

# Normalization Methods in Algorithms for Empirical Equations in Terms of the Cosmic Microwave Background Temperature

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## Abstract

Previously, we presented several empirical equations using the cosmic microwave background (CMB) temperature. Next, we propose an empirical equation for the fine-structure constant. Considering the compatibility among these empirical equations, the CMB temperature ( $T_c$ ) and gravitational constant ( $G$ ) were calculated to be 2.726312 K and  $6.673778 \times 10^{-11} \text{ m}^3 \cdot \text{kg}^{-1} \cdot \text{s}^{-2}$ , respectively. Every equation can be explained numerically in terms of the Compton length of an electron ( $\lambda_e$ ), the Compton length of a proton ( $\lambda_p$ ) and  $\alpha$ . After several trials, we describe the algorithms used to explain these equations. Thus, no dimension mismatch problems were observed. In this report, we describe the normalization methods in our algorithms used to explain these equations in detail. Our redefinition method is a part of the normalization in the algorithms. Furthermore, the definitions of the gravitational constant are discussed.

## Keywords

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

## 1. Introduction

The symbol list is shown in Section 2. Previously, we described three Equations (1), (2) and (3) in terms of the cosmic microwave background (CMB) temperature [1]-[4] and [5].

$$\frac{Gm_p^2}{hc} = \frac{4.5}{2} \times \frac{kT_c}{1 \text{ kg} \times c^2} \quad (1)$$

$$\frac{Gm_p^2}{\left(\frac{e^2}{4\pi\epsilon_0}\right)} = \frac{4.5}{2\pi} \times \frac{m_e}{e} \times hc \quad (2)$$

$$\frac{m_e c^2}{e} \times \left(\frac{e^2}{4\pi\epsilon_0}\right) = \pi \times kT_c \quad (3)$$

We then derived an empirical equation for the fine-structure constant [6].

$$137.0359991 = 136.0113077 + \frac{1}{3 \times 13.5} + 1 \quad (4)$$

$$13.5 \times 136.0113077 = 1836.152654 = \frac{m_p}{m_e} \quad (5)$$

Equations (4) and (5) are related to the transference number [7] [8]. Next, the following values are proposed as deviations of the values of 9/2 and  $\pi$  [8] [9].

$$3.13201(\text{V} \cdot \text{m}) = \frac{\left(\frac{m_p}{m_e} + \frac{4}{3}\right) m_e c^2}{ec} \quad (6)$$

$$4.48852\left(\frac{1}{\text{A} \cdot \text{m}}\right) = \frac{q_m c}{\left(\frac{m_p}{m_e} + \frac{4}{3}\right) m_p c^2} \quad (7)$$

Then,  $\left(\frac{m_p}{m_e} + \frac{4}{3}\right)$  has units of  $\left(\frac{\text{m}^2}{\text{s}}\right)$ . By redefining the Avogadro number and the Faraday constant, these values can be adjusted back to 9/2 and  $\pi$  [9].

$$\pi(\text{V} \cdot \text{m}) = \frac{\left(\frac{m_p}{m_e} + \frac{4}{3}\right) m_{e\_new} c^2}{e_{new} c} \quad (8)$$

$$4.5\left(\frac{1}{\text{A} \cdot \text{m}}\right) = \frac{q_{m\_new} c}{\left(\frac{m_p}{m_e} + \frac{4}{3}\right) m_{p\_new} c^2} \quad (9)$$

Every equation can be explained in terms of the Compton length of an electron ( $\lambda_e$ ), the Compton length of a proton ( $\lambda_p$ ) and  $\alpha$  [10]. After several trials [11] [12] using the correspondence principle with thermodynamic principles in solid-state ionics [13], we propose a canonical ensemble to explain the concept of the minimum mass. Next, we describe the algorithms used to explain these equations [14]. Then, every dimension mismatch problem can be solved. The ratio of the gravitational force to the electric force can be uniquely determined with the assumption of minimum mass.

$$\frac{Gm_p^2}{\left(\frac{e^2}{4\pi\epsilon_0}\right)} = 4.5(1) \times \pi(1) \times \frac{kT_c/\alpha}{1 \text{ kg} \times c^2} \quad (10)$$

Quantum mechanics [15] and gravity [16] have been used to provide thermo-

dynamic explanations. Our motivation is to use thermodynamic principles in the area of solid-state ionics, which we discovered. In this report, we describe the normalization methods in our algorithms used to explain these equations. Our re-definition method is a part of the normalization methods in our algorithms.

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 normalization methods in our algorithms to explain these equations. In Section 4, using the normalization methods in our algorithms, we explain Equations (1), (2), (3) and (10). Furthermore, the definitions of the gravitational constant are discussed. In Section 5, our conclusions are provided.

## 2. Symbol List

### 2.1. MKSA Units (These Values Were Obtained from Wikipedia)

$G$ :	gravitational constant: $6.6743 \times 10^{-11} \text{ (m}^3 \cdot \text{kg}^{-1} \cdot \text{s}^{-2}\text{)}$ (we used the compensated value $6.673778 \times 10^{-11}$ in this study)
$T_c$ :	CMB temperature: 2.72548 (K) (we used the compensated value 2.726312 K in this study)
$k$ :	Boltzmann constant: $1.380649 \times 10^{-23} \text{ (J} \cdot \text{K}^{-1}\text{)}$
$c$ :	speed of light: 299792458 (m/s)
$h$ :	Planck constant: $6.62607015 \times 10^{-34} \text{ (J} \cdot \text{s)}$
$\epsilon_0$ :	Electric constant: $8.8541878128 \times 10^{-12} \text{ (N} \cdot \text{m}^2 \cdot \text{C}^{-2}\text{)}$
$\mu_0$ :	magnetic constant: $1.25663706212 \times 10^{-6} \text{ (N} \cdot \text{A}^{-2}\text{)}$
$e$ :	electric charge of one electron: $-1.602176634 \times 10^{-19} \text{ (C)}$
$q_m$ :	magnetic charge of one magnetic monopole: $4.13566770 \times 10^{-15} \text{ (Wb)}$ (this value is only a theoretical value, $q_m = h/e$ )
$m_p$ :	rest mass of a proton: $1.672621923 \times 10^{-27} \text{ (kg)}$ (We used the compensated value of $1.6726219059 \times 10^{-27} \text{ kg}$ to explain 137.0359990841)
$m_e$ :	rest mass of an electron: $9.1093837 \times 10^{-31} \text{ (kg)}$
$Rk$ :	von Klitzing constant: 25812.80745 ( $\Omega$ )
$Z_0$ :	wave impedance in free space: 376.730313668 ( $\Omega$ )
$\alpha$ :	fine-structure constant: 1/137.035999081
$\lambda_p$ :	Compton wavelength of a proton: $1.32141 \times 10^{-15} \text{ (m)}$
$\lambda_e$ :	Compton wavelength of an electron: $2.4263102367 \times 10^{-12} \text{ (m)}$

