{m_p}{m_e}+1.7927128\right)^{-2}\left(\frac{\text{J}\cdot\text{m}^2}{\text{s}}\right) = hc^2 \\ &= 5.95521\text{E}-17\left(\frac{\text{J}\cdot\text{m}^2}{\text{s}}\right) \end{aligned} \tag{43}$$

$$\begin{aligned} \frac{kT_{c\_new}}{\alpha}(\text{J}) &= \frac{1}{2\pi(1)}\times\frac{\pi}{4.5}\times\frac{h}{m_p}\times\frac{h}{m_e}\times\left(\frac{m_p}{m_e}+1.7927128\right)^{-3}(\text{J}) = \frac{kT_c}{\alpha}(\text{J}) \\ &= 5.15685567\text{E}-21(\text{J}) \end{aligned} \tag{44}$$

$$\begin{aligned} G_{N\_new}\left(\frac{\text{m}^3}{\text{s}^2}\right) &= \alpha c\frac{4.5(1)}{4\pi(1)}\times\left(\frac{h}{m_p}\right)^2\times\left(\frac{m_p}{m_e}+1.7927128\right)^{-1}\left(\frac{\text{m}^3}{\text{s}^2}\right) \\ &= 6.68917527\text{E}-11 \end{aligned} \tag{45}$$

2.5.2. Equations for Establishing the Second Symbol List

An arbitrary value of the speed of light is used to establish the second symbol list, and the following example is given:

$$c_{\text{arbitrary}} = 12345\left(\frac{\text{m}_{\text{arbitrary}}}{\text{s}}\right) \tag{46}$$

where $c_{\text{arbitrary}}$ and 1 $\text{m}_{\text{arbitrary}}$ are the values for c and 1 m when an arbitrary value of the speed of light is used, respectively. Importantly, Equation (46) does not indicate a change in the speed of light. The first list in Section 2.5.1 remains useful [13] when the definition of the unit of a meter is changed.

2.6. Normalization Methods from the Previous Study

In a previous study [14], Equation (47) and Equation (48) were verified as correct.

$$\frac{1}{\varepsilon_{0\_new}c}\left(\Omega=\frac{\text{kg}}{\text{C}^2}\times\frac{\text{m}^2}{\text{s}}\right)=\frac{kT_{c\_new}/\alpha c^2}{(e_{new})^2}\times\left(\frac{m_p}{m_e}+1.7927128\right)\times 2\pi(1)\times 2\alpha = 378.8493064(\Omega) \tag{47}$$

$$\mu_{0\_new}c(\Omega)=\frac{kT_{c\_new}/\alpha c^2}{(e_{new})^2}\times\left(\frac{m_p}{m_e}+1.7927128\right)\times 2\pi(1)\times 2\alpha = 378.8493064(\Omega) \tag{48}$$

The conceptual expression for the standard second [14] is as follows, but it should be rejected in this report.

$$1s_{\text{standard}}=\frac{1}{299792458^2}(\text{s})=1.11265\text{E}-17(\text{s}) \tag{49}$$

In Equation (49), we use 1 cm instead of 1 m, and the definition of the standard second is changed.

$$1s_{\text{standard}}=\frac{1}{29979245800^2}(\text{s})=1.11265\text{E}-21(\text{s}) \tag{50}$$

3. Methods

In this section, we explain Equation (10). For convenience, Equation (10) is rewritten as follows:

$$m_pc^2\times m_ec^2\times\frac{4.5}{\pi}hc^2=\left(2\pi(1)\times\frac{kT_c}{\alpha}\right)^2=1.04985584\text{E}-39 \tag{51}$$

Using Equation (10), T_c can be calculated. The calculated value was 2.72563070 K. The observed value was 2.72548 ± 0.00057 K. Therefore, the calculated value was adjusted. Clearly, this is not a coincidence. We explain Equation (10) via the following procedure. In this section, we examine Step 1 below.

Step 1: Explanation for the consistency of Equation (10);

Step 2: Without using MKSA units, mathematically prove Equation (10).

3.1. Step 1: Explanation for the Consistency of Equation (10)

3.1.1. Relationships between the Equations in Section 2.5.1 and Equation (10)

First, we name the coefficient related to length (m^2/s) as follows. In general, we used k_L. When we used MKSA units, we used k_{L0}.

$$k_L\left(\frac{\text{m}^2}{\text{s}}\right)=\left(\frac{m_p}{m_e}+1.7927128\right)\left(\frac{\text{m}^2}{\text{s}}\right)\equiv k_{L0} \tag{52}$$

Equations (37)-(45) are correct, even if the value of k_L is changed. For example,

$$k_L\left(\frac{\text{m}^2}{\text{s}}\right)=\left(\frac{m_p}{m_e}+\frac{4}{3}\right)\left(\frac{\text{m}^2}{\text{s}}\right) \tag{53}$$

$$m_{e\_new}c^2\left(\text{J}\right)=\frac{\pi}{4.5}\times\frac{h}{m_p}\times\left(\frac{m_p}{m_e}+\frac{4}{3}\right)^{-2}\left(\text{J}\right)=8.19120012\text{E}-14\left(\text{J}\right)\neq m_ec^2 \tag{54}$$

Equation (53) has already been explored. However, the values of other mass energy terms for electrons are changed. This means that Equation (54) is not based on MKSA units. From Equation (43),

$$\left(hc^2\right)^3=\left(\frac{\pi}{4.5}\times\frac{h}{m_p}\times\frac{h}{m_e}\right)^3\times\left(\frac{m_p}{m_e}+1.7927128\right)^{-6} \tag{55}$$

From Equation (44),

$$\left(\frac{kT_c}{\alpha}\right)^2=\left(\frac{1}{2\pi(1)}\times\frac{\pi}{4.5}\times\frac{h}{m_p}\times\frac{h}{m_e}\right)^2\times\left(\frac{m_p}{m_e}+1.7927128\right)^{-6} \tag{56}$$

k_{L0} can be removed from Equation (55) and Equation (56), and Equation (51) can be obtained.

3.1.2. Relationship between the Avogadro Number and k_{L0}

Using k_{L0}, the Avogadro number can be defined as follows. Strictly speaking, in the following Equations, we calculate the number of a particle mass in 1 kg (MKSA units), which is different from the Avogadro number.

$$\begin{aligned}\frac{1\,\text{kg}}{m_p}&=5.9786374066\text{E}+26\\&=\frac{4.5}{\pi}\left(\frac{1}{\text{A}\cdot\text{m}\cdot\text{V}\cdot\text{m}}=\frac{\text{s}}{\text{J}\cdot\text{m}^2}\right)\times\frac{\pi}{q_mc}\times k_{L0}\times 1\,\text{kg}\times c^2\end{aligned} \tag{57}$$

$$\frac{1\,\text{kg}}{m_e}=1.09776911\text{E}+30=\frac{4.5}{\pi}\times\frac{1}{4.5ec}\times k_{L0}\times 1\,\text{kg}\times c^2 \tag{58}$$

$$\frac{\alpha c^2}{kT_c}\times 1\,\text{kg}=1.74283567\text{E}+37=\frac{2\pi(1)}{hc^2}\times k_{L0}\times 1\,\text{kg}\times c^2 \tag{59}$$

In Equation (57) and Equation (58),

$$\frac{\pi}{q_{m\_new}c}(1)=\frac{m_ec^2}{2\pi(1)}\times\frac{\alpha}{kT_c\left(\text{J}\right)}=2.52676916\text{E}+06 \tag{60}$$

Equation (60) represents the mass ratio between the electron mass and the minimum mass.

$$\frac{1}{4.5e_{new}c}(1)=\frac{m_pc^2}{2\pi(1)}\times\frac{\alpha}{kT_c\left(\text{J}\right)}=4.63953394\text{E}+09 \tag{61}$$

Equation (61) represents the mass ratio between the proton mass and the minimum mass. From Equation (59),

$$\frac{h}{2\pi(1)}=\frac{kT_c}{\alpha c^2}\times k_{L0} \tag{62}$$

Equation (62) expresses the relationship between the Dirac constant and the minimum mass. From Equation (57) and Equation (58), the following equation can be obtained.

$$m_p c^2 \times k_{L0} \times m_e c^2 \times k_{L0} = \frac{\pi}{4.5} \times hc^2 = 4.15752428\text{E}-17 \quad (63)$$

From Equation (63), k_{L0} can be precisely expressed as follows.

$$k_{L0} = 1837.94538246966 \left(\frac{\text{m}^2}{\text{s}} \right) \quad (64)$$

The value of k_{L0} depends on the Avogadro number and is not related to the mass ratio between a proton and an electron. Therefore, Equation (64) is the correct expression rather than Equation (52). However, we use Equation (52) for compatibility with past reports.