### 2.2. Symbol List after Redefinition

$$e_{new} = e \times \frac{4.48852}{4.5} = 1.59809\text{E} - 19 \text{ (C)} \quad (11)$$

$$q_{m\_new} = q_m \times \frac{\pi}{3.13201} = 4.14832\text{E} - 15 \text{ (Wb)} \quad (12)$$

$$h_{new} = e_{new} \times q_{m\_new} = h \times \frac{4.48852}{4.5} \times \frac{\pi}{3.13201} = 6.62938\text{E} - 34 \text{ (J} \cdot \text{s)} \quad (13)$$

$$Rk_{new} = \frac{q_{m\_new}}{e_{new}} = Rk \times \frac{4.5}{4.48852} \times \frac{\pi}{3.13201} = 25958.0(\Omega) \quad (14)$$

Equation (13) can be rewritten as follows:

$$Rk_{new} = 4.5 \left( \frac{1}{A \cdot m} \right) \times \pi (V \cdot m) \times \frac{m_p}{m_e} = 25957.9966027(\Omega) \quad (15)$$

$$Z_{0\_new} = \alpha \times \frac{2h_{new}}{e_{new}^2} = 2\alpha \times Rk_{new} = Z_0 \times \frac{4.5}{4.48852} \times \frac{\pi}{3.13201} = 378.849(\Omega) \quad (16)$$

Equation (16) can be rewritten as follows:

$$Z_{0\_new} = 4.5 \left( \frac{1}{A \cdot m} \right) \times \pi (V \cdot m) \times 2\alpha \times \frac{m_p}{m_e} = 378.8493064(\Omega) \quad (17)$$

$$\mu_{0\_new} = \frac{Z_{0\_new}}{c} = \mu_0 \times \frac{4.5}{4.48852} \times \frac{\pi}{3.13201} = 1.26371E-06(N \cdot A^{-2}) \quad (18)$$

$$\epsilon_{0\_new} = \frac{1}{Z_{0\_new} \times c} = \epsilon_0 \times \frac{4.48852}{4.5} \times \frac{3.13201}{\pi} = 8.80466E-12(F \cdot m^{-1}) \quad (19)$$

$$c_{new} = \frac{1}{\sqrt{\epsilon_{0\_new} \mu_{0\_new}}} = \frac{1}{\sqrt{\epsilon_0 \mu_0}} = c = 299792458(m \cdot s^{-1}) \quad (20)$$

The Compton wavelength ( $\lambda$ ) is as follows:

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

The value ( $\lambda$ ) should be unchanged since the unit for 1 m is unchanged. However, in Equation (13), Planck's constant changes. Therefore, the units for the masses of one electron and one proton need to be redefined.

$$m_{e\_new} = \frac{4.48852}{4.5} \times \frac{\pi}{3.13201} \times m_e = 9.11394E-31(kg) \quad (22)$$

$$m_{p\_new} = \frac{4.48852}{4.5} \times \frac{\pi}{3.13201} \times m_p = 1.67346E-27(kg) \quad (23)$$

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

$$kT_{c\_new} = \frac{4.48852}{4.5} \times \frac{\pi}{3.13201} \times kT_c = 3.7659625E-23(J) \quad (24)$$

To simplify the calculation,  $G_N$  is defined as follows:

$$G_N = G \times 1 \text{ kg} (m^3 \cdot s^{-2}) = 6.673778E-11(m^3 \cdot s^{-2}) \quad (25)$$

Now, the value of  $G_N$  remains unchanged. However, the value of  $G_{N\_new}$  should change [9] as follows:

$$G_{N\_new} = G_N \times \frac{e}{e_{new}} = G_N \times \frac{4.5}{4.48852} \left( \frac{m^3}{s^2} \right) = 6.69084770E-11 \left( \frac{m^3}{s^2} \right) \quad (26)$$

### 2.3. Symbol List in Terms of the Compton Length of an Electron ( $\lambda_e$ ), the Compton Length of a Proton ( $\lambda_p$ ) and $\alpha$

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

$$\begin{aligned} & m_{e\_new} c^2 \times \left( \frac{m_p}{m_e} + \frac{4}{3} \right)^2 \left( \frac{\text{J} \cdot \text{m}^4}{\text{s}^2} \right) \\ &= \frac{\pi}{4.5} \left( \text{V} \cdot \text{m} \cdot \text{A} \cdot \text{m} = \frac{\text{J} \cdot \text{m}^2}{\text{s}} \right) \times \lambda_p c \left( \frac{\text{m}^2}{\text{s}} \right) \\ &= 2.76564\text{E} - 07 \left( \frac{\text{J} \cdot \text{m}^4}{\text{s}^2} \right) = \text{constant} \end{aligned} \quad (27)$$

$$\begin{aligned} & e_{new} c \times \left( \frac{m_p}{m_e} + \frac{4}{3} \right) \left( \frac{\text{A} \cdot \text{m}^3}{\text{s}} \right) \\ &= \frac{1}{4.5} (\text{A} \cdot \text{m}) \times \lambda_p c \left( \frac{\text{m}^2}{\text{s}} \right) = 8.80330\text{E} - 08 \left( \frac{\text{A} \cdot \text{m}^3}{\text{s}} \right) = \text{constant} \end{aligned} \quad (28)$$

$$\begin{aligned} & m_{p\_new} c^2 \times \left( \frac{m_p}{m_e} + \frac{4}{3} \right)^2 \left( \frac{\text{J} \cdot \text{m}^4}{\text{s}^2} \right) \\ &= \frac{\pi}{4.5} \left( \frac{\text{J} \cdot \text{m}^2}{\text{s}} \right) \times \lambda_e c \left( \frac{\text{m}^2}{\text{s}} \right) = 5.07814\text{E} - 04 \left( \frac{\text{J} \cdot \text{m}^4}{\text{s}^2} \right) = \text{constant} \end{aligned} \quad (29)$$

$$\begin{aligned} & q_{m\_new} c \times \left( \frac{m_p}{m_e} + \frac{4}{3} \right) \left( \frac{\text{V} \cdot \text{m}^3}{\text{s}} \right) \\ &= \pi (\text{V} \cdot \text{m}) \times \lambda_e c \left( \frac{\text{m}^2}{\text{s}} \right) = 2.28516\text{E} - 03 \left( \frac{\text{V} \cdot \text{m}^3}{\text{s}} \right) = \text{constant} \end{aligned} \quad (30)$$

$$\begin{aligned} & kT_{c\_new} \times \frac{2\pi}{\alpha} \times \left( \frac{m_p}{m_e} + \frac{4}{3} \right)^3 \left( \frac{\text{J} \cdot \text{m}^6}{\text{s}^3} \right) \\ &= \frac{\pi}{4.5} \left( \frac{\text{J} \cdot \text{m}^2}{\text{s}} \right) \times \lambda_p c \times \lambda_e c = 2.011697\text{E} - 10 \left( \frac{\text{J} \cdot \text{m}^6}{\text{s}^3} \right) = \text{constant} \end{aligned} \quad (31)$$