3.1.3. Explanation for Equation (63)

Equation (63) is explained in this section. For convenience, Equation (22) is rewritten as follows:

$$m_{e\_new} = m_e \times \frac{4.4873976}{4.5} \times \frac{\pi}{3.1327945} = m_e = 9.1093837\text{E}-31(\text{kg}) \quad (65)$$

For convenience, Equation (6) is rewritten as follows:

$$3.1327945(\text{V} \cdot \text{m}) = \frac{k_{L0} \times m_e c^2}{ec} \quad (66)$$

For convenience, Equation (7) is rewritten as follows:

$$4.4873976 \left(\frac{1}{\text{A} \cdot \text{m}} \right) = \frac{q_m c}{k_{L0} \times m_p c^2} \quad (67)$$

When Equation (66) and Equation (67) are used, Equation (65) becomes

$$m_{e\_new} = m_e \times \frac{\pi}{4.5} \times \frac{ec}{k_{L0} \times m_e c^2} \times \frac{q_m c}{k_{L0} \times m_p c^2} \quad (68)$$

Therefore, when m_{e_new} equals m_e,

$$m_p c^2 \times k_{L0} \times m_e c^2 \times k_{L0} = \frac{\pi}{4.5} \times hc^2 = 4.15752428\text{E}-17 \quad (69)$$

3.1.4. Explanation for kT_c/α

In Equation (10), kT_c/α plays an important role and requires an explanation. In the area of solid-state ionics, the equation is

$$Vth - OCV = \frac{Ea}{2e} \times (1 - t_{ion}) \quad (70)$$

where Vth, OCV, Ea and t_{ion} are the Nernst voltage, open-circuit voltage, ionic activation energy and ionic transference number, respectively. Equation (70) can be explained by Jarzynski's equality [17]. Further detailed investigations will be continuously undertaken.

For example, Vth is 1.15 V, the OCV is 0.80 V, Ea is 0.7 eV, and t_{ion} is 0.

$$1.15\ \text{V} - 0.80\ \text{V} = \frac{0.7\ \text{eV}}{2e} \times (1-0) \tag{71}$$

Here, α is the interaction coefficient. Therefore,

$$\alpha = 1 - t_{ion} \tag{72}$$

From Equation (70),

$$(Vth - OCV) \times 2e = Ea \times \alpha \tag{73}$$

The left side of Equation (73) represents the energy loss due to dissipation. Therefore,

$$kT_c = Ea \times \alpha \tag{74}$$

Accordingly, the CMB temperature is the dissipation energy. From Equation (74),

$$Ea = \frac{kT_c}{\alpha} \tag{75}$$

Thus, we suggest that Equation (75) expresses the activation energy of the space.

3.1.5. Explanation for the Redefinition Method Using k_{L0}

After redefinition, only the values of the electric charge and the magnetic charge can be changed.

Paul Dirac proposed the following equation.

$$h = e \times q_m \tag{76}$$

He subsequently proposed the concept of the monopole, which has never been observed. However, he did not know about R_k (von Klitzing constant). We changed the value of R_k.

For convenience, Equation (11), Equation (12) and Equation (14) are rewritten as follows:

$$e_{new} = e \times \frac{4.4873976}{4.5} = 1.5976897\text{E}-19(\text{C}) \tag{77}$$

$$q_{m\_new} = q_m \times \frac{\pi}{3.1327945} = 4.1472823\text{E}-15(\text{Wb}) \tag{78}$$

$$Rk_{\_new} = \frac{q_{m\_new}}{e_{\_new}} = Rk \times \frac{4.5}{4.4873976} \times \frac{\pi}{3.1327945} = 25957.997(\Omega) \tag{79}$$