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

### 2.4. Symbol List in Terms of the Avogadro Number and the Number of Electrons in 1 C

This section is omitted for the following reasons.

The Avogadro number ( $N_A$ ) is  $6.02214076 \times 10^{23}$ . This value is related to the following value.

$$N_A = \frac{1 \text{ g}}{m_p} = 5.978637\text{E} + 23 \quad (33)$$

Using the redefined values, the new definition of the Avogadro number ( $N_{A\_new}$ )

is as follows:

$$N_{A\_new} = \frac{1 \text{ kg}}{m_{p\_new}} = \frac{1 \text{ kg}_{new}}{m_p} = 5.975649\text{E} + 26 \neq \frac{1 \text{ kg}_{new}}{m_{p\_new}} \quad (34)$$

In this report, Equation (34) is incorrect. The correct equation is as follows:

$$N_{A\_new} = \frac{1 \text{ kg}_{new}}{m_{p\_new}} = 1 \text{ kg} \times \frac{e_{new}}{e} \times \frac{1}{m_{p\_new}} = 5.96040380\text{E} + 26 \quad (35)$$

However, the main point in our explanation for Equation (26) in the previous report [14] can still be useful.

## 2.5. Symbol List for the Advanced Expressions for $kT_c$ and $G_N$

Furthermore, we propose the following four equations [11]:

$$kT_{c\_new} (\text{J}) = \frac{\alpha}{2\pi(1)} \times \frac{1}{\pi} \left( \frac{1}{\text{V} \cdot \text{m}} \right) \times q_{m\_new} c \times m_{e\_new} c^2 = 3.76596254\text{E} - 23 \quad (36)$$

$$kT_{c\_new} (\text{J}) = \frac{\alpha}{2\pi(1)} \times 4.5 \left( \frac{1}{\text{A} \cdot \text{m}} \right) \times e_{new} c \times m_{p\_new} c^2 = 3.76596254\text{E} - 23 \quad (37)$$

In Equations (36) and (37),  $2\pi(1)$  is dimensionless. For  $G$ , two equations exist, as follows:

$$\begin{aligned} G_{N\_new} \left( \frac{\text{m}^3}{\text{s}^2} \right) &= \alpha c \frac{4.5(1)}{4\pi(1)} \times (4.5 \times e_{new} c) \times e_{new} c \times \frac{q_{m\_new} c}{m_{p\_new} c^2} \\ &= 6.69084770\text{E} - 11 \left( \frac{\text{m}^3}{\text{s}^2} \right) \end{aligned} \quad (38)$$

$$\begin{aligned} G_{N\_new} \left( \frac{\text{m}^3}{\text{s}^2} \right) &= \alpha c \frac{4.5(1)}{4\pi(1)} \times (4.5 \times e_{new} c)^2 \times e_{new} c \times \frac{\pi(\text{V} \cdot \text{m})}{m_{e\_new} c^2} \\ &= 6.69084770\text{E} - 11 \left( \frac{\text{m}^3}{\text{s}^2} \right) \end{aligned} \quad (39)$$

In Equations (38) and (39),  $4\pi(1)$  and  $4.5(1)$  are dimensionless.

## 2.6. Symbol List When the Planck Constant Is Changed to 1 Js

When we define the Planck constant as (1 Js), the following equations can be used:

$$\begin{aligned} c_{general} \left( \frac{\text{m}_{general}}{\text{s}} \right) &= c \times \sqrt{h_{new}(1)} = 299792458 \times \sqrt{6.62938\text{E} - 34} \\ &= 7.71893\text{E} - 09 \left( \frac{\text{m}_{general}}{\text{s}} \right) \end{aligned} \quad (40)$$

where  $h_{new}(1)$  ( $= 6.62938\text{E} - 34$ ) is dimensionless.  $c_{general}$  and  $1 \text{ m}_{general}$  are the values for  $c$  and  $1 \text{ m}$ , respectively, after Planck's constant is changed. Thus, the unit of the meter needs to be changed. Importantly, Equation (40) does not indicate a change in the light speed.

$$e_{general} = \sqrt{\frac{1(\text{J}\cdot\text{s})}{4.5\pi \times m_p/m_e}} = 6.20675231\text{E} - 03(\text{C}_{general}) \quad (41)$$

$$q_{m\_general} = \sqrt{1(\text{J}\cdot\text{s}) \times 4.5\pi \times m_p/m_e} = 1.61114855\text{E} + 02(\text{Wb}_{general}) \quad (42)$$

$$m_{e\_general} = \sqrt{\frac{1(\text{J}\cdot\text{s}) \times \pi \times m_e/m_p}{c_{general}^2 \times 4.5}} \times \left(\frac{m_p}{m_e} + \frac{4}{3}\right)^{-1} = 1.37477924\text{E} + 03(\text{kg}_{general}) \quad (43)$$

$$m_{p\_general} = \sqrt{\frac{1(\text{J}\cdot\text{s}) \times \pi \times m_p/m_e}{c_{general}^2 \times 4.5}} \times \left(\frac{m_p}{m_e} + \frac{4}{3}\right)^{-1} = 2.52430455\text{E} + 06(\text{kg}_{general}) \quad (44)$$

$$\frac{kT_{c\_general}}{\alpha \times c_{general}^2} = \frac{1(\text{J}\cdot\text{s})}{2\pi(1)} \times \left(\frac{m_p}{m_e} + \frac{4}{3}\right)^{-1} = 8.66155955\text{E} - 05(\text{kg}_{general}) \quad (45)$$

$$G_{N\_general} = \frac{\alpha c_{general}^3}{m_p/m_e} \times \frac{4.5^2}{4\pi^2} \times 1(\text{J}\cdot\text{s}) \times \left(\frac{m_p}{m_e} + \frac{4}{3}\right) = 1.72273202\text{E} - 27\left(\frac{\text{m}_{general}^3}{\text{s}^2}\right) \quad (46)$$

where  $1 \text{ C}_{general}$ ,  $1 \text{ Wb}_{general}$ ,  $1 \text{ kg}_{general}$ ,  $e_{general}$ ,  $q_{m\_general}$ ,  $m_{e\_general}$ ,  $m_{p\_general}$ ,  $T_{c\_general}$  and  $G_{N\_general}$  are the values for 1 C, 1 Wb, 1 kg,  $e$ ,  $q_m$ ,  $m_e$ ,  $m_p$ ,  $T_c$  and  $G_N$ , respectively, when the Planck constant is changed to 1 Js.