When using k_{L0},

$$\frac{4.4873976}{4.5} \times \frac{\pi}{3.1327945} = 1 \tag{80}$$

Therefore, the value of the Planck constant is unchanged, where

$$h = e_{new} \times e_{new} \times Rk_{new} \tag{81}$$

$$h = q_{m\_new} \times q_{m\_new} / Rk_{new} \tag{82}$$

For convenience, Equation (15) is rewritten as follows:

$$Rk_{new} = 4.5\left(\frac{1}{\text{A}\cdot\text{m}}\right) \times \pi(\text{V}\cdot\text{m}) \times \frac{m_p}{m_e} = 25957.997(\Omega) \tag{83}$$

Therefore,

$$e_{new}\left(\mathrm{C}\right)=\sqrt{\frac{h}{4.5\pi\frac{m_p}{m_e}}}=1.597689670\mathrm{E}-19\left(\mathrm{C}\right) \tag{84}$$

$$q_{m\_new}\left(\mathrm{Wb}\right)=\sqrt{h\times 4.5\pi\frac{m_p}{m_e}}=4.147282338\mathrm{E}-15\left(\mathrm{Wb}\right) \tag{85}$$

The values in Equation (84) and Equation (85) are the same as the values in Equation (77) and Equation (78). Thus,

$$4.5\times e_{new}c\left(1\right)=\sqrt{\frac{4.5}{\pi}hc^2\times\frac{m_e}{m_p}}=2.15538891\mathrm{E}-10 \tag{86}$$

$$\frac{q_{m\_new}c}{\pi}\left(1\right)=\sqrt{\frac{4.5}{\pi}hc^2\times\frac{m_p}{m_e}}=3.95762310\mathrm{E}-07 \tag{87}$$

In Equation (86) and Equation (87), the symbol (1) is dimensionless. Consequently, the consistency of Equation (10) can be ensured in this section.

4. Results

In this section, without using MKSA units, Equation (10) should be proven. For convenience, Equation (10) is rewritten as follows:

$$m_pc^2\times m_ec^2\times\frac{4.5}{\pi}hc^2=\left(2\pi\left(1\right)\times\frac{kT_c}{\alpha}\right)^2=1.04985584\mathrm{E}-39 \tag{88}$$

If Equation (88) is not correct without using MKSA units, Equation (88) is only coincidentally valid. The difficulty is that the constant value of 4.5 has units of 1/A·m, and π has units of V·m. However, at the same time, the value of $4.5/\pi\times hc^2$ is dimensionless and can be treated as the fundamental constant.

4.1. Preparation for the Proof

4.1.1. Separation of Equation (88)

Equation (88) can be separated as follows.

$$m_pc^2\times 4.5ec=2\pi\left(1\right)\times\frac{kT_c}{\alpha c^2}\left(\mathrm{kg}\right)\times c^2=3.24014789\mathrm{E}-20\left(\mathrm{J}\right) \tag{89}$$

$$m_ec^2\times\frac{q_mc}{\pi}=2\pi\left(1\right)\times\frac{kT_c}{\alpha c^2}\left(\mathrm{kg}\right)\times c^2=3.24014789\mathrm{E}-20\left(\mathrm{J}\right) \tag{90}$$

From Equation (89) and Equation (90), Equation (60) and Equation (61) can be obtained. For convenience, Equation (60) and Equation (61) are rewritten as follows:

$$\frac{\pi}{q_{m\_new}c}\left(1\right)=\frac{m_ec^2}{2\pi\left(1\right)}\times\frac{\alpha}{kT_c\left(\mathrm{J}\right)}=2.52676916\mathrm{E}+06 \tag{91}$$

$$\frac{1}{4.5e_{new}c}\left(1\right)=\frac{m_pc^2}{2\pi\left(1\right)}\times\frac{\alpha}{kT_c\left(\mathrm{J}\right)}=4.63953394\mathrm{E}+09 \tag{92}$$

Then, 4.5ec and q_mc/π are dimensionless and fundamental constants. Thus,

$$\frac{q_{m\_new}c}{\pi} \bigg/ 4.5e_{new}c(1) = \frac{q_{m\_new}c}{ec} \times \frac{1}{4.5\pi} = \frac{m_p}{m_e} = \text{fundamental constant} \tag{93}$$

The connection between these fundamental connections is as follows.

$$\begin{aligned} \frac{4.5}{\pi}hc^2(1) &= 4.5e_{new}c \times \frac{q_{m\_new}c}{\pi} = (4.5e_{new}c)^2 \times \frac{m_p}{m_e} \\ &= \left(\frac{q_{m\_new}c}{\pi}\right)^2 \times \frac{m_e}{m_p} = 8.53021694\text{E}-17 \end{aligned} \tag{94}$$

Consequently, when Equation (95) can be proven to be constant without using MKSA units, Equations (91)-(93) can be proven to be constant without using MKSA units.

$$\frac{4.5}{\pi}hc^2(1) = 8.53021694\text{E}-17 \tag{95}$$

4.1.2. The Unit of the Planck Constant

The unit of the Planck constant is as follows.

$$h = 6.62607015\text{E}-34\left(\frac{\text{kg}\cdot\text{m}^2}{\text{s}}\right) \tag{96}$$

We changed the unit of the Planck constant to Lorentz invariant mass 1 (1 kg × 1 s) instead of 1 kg.

$$h = 6.62607015\text{E}-34\left((\text{kg}\cdot\text{s})\cdot\frac{\text{m}^2}{\text{s}^2}\right) \tag{97}$$

Equation (97) is used for explanation only. Notably, the units of Js, C, Wb, Ω and m/s are Lorentzian invariant units. When the Lorentz transformation is used, 1 kg becomes larger, and 1 s decreases.

4.2. The Proof for Equation (88)

We want to prove that $4.5/\pi \times hc^2$ in Equation (88) is unchanged without using MKSA units, and the following three steps are needed.

Step 1: The value is unchanged when the definition of 1 m is changed.

Step 2: The value is unchanged when the definition of 1 kg × 1 s is changed.

Step 3: The value is unchanged when the definition of 1 s is changed.

Step 4: Our conclusion is explained.

4.2.1. Explanation for Changing the Definition of 1 m

When we used a distance of 1 mm instead of 1 m,

$$h = 6.62607015\text{E}-34\times 10^6 = 6.62607015\text{E}-28\left((\text{kg}\cdot\text{s})\cdot\frac{\text{mm}^2}{\text{s}^2}\right) \tag{98}$$

From Equation (84) and Equation (85),

$$e_{new}(\text{C}) = \sqrt{\frac{h}{4.5\pi\frac{m_p}{m_e}}} = 1.5976897\text{E}-16 = 1.5976897\text{E}-19\times 10^3(\text{C}) \tag{99}$$

$$q_{m\_new}(\mathrm{Wb}) = \sqrt{h \times 4.5\pi \frac{m_p}{m_e}} = 4.1472823\mathrm{E}-12 = 4.1472823\mathrm{E}-15 \times 10^3 (\mathrm{Wb}) \quad (100)$$

Then, the definition of the speed of light is changed.

$$c = 299792458 \times 10^3 \left(\frac{\mathrm{mm}}{\mathrm{s}}\right) \quad (101)$$

Next,

$$4.5\left(\frac{1}{\mathrm{A} \cdot \mathrm{m}}\right)_{MKSA} = 4.5 \times 10^{-3}\left(\frac{1}{\mathrm{C}}\right) \times 10^{-3}\left(\frac{\mathrm{s}}{\mathrm{mm}}\right) = 4.5 \times 10^{-6}\left(\frac{\mathrm{s}}{\mathrm{C} \cdot \mathrm{mm}}\right) \quad (102)$$

$$\frac{1}{\pi}\left(\frac{1}{\mathrm{V} \cdot \mathrm{m}}\right)_{MKSA} = \frac{1}{\pi} \times 10^{-3}\left(\frac{1}{\mathrm{Wb}}\right) \times 10^{-3}\left(\frac{\mathrm{s}}{\mathrm{mm}}\right) = \frac{1}{\pi} \times 10^{-6}\left(\frac{\mathrm{s}}{\mathrm{Wb} \cdot \mathrm{mm}}\right) \quad (103)$$

So,

$$\frac{4.5}{\pi} hc^2 (1) = 8.53021694\mathrm{E}-17 \quad (104)$$

Consequently, 4.5/π can be adjusted to account for this difference.