The minimum mass ( $M_{\min}$ ) is defined as follows:

$$M_{\min}(\text{kg}_{general}) = \frac{kT_c}{\alpha \times c^2} = \frac{1(\text{J}\cdot\text{s})}{2\pi} \times \left(\frac{m_p}{m_e} + \frac{4}{3}\right)^{-1} = 8.661556\text{E} - 05 \quad (47)$$

The ratio between the mass of an electron and the minimum mass is defined as follows:

$$m_{e\_general} \times \frac{\alpha c_{general}^2}{kT_{c\_general}} = 2\pi(1) \times \frac{\pi}{q_{m\_general} c_{general}} = 1.587219\text{E} + 07 \quad (48)$$

The mass ratio of a proton to its minimum mass is defined as follows:

$$m_{p\_general} \times \frac{\alpha c_{general}^2}{kT_{c\_general}} = \frac{2\pi(1)}{4.5 \times e_{general} c_{general}} = 2.914376\text{E} + 10 \quad (49)$$

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

### 2.7.1. Algorithms for Making the First List

Equations (50) and (51) are important for making the first list. Using Equations (27)-(32), the following list can be obtained [14].

$$\frac{h}{m_p} = \frac{h_{new}}{m_{p\_new}} = 3.9614871\text{E} - 07 = \text{experimental result} \quad (50)$$

$$\frac{h}{m_e} = \frac{h_{new}}{m_{e\_new}} = 7.2738951\text{E} - 04 = \text{experimental result} \quad (51)$$

$$e_{new} c(\text{A}\cdot\text{m}) = \frac{1}{4.5} \times \frac{h}{m_p} \times \left(\frac{m_p}{m_e} + \frac{4}{3}\right)^{-1} (\text{A}\cdot\text{m}) = 4.79095067\text{E} - 11(\text{A}\cdot\text{m}) \quad (52)$$

$$q_{m\_new}c(\mathbf{V} \cdot \mathbf{m}) = \pi \times \frac{h}{m_e} \times \left( \frac{m_p}{m_e} + \frac{4}{3} \right)^{-1} (\mathbf{V} \cdot \mathbf{m}) = 1.24363481\text{E} - 06(\mathbf{V} \cdot \mathbf{m}) \quad (53)$$

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

$$m_{p\_new}c^2(\mathbf{J}) = \frac{\pi}{4.5} \times \frac{h}{m_e} \times \left( \frac{m_p}{m_e} + \frac{4}{3} \right)^{-2} (\mathbf{J}) = 1.50402938\text{E} - 10(\mathbf{J}) \quad (55)$$

$$\begin{aligned} h_{new}c^2 \left( \frac{\mathbf{J} \cdot \mathbf{m}^2}{\text{s}} \right) &= \frac{\pi}{4.5} \times \frac{h}{m_p} \times \frac{h}{m_e} \times \left( \frac{m_p}{m_e} + \frac{4}{3} \right)^{-2} \left( \frac{\mathbf{J} \cdot \mathbf{m}^2}{\text{s}} \right) \\ &= 5.9581930\text{E} - 17 \left( \frac{\mathbf{J} \cdot \mathbf{m}^2}{\text{s}} \right) \end{aligned} \quad (56)$$

$$\begin{aligned} \frac{kT_{c\_new}}{\alpha}(\mathbf{J}) &= \frac{1}{2\pi(1)} \times \frac{\pi}{4.5} \times \frac{h}{m_p} \times \frac{h}{m_e} \times \left( \frac{m_p}{m_e} + \frac{4}{3} \right)^{-3} (\mathbf{J}) \\ &= 5.1607244\text{E} - 21(\mathbf{J}) \end{aligned} \quad (57)$$

$$\begin{aligned} G_{N\_new} \left( \frac{\mathbf{m}^3}{\text{s}^2} \right) &= \alpha c \frac{4.5(1)}{4\pi(1)} \times \left( \frac{h}{m_p} \right)^2 \times \left( \frac{m_p}{m_e} + \frac{4}{3} \right)^{-1} \left( \frac{\mathbf{m}^3}{\text{s}^2} \right) \\ &= 6.6908477\text{E} - 11 \end{aligned} \quad (58)$$

### 2.7.2. Algorithms for Making the Second List

Using the arbitrary value of the light speed, we use the second list. The following example can be used:

$$c_{\text{arbitrary}} = 12345 \left( \frac{\text{m}_{\text{arbitrary}}}{\text{s}} \right) \quad (59)$$

where  $c_{\text{arbitrary}}$  and  $1 \text{ m}_{\text{arbitrary}}$  are the values for  $c$  and  $1 \text{ m}$  when an arbitrary value of light speed is used, respectively. Thus, the first list remains useful [14].

From Equations (36) and (37),

$$\pi(\mathbf{V} \cdot \mathbf{m}) = \frac{1}{2\pi(1)} \times \frac{\alpha}{kT_{c\_new}} \times q_{m\_new}c \times m_{e\_new}c^2 \quad (60)$$

$$\frac{1}{4.5}(\mathbf{A} \cdot \mathbf{m}) = \frac{1}{2\pi(1)} \times \frac{\alpha}{kT_{c\_new}} \times e_{new}c \times m_{p\_new}c^2 \quad (61)$$

Consequently,  $\pi(\mathbf{V}\mathbf{m})$  and  $1/4.5(\mathbf{A}\mathbf{m})$  are unchanged in the second list.

## 3. Methods

In this section, the normalization methods in our algorithms used to explain these equations are proposed. The normalization methods can be performed in three steps.

Step 1: The redefinition method.

Step 2: Use the standard values of  $1 \text{ m}$  and  $1 \text{ s}$ .

Step 3: Use the standard value of  $1 \text{ kg}$ .

### 3.1. Step 1: Explanation for the Redefinition Method

The procedure of the redefinition method has already been provided. The theoretical meaning of the redefinition method is normalization of the electric constant ( $\epsilon_0$ ) and the magnetic constant ( $\mu_0$ ). The numerical explanation is as follows:

$$\begin{aligned} \frac{1}{\epsilon_{0\_new} c} \left( \Omega = \frac{\text{kg}}{\text{C}^2} \times \frac{\text{m}^2}{\text{s}} \right) &= \mu_{0\_new} c (\Omega) \\ &= \frac{kT_{c\_new} / \alpha c^2}{(e_{new})^2} \times \left( \frac{m_p}{m_e} + \frac{4}{3} \right) \times 2\pi(1) \times 2\alpha \quad (62) \\ &= 378.8493064 (\Omega) \end{aligned}$$

The value in Equation (62) is equal to the value in Equation (17). Clearly, this is not a coincidence. However, after applying the redefinition method, the calculated value only slightly changes. The unit of the electric current (1A) is, which is defined by Ampère's force law. After several centuries, the Faraday constant was defined as 96485.332 (C/mol). The unit of mol is defined as 1 g. When the unit of mol is defined as 1 kg, the Faraday constant becomes  $9.6485332 \times 10^7$  (C/mol).

Our redefinition method is as follows:

$$\pi(\text{V} \cdot \text{m}) = \frac{\left( \frac{m_p}{m_e} + \frac{4}{3} \right) m_{e\_new} c^2}{e_{new} c} \quad (63)$$

Thus, the following equation can be used:

$$\frac{e_{new}}{m_{p\_new}} = \frac{c}{\pi} \times \left( \frac{m_p}{m_e} + \frac{4}{3} \right) \times \frac{m_e}{m_p} = 9.5496198\text{E} + 07 \quad (64)$$

In Equation (64), the calculated value is very similar to the Faraday constant when the unit of mol is defined as 1 kg. Consequently, the definition of the electric current (1A) is highly suitable coincidentally. In more concrete terms, the force (2 dyn = 2 g·cm/s<sup>2</sup>) was used to define the electric current (1A). When the force (1 dyn = 1 g·cm/s<sup>2</sup>) was used, the Faraday constant changed. After the redefinition method is applied, the calculated value should change substantially. This means that the symbol list in Section 2.2 has changed substantially.

### 3.2. Step 2: Use of the Standard Values of 1 m and 1 s

#### 3.2.1. Explanation of the Arbitrary Value of the Light Speed

In a previous report, an arbitrary value of light speed was used:

$$c_{\text{arbitrary}} = 12345 \left( \frac{\text{m}_{\text{arbitrary}}}{\text{s}} \right) \quad (65)$$

However, the correct equation is as follows:

$$c_{\text{arbitrary}} = 12345 \left( \frac{\text{m}_{\text{arbitrary}}}{\text{s}_{\text{arbitrary}}} \right) \quad (66)$$

where 1 s<sub>arbitrary</sub> is the value for 1 s when an arbitrary value of light speed is used.

Then, the following can be attained:

$$1 \text{ m}_{\text{arbitrary}} = \frac{1}{12345}(\text{m}) = 8.10045\text{E} - 05(\text{m}) \quad (67)$$

$$1 \text{ s}_{\text{arbitrary}} = \frac{1}{12345^2}(\text{s}) = 6.56172\text{E} - 09(\text{s}) \quad (68)$$

Thus, the following equations can be defined:

$$c_{\text{arbitrary}} = 12345 \frac{\text{m}_{\text{arbitrary}}}{\text{s}_{\text{arbitrary}}} \quad (69)$$

$$\frac{(1 \text{ m}_{\text{arbitrary}})^2}{1 \text{ s}_{\text{arbitrary}}} = \frac{12345}{12345} \left( \frac{\text{m}^2}{\text{s}} \right) = 1 \left( \frac{\text{m}^2}{\text{s}} \right) \quad (70)$$

Consequently, the unit of  $\text{m}^2/\text{s}$  is 1. Then,  $\pi$  (Vm) and  $1/4.5$  (Am) are unchanged in the second list.

### 3.2.2. Explanation of the Standard Values of 1 m and 1 s

We propose standard values of 1 m and 1 s as follows.

$$1 \text{ m}_{\text{standard}} = \frac{1}{299792458}(\text{m}) = 3.33564\text{E} - 09(\text{m}) \quad (71)$$

$$1 \text{ s}_{\text{standard}} = \frac{1}{299792458^2}(\text{s}) = 1.11265\text{E} - 17(\text{s}) \quad (72)$$

$$\frac{(1 \text{ m}_{\text{standard}})^2}{1 \text{ s}_{\text{standard}}} = 1 \left( \frac{\text{m}^2}{\text{s}} \right) \quad (73)$$

where  $1 \text{ m}_{\text{standard}}$  and  $1 \text{ s}_{\text{standard}}$  are the standard values of 1 m and 1 s, respectively. The light speed using these values ( $c_{\text{standard}}$ ) is defined as follows:

$$c_{\text{standard}} = 299792458 \left( \frac{\text{m}}{\text{s}} \right) = 1 \left( \frac{\text{m}_{\text{standard}}}{\text{s}_{\text{standard}}} \right) \quad (74)$$

Then, the value of 1 J becomes equivalent to 1 kg. From the first list written in Section 2.7.1,

$$\begin{aligned} e_{\text{standard}} (\text{C}) &= \frac{1}{4.5} \times \frac{h}{m_p} \times \left( \frac{m_p}{m_e} + \frac{4}{3} \right)^{-1} \times \left( \frac{1}{c_{\text{standard}}} \right) \\ &= 4.79095067\text{E} - 11(\text{C}) \end{aligned} \quad (75)$$

$$\begin{aligned} q_{\text{standard}} (\text{Wb}) &= \pi \times \frac{h}{m_e} \times \left( \frac{m_p}{m_e} + \frac{4}{3} \right)^{-1} \times \left( \frac{1}{c_{\text{standard}}} \right) \\ &= 1.24363481\text{E} - 06(\text{Wb}) \end{aligned} \quad (76)$$

$$\begin{aligned} m_{e\_standard} (\text{kg}) &= \frac{\pi}{4.5} \times \frac{h}{m_p} \times \left( \frac{m_p}{m_e} + \frac{4}{3} \right)^{-2} \times \left( \frac{1}{c_{\text{standard}}} \right)^2 \\ &= 8.19120012\text{E} - 14(\text{kg}) \end{aligned} \quad (77)$$