4.2.2. Explanation for Changing the Definition of 1 kg × 1 s

When we used 1 mg and 1 s as the definition of the Lorentz invariant mass instead of 1 kg and 1 s,

$$h = 6.62607015\mathrm{E}-34 \times 10^6 = 6.62607015\mathrm{E}-28\left((\mathrm{mg} \cdot \mathrm{s}) \cdot \frac{\mathrm{m}^2}{\mathrm{s}^2}\right) \quad (105)$$

From Equation (84) and Equation (85),

$$e_{new}(\mathrm{C}) = \sqrt{\frac{h}{4.5\pi \frac{m_p}{m_e}}} = 1.5976897\mathrm{E}-16 = 1.5976897\mathrm{E}-19 \times 10^3 (\mathrm{C}) \quad (106)$$

$$q_{m\_new}(\mathrm{Wb}) = \sqrt{h \times 4.5\pi \frac{m_p}{m_e}} = 4.1472823\mathrm{E}-12 = 4.1472823\mathrm{E}-15 \times 10^3 (\mathrm{Wb}) \quad (107)$$

In this case, the definition of the speed of light is unchanged.

Next,

$$4.5\left(\frac{1}{\mathrm{A} \cdot \mathrm{m}}\right)_{MKSA} = 4.5 \times 10^{-3}\left(\frac{1}{\mathrm{C}}\right) \times 1\left(\frac{\mathrm{s}}{\mathrm{m}}\right) = 4.5 \times 10^{-3}\left(\frac{1}{\mathrm{A} \cdot \mathrm{m}}\right) \quad (108)$$

$$\frac{1}{\pi}\left(\frac{1}{\mathrm{V} \cdot \mathrm{m}}\right)_{MKSA} = \frac{1}{\pi} \times 10^{-3}\left(\frac{1}{\mathrm{Wb}}\right) \times 1\left(\frac{\mathrm{s}}{\mathrm{m}}\right) = \frac{1}{\pi} \times 10^{-3}\left(\frac{1}{\mathrm{V} \cdot \mathrm{m}}\right) \quad (109)$$

So,

$$\frac{4.5}{\pi} hc^2 (1) = 8.53021694\mathrm{E}-17 \quad (110)$$

Consequently, 4.5/π can be adjusted to account for this difference.

4.2.3. Explanation for Changing the Definition of 1 s

When we used 1 ms as the definition of time instead of 1 s, 0.001 kg was used instead of 1 kg at the same time.

$$h = 6.62607015\text{E} - 34 \times 10^{-3} = 6.62607015\text{E} - 37\left(0.001\left(\text{kg} \cdot \text{s}\right) \cdot \frac{\text{m}^2}{\text{ms}^2}\right) \quad (111)$$

Therefore, we must use 1000 kg instead of 1 kg to calculate h with the same 1 kg × 1 s,

$$h = 6.62607015\text{E} - 34 \times 10^{-6} = 6.62607015\text{E} - 40\left(\left(\text{kg} \cdot \text{s}\right) \cdot \frac{\text{m}^2}{\text{ms}^2}\right) \quad (112)$$

From Equation (84) and Equation (85),

$$e_{new}\left(\text{C}\right) = \sqrt{\frac{h}{4.5\pi \frac{m_p}{m_e}}} = 1.5976897\text{E} - 22 = 1.5976897\text{E} - 19 \times 10^{-3}\left(\text{C}\right) \quad (113)$$

$$q_{m\_new}\left(\text{Wb}\right) = \sqrt{h \times 4.5\pi \frac{m_p}{m_e}} = 4.1472823\text{E} - 18 = 4.1472823\text{E} - 15 \times 10^{-3}\left(\text{Wb}\right) \quad (114)$$

Then, the definition of the speed of light is changed.

$$c = 299792458 \times 10^{-3}\left(\frac{\text{m}}{\text{ms}}\right) \quad (115)$$

Next,

$$4.5\left(\frac{1}{\text{A} \cdot \text{m}}\right)_{MKSA} = 4.5 \times 10^3\left(\frac{1}{\text{C}}\right) \times 10^3\left(\frac{\text{ms}}{\text{m}}\right) = 4.5 \times 10^6\left(\frac{\text{ms}}{\text{C} \cdot \text{m}}\right) \quad (116)$$

$$\frac{1}{\pi}\left(\frac{1}{\text{V} \cdot \text{m}}\right)_{MKSA} = \frac{1}{\pi} \times 10^3\left(\frac{1}{\text{Wb}}\right) \times 10^3\left(\frac{\text{ms}}{\text{m}}\right) = \frac{1}{\pi} \times 10^6\left(\frac{\text{ms}}{\text{Wb} \cdot \text{m}}\right) \quad (117)$$

So,

$$\frac{4.5}{\pi} hc^2\left(1\right) = 8.53021694\text{E} - 17 \quad (118)$$

Consequently, 4.5/π can be adjusted to account for this difference.