$$m_{p\_standard} (\text{kg}) = \frac{\pi}{4.5} \times \frac{h}{m_e} \times \left( \frac{m_p}{m_e} + \frac{4}{3} \right)^{-2} \times \left( \frac{1}{c_{standard}} \right)^2$$

$$= 1.50402938\text{E} - 10 (\text{kg}) \quad (78)$$

$$h_{standard} (\text{J} \cdot \text{s}) = \frac{\pi}{4.5} \times \frac{h}{m_p} \times \frac{h}{m_e} \times \left( \frac{m_p}{m_e} + \frac{4}{3} \right)^{-2} \times \left( \frac{1}{c_{standard}} \right)^2$$

$$= 5.9581930\text{E} - 17 (\text{J} \cdot \text{s}) \quad (79)$$

$$\frac{kT_{c\_standard}}{\alpha} (\text{J}) = \frac{1}{2\pi(1)} \times \frac{\pi}{4.5} \times \frac{h}{m_p} \times \frac{h}{m_e} \times \left( \frac{m_p}{m_e} + \frac{4}{3} \right)^{-3} (\text{J})$$

$$= 5.1607244\text{E} - 21 (\text{J}) \quad (80)$$

$$G_{N\_standard} \left( \frac{\text{m}^3}{\text{s}^2} \right) = \alpha \frac{4.5(1)}{4\pi(1)} \times \left( \frac{h}{m_p} \right)^2 \times \left( \frac{m_p}{m_e} + \frac{4}{3} \right)^{-1} \times c_{standard}$$

$$= 2.23182656\text{E} - 19 \left( \frac{(1 \text{ m}_{standard})^3}{(1 \text{ s}_{standard})^2} \right) \quad (81)$$

where  $e_{standard}$ ,  $q_{m\_standard}$ ,  $m_{e\_standard}$ ,  $m_{p\_standard}$ ,  $kT_{c\_standard}$  and  $G_{N\_standard}$  are the values for  $e$ ,  $q_m$ ,  $m_e$ ,  $m_p$ ,  $kT_c$  and  $G_N$ , respectively, when the standard values of 1 m and 1 s are used.

From Equation (62),

$$\varepsilon_{0\_standard} \left( \frac{\text{C}^2}{\text{kg}} \times \frac{\text{s}^2}{\text{m}^3} \right) = \frac{(e_{new})^2}{kT_{c\_new}/\alpha} \times \left( \frac{m_p}{m_e} + \frac{4}{3} \right)^{-1} \times \frac{1}{2\pi(1) \times 2\alpha} \times \left( \frac{1}{c_{standard}} \right)$$

$$= \frac{1}{378.8493064} \quad (82)$$

$$\mu_{0\_standard} \left( \frac{\text{kg}}{\text{C}^2} \cdot \text{m} \right) = \frac{kT_{c\_new}/\alpha}{(e_{new})^2} \times \left( \frac{m_p}{m_e} + \frac{4}{3} \right) \times 2\pi(1) \times 2\alpha \times \left( \frac{1}{c_{standard}} \right)$$

$$= 378.8493064 \quad (83)$$

### 3.3. Step 3: The Use of the Normalized Value of 1 kg

In Section 3.2, the unit of  $\text{m}^2/\text{s}$  can be 1. Then, the following equation can be used:

$$\left( \frac{m_p}{m_e} + \frac{4}{3} \right) \left( \frac{\text{m}^2}{\text{s}} \right) = 1.837486\text{E} + 03(1) \times 1 \left( \frac{\text{m}^2}{\text{s}} \right)$$

$$= 1.837486\text{E} + 03(1) \times 1 \left( \frac{(\text{m}_{standard})^2}{\text{s}_{standard}} \right) \quad (84)$$

where  $1.837486\text{E}+03(1)$  is dimensionless. We propose a normalized value of 1 kg as follows:

$$m_{e\_Normalized} (\text{kg}) = m_{e\_standard} (\text{kg}) \times 1.837486\text{E} + 03(1)$$

$$= 1.50512154\text{E} - 10 (\text{kg}) \quad (85)$$

$$m_{p\_Normalized} (\text{kg}) = m_{p\_standard} (\text{kg}) \times 1.837486\text{E} + 03(1)$$

$$= 2.7636329\text{E} - 07 (\text{kg}) \quad (86)$$

$$\begin{aligned}\frac{kT_{c\_Normalized}}{\alpha}(\text{J}) &= \frac{kT_{c\_standard}}{\alpha}(\text{J}) \times 1.837486\text{E} + 03(1) \\ &= 9.48275875\text{E} - 18(\text{J})\end{aligned}\quad (87)$$

where  $m_{e\_Normalized}$ ,  $m_{p\_Normalized}$  and  $kT_{c\_Normalized}$  are the values for  $m_e$ ,  $m_p$  and  $kT_c$  respectively, when the normalized value of 1 kg is used. For convenience, Equation (31) is rewritten as follows:

$$G_N = G \times 1 \text{ kg} (\text{m}^3 \cdot \text{s}^{-2}) = 6.673778\text{E} - 11 (\text{m}^3 \cdot \text{s}^{-2}) \quad (88)$$

Thus, the following equation can be obtained:

$$\begin{aligned}G_{N\_Normalized} \left( \frac{\text{m}^3}{\text{s}^2} \right) &= \frac{G_{N\_standard}}{1.837486\text{E} + 03(1)} = \frac{2.23182656\text{E} - 19}{1.837486\text{E} + 03(1)} \\ &= 1.21460875\text{E} - 22 \left( \frac{(1 \text{ m}_{standard})^3}{(1 \text{ s}_{standard})^2} \right)\end{aligned}\quad (89)$$

where  $G_{N\_Normalized}$  is the  $G_N$  when the normalized value of 1 kg is used. From Equations (75)-(83), the following can be defined:

$$\begin{aligned}e_{Normalized} (\text{C}) &= \frac{1}{4.5} \times \frac{h}{m_{p\_Normalized}} \times \left( \frac{\text{s}}{\text{m}^2} \right) \times \left( \frac{1}{c_{standard}} \right) \\ &= 4.79095067\text{E} - 11 (\text{C})\end{aligned}\quad (90)$$

$$\begin{aligned}q_{Normalized} (\text{Wb}) &= \pi \times \frac{h}{m_{e\_Normalized}} \times \left( \frac{\text{s}}{\text{m}^2} \right) \times \left( \frac{1}{c_{standard}} \right) \\ &= 1.24363481\text{E} - 06 (\text{Wb})\end{aligned}\quad (91)$$

$$\begin{aligned}m_{e\_Normalized} (\text{kg}) &= \frac{\pi}{4.5} \times \frac{h}{m_{p\_Normalized}} \times \left( \frac{\text{s}}{\text{m}^2} \right)^2 \times \left( \frac{1}{c_{standard}} \right)^2 \\ &= 1.50512154\text{E} - 10 (\text{kg})\end{aligned}\quad (92)$$

$$\begin{aligned}m_{p\_Normalized} (\text{kg}) &= \frac{\pi}{4.5} \times \frac{h}{m_{e\_Normalized}} \times \left( \frac{\text{s}}{\text{m}^2} \right)^2 \times \left( \frac{1}{c_{standard}} \right)^2 \\ &= 2.7636329\text{E} - 07 (\text{kg})\end{aligned}\quad (93)$$

$$\begin{aligned}h_{Normalized} (\text{J} \cdot \text{s}) &= \frac{\pi}{4.5} \times \frac{h}{m_{p\_Normalized}} \times \frac{h}{m_{e\_Normalized}} \times \left( \frac{\text{s}}{\text{m}^2} \right)^2 \times \left( \frac{1}{c_{standard}} \right)^2 \\ &= 5.9581930\text{E} - 17 (\text{J} \cdot \text{s})\end{aligned}\quad (94)$$

$$\begin{aligned}\frac{kT_{c\_Normalized}}{\alpha}(\text{J}) &= \frac{1}{2\pi(1)} \times \frac{\pi}{4.5} \times \frac{h}{m_{p\_Normalized}} \times \frac{h}{m_{e\_Normalized}} \times \left( \frac{\text{s}}{\text{m}^2} \right)^3 \\ &= 9.48275875\text{E} - 18(\text{J})\end{aligned}\quad (95)$$

$$\begin{aligned}G_{N\_Normalized} \left( \frac{\text{m}^3}{\text{s}^2} \right) &= \alpha \frac{4.5(1)}{4\pi(1)} \times \left( \frac{h}{m_{p\_Normalized}} \right)^2 \times \left( \frac{\text{s}}{\text{m}^2} \right) \times c_{standard} \\ &= 1.21460875\text{E} - 22 \left( \frac{(1 \text{ m}_{standard})^3}{(1 \text{ s}_{standard})^2} \right)\end{aligned}\quad (96)$$

$$\begin{aligned}\varepsilon_{0\_Normalized} \left( \frac{C^2}{\text{kg}} \times \frac{s^2}{\text{m}^3} \right) &= \frac{(e_{new})^2}{kT_{c\_Normalized}/\alpha} \times \frac{1}{2\pi(1) \times 2\alpha} \times \left( \frac{1}{c_{standard}} \right) \\ &= \frac{1}{378.8493064}\end{aligned}\quad (97)$$

$$\begin{aligned}\mu_{0\_Normalized} \left( \frac{\text{kg}}{C^2} \times \text{m} \right) &= \frac{kT_{c\_Normalized}/\alpha}{(e_{new})^2} \times 2\pi(1) \times 2\alpha \times \left( \frac{1}{c_{standard}} \right) \\ &= 378.8493064\end{aligned}\quad (98)$$

## 4. Results

### 4.1. Explanation of Our Main Four Equations Using the Values in Section 3.2.2

In this section, we ensure that Equations (75)-(83) are correct using our four equations (Equations (1), (2), (3) and (10)). Strictly speaking,  $m_e$  should be written as  $m_{e\_standard}$ . However, we omit the subscript "standard" to avoid unnecessary notational complexity.

For convenience, Equation (1) is rewritten as follows:

$$\frac{Gm_p^2}{hc} = \frac{4.5}{2} \times \frac{kT_c}{1 \text{ kg} \times c^2} \quad (99)$$

When the light speed is 1 m/s, the following equation is obtained:

$$\frac{G_N m_p^2}{h} = \frac{4.5(1)}{2} \times kT_c = 8.47341571\text{E} - 23 \quad (100)$$

where 4.5(1) is dimensionless. When Equations (75)-(83) are used, Equation (1) is correct, because the left side is equal to the right side. For convenience, Equation (2) is rewritten as follows:

$$\frac{Gm_p^2}{\left( \frac{e^2}{4\pi\varepsilon_0} \right)} = \frac{4.5(1)}{2\pi(1)} \times \frac{m_e}{e} \times hc \quad (101)$$

When the light speed is 1 m/s, the following equation is obtained:

$$\frac{Gm_p^2}{\left( \frac{e^2}{4\pi\varepsilon_0} \right)} = \frac{4.5(1)}{2\pi(1)} \times \frac{m_e}{e} \times h = 7.29580222\text{E} - 20 \quad (102)$$

When Equations (75)-(83) are used, Equation (2) is correct. For convenience, Equation (3) is rewritten as follows:

$$\frac{m_e c^2}{e} \times \left( \frac{e^2}{4\pi\varepsilon_0} \right) = \pi \times kT_c = 1.18311202\text{E} - 22 \quad (103)$$

When Equations (75)-(83) are used, Equation (3) is correct. For convenience, Equation (10) is rewritten as follows:

$$\frac{Gm_p^2}{\left(\frac{e^2}{4\pi\epsilon_0}\right)} = 4.5(1) \times \pi(1) \times \frac{kT_c/\alpha}{1 \text{ kg} \times c^2} \quad (104)$$

When the light speed is 1 m/s, the following equation is obtained:

$$\frac{G_N m_p^2}{\left(\frac{e^2}{4\pi\epsilon_0}\right)} = 4.5(1) \times \pi(1) \times \frac{kT_c}{\alpha} = 7.29580222\text{E} - 20 \quad (105)$$

Consequently, when Equations (75)-(83) are used, our main four equations are correct.

#### 4.2. Explanation of Our Main Four Equations Using the Values in Section 3.3

In this section, we ensure that Equations (90)-(98) are correct using our four equations (Equations (1), (2), (3) and (10)). Strictly speaking,  $m_e$  should be written as  $m_{e\_Normalized}$ . However, we omit the subscript "Normalized" to avoid unnecessary notational complexity.

For convenience, Equation (1) is rewritten as follows:

$$\frac{Gm_p^2}{hc} = \frac{4.5}{2} \times \frac{kT_c}{1 \text{ kg} \times c^2} \quad (106)$$

When the light speed is 1 m/s, the following equation is obtained:

$$\frac{G_N m_p^2}{h} = \frac{4.5(1)}{2} \times kT_c = 1.55697826\text{E} - 19 \quad (107)$$

When Equations (90)-(98) are used, Equation (1) is correct. For convenience, Equation (2) is rewritten as follows:

$$\frac{Gm_p^2}{\left(\frac{e^2}{4\pi\epsilon_0}\right)} = \frac{4.5(1)}{2\pi(1)} \times \frac{m_e}{e} \times hc \quad (108)$$

When the light speed is 1 m/s, the following equation is obtained:

$$\frac{Gm_p^2}{\left(\frac{e^2}{4\pi\epsilon_0}\right)} = \frac{4.5(1)}{2\pi(1)} \times \frac{m_e}{e} \times h = 1.34059343\text{E} - 16 \quad (109)$$

When Equations (90)-(98) are used, Equation (2) is correct. For convenience, Equation (3) is rewritten as follows:

$$\frac{m_e c^2}{e} \times \left(\frac{e^2}{4\pi\epsilon_0}\right) = \pi \times kT_c = 2.17395177\text{E} - 19 \quad (110)$$

When Equations (90)-(98) are used, Equation (3) is correct. For convenience, Equation (10) is rewritten as follows:

$$\frac{Gm_p^2}{\left(\frac{e^2}{4\pi\epsilon_0}\right)} = 4.5(1) \times \pi(1) \times \frac{kT_c/\alpha}{1 \text{ kg} \times c^2} \quad (111)$$

When the light speed is 1 m/s, the following equation is obtained:

$$\frac{G_N m_p^2}{\left(\frac{e^2}{4\pi\epsilon_0}\right)} = 4.5(1) \times \pi(1) \times \frac{kT_c}{\alpha} = 1.34059343E-16 \quad (112)$$

Consequently, for Equations (90)-(98), our main four equations are correct.

### 4.3. Ratio of the Gravitational Force to the Electric Force Should Be the Fundamental Constant and Unchanged

The ratio of the gravitational force to the electric force is a fundamental constant. The ratio should not be changed, even when the unit of mass is changed. According to Einstein, the following equation applies:

$$E = mc^2 \quad (113)$$

Therefore, the unit of mass (kg) is connected with the unit of work (J). Thus, the definition of the gravitational constant was changed from the relationship between the unit of mass to the relationship between the unit of work.

For convenience, Equations (10) and (105) are rewritten as follows:

$$\frac{Gm_p^2}{\left(\frac{e^2}{4\pi\epsilon_0}\right)} = 4.5(1) \times \pi(1) \times \frac{kT_c/\alpha}{1 \text{ kg} \times c^2} = 8.11767475E-37 \quad (114)$$

$$\frac{G_N m_p^2}{\left(\frac{e^2}{4\pi\epsilon_0}\right)} = 4.5(1) \times \pi(1) \times \frac{kT_c}{\alpha} = 7.29580222E-20 \quad (115)$$

So,

$$\frac{7.29580222E-20}{8.11767475E-37} = 299792458^2 = c(1)^2 \quad (116)$$

where  $c(1)$  is dimensionless. Consequently, gravity can be explained by the unit of work (J). This is very important because we strongly believe that gravity should be explained by PVs (Gibbs energy).

For convenience, Equation (112) is rewritten as follows:

$$\frac{G_N m_p^2}{\left(\frac{e^2}{4\pi\epsilon_0}\right)} = 4.5(1) \times \pi(1) \times \frac{kT_c}{\alpha} = 1.34059343E-16 \quad (117)$$

Here, the same problem occurs: the ratio should not be changed, even when the unit of mass is changed. Therefore, we changed the definition of the gravitational constant.

For convenience, Equation (38) is rewritten as follows:

$$G_{N\_new} \left( \frac{m^3}{s^2} \right) = \alpha c \frac{4.5(1)}{4\pi(1)} \times (4.5 \times e_{new} c) \times e_{new} c \times \frac{q_{m\_new} c}{m_{p\_new} c^2} \tag{118}$$

$$= 6.69084770E - 11 \left( \frac{m^3}{s^2} \right)$$

Then, we consider the unit.

$$\frac{q_{m\_new} c}{m_{p\_new} c^2} \left( \frac{Wb \times c}{kg \times c^2} = \frac{V \cdot s \times m/s}{J} = \frac{s}{C} \times \frac{m}{s} = \frac{1}{A \cdot m} \times \frac{m^2}{s} \right) \tag{119}$$

From Equations (91) and (93),

$$\frac{q_{Normalized} \times c_{standard}}{m_{p\_Normalized} \times c_{standard}^2} = \frac{1.24363E - 06}{2.76363E - 07} = 4.5 \left( \frac{1}{A \cdot m} \times \frac{m^2}{s} \right) \tag{120}$$

Therefore,

$$G_{N\_Normalized} \left( \frac{m^3}{s^2} \right) = \alpha c_{standard} \frac{4.5(1)}{4\pi(1)} \times (4.5 \times e_{Normalized} \times c_{standard})^2 \times 1 \left( \frac{m^2}{s} \right) \tag{121}$$

$$= 1.21460875E - 22 \left( \frac{m^3}{s^2} \right)$$

From Equation (49), the mass ratio of a proton to its minimum mass is defined as follows:

$$m_{p\_Normalized} \times \frac{\alpha c_{standard}^2}{kT_{c\_Normalized}} = \frac{2\pi(1)}{4.5 \times e_{Normalized} c_{standard}} = 2.914376E + 10 \tag{122}$$

Therefore,

$$G_{N\_Normalized} \left( \frac{m^3}{s^2} \right) = \alpha c_{standard} \frac{4.5(1)}{4\pi(1)} \times \left( 2\pi(1) \times \frac{kT_{c\_Normalized} / \alpha}{m_{p\_Normalized} \times c_{standard}^2} \right)^2 \times 1 \left( \frac{m^2}{s} \right) \tag{123}$$

$$= 1.21460875E - 22 \left( \frac{m^3}{s^2} \right)$$

In Equation (123), the unit of m<sup>3</sup>/s<sup>2</sup> can be omitted. Therefore,

$$G_{N\_Normalized} (1) = \alpha \times 4.5(1) \times \pi(1) \times \left( \frac{kT_{c\_Normalized} / \alpha}{m_{p\_Normalized} \times c_{standard}^2} \right)^2 \tag{124}$$

$$= 1.21460875E - 22$$

where  $G_{N\_Normalized} (1)$  is dimensionless. The gravitational constant can be explained by the mass ratio of a proton to its minimum