4.2.4. Our Conclusion

When we changed the unit (1 m, 1 kg and 1 s), we redefined these units as being converted back to the MKSA units. The calculated value in Equation (88) becomes the same value in the MKSA units. 4.5/π can be adjusted to account for this difference. Therefore, Equation (10) is correct without using the MKSA units. The value of 4.5/π × hc^2 is dimensionless and can be treated as the fundamental constant.

Then, the unit of 4.5/π is changed when we do not use the MKSA units. However, the unit of 4.5/π is not expressed in Equation (10). With respect to the coefficients 4.5 and π, we cannot answer the real meaning in this report. According to Ted Jacobson, there should be a finite number of degrees of freedom in any finite volume. Therefore, we propose a local Lorentzian invariant mass with degrees of freedom.

A more suitable explanation will be published in a future report. The unit of resistance (4.5π (Ω)) is unchanged. Therefore, in the SI unit, the main unit should be the unit of resistance. This concept is compatible with the fact that the fine-structure constant should be related to the transference number.

4.3. Explanation for Equation (26)

For convenience, Equation (10) is rewritten as follows:

$$G_{N\_new} = G_N \times \frac{1}{(1.001113745)^2}\left(\frac{\mathrm{m}^3}{\mathrm{s}^2}\right) = 6.6743\mathrm{E}-11\left(\frac{\mathrm{m}^3}{\mathrm{s}^2}\right) \tag{119}$$

The error is 0.11%, which is too large to explain via general relative theory. The reason is that such differences have never been observed. For convenience, Equation (1) is rewritten as follows:

$$\frac{Gm_p^2}{hc} = \frac{4.5}{2} \times \frac{kT_c}{1\ \mathrm{kg} \times c^2} \tag{120}$$

The correct equation for calculating G is

$$\frac{Gm_x^2}{hc} = \frac{4.5}{2} \times \frac{kT_c}{1\ \mathrm{kg} \times c^2} \tag{121}$$

Here, m_x is the standard mass for calculating G and is larger than that of a proton and smaller than that of a neutron.

$$m_x = 1.001113745 \times m_p = m_p + 2.04 \times m_e \tag{122}$$

At present, we cannot determine the relationship between Equation (122) and any other concept.

5. Conclusions

We introduce a procedure for calculating the CMB temperature. We propose Equation (10), which is very simple, and comprehensively compares it with equations from a past study. In the previous study, the equations were used without MKSA units, but in this case, the precision of the Avogadro number becomes unclear. The equations from previous studies are modified in this study. Notably, in this study, we express the correct Avogadro number and explain it in detail. Moreover, the Dirac constant is related to the minimum mass.

The calculated value was 2.7256307 K, and the observed value was 2.72548 ± 0.00057 K. Therefore, the calculated value was adjusted. In Equation (10), kT_c/α plays an important role. We explain this value via the correspondence principle, thermodynamic principles from solid-state ionics and the Jarzynski equality.

In this report, our main point is that Equation (10) should be valid without using MKSA units. To prove this theory, we used the concept of the Lorentz invariant mass (1 kg × 1 s). With respect to the coefficients 4.5 and π, 4.5/π can be adjusted to account for this difference without using MKSA units.

The calculated G was 6.68917534 × 10^{-11} $\mathrm{m^3{\cdot}kg^{-1}{\cdot}s^{-2}}$, which was greater than the observed value of 6.6743 × 10^{-11} $\mathrm{m^3{\cdot}kg^{-1}{\cdot}s^{-2}}$. In a previous study, we thought that this error could be resolved by using modified equations. However, the error is

0.11%, which is too large to explain via general relative theory. The reason is that such differences have never been observed. Thus, we propose a standard mass that is larger than that of a proton and smaller than that of a neutron for calculating *G*.

Conflicts of Interest

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

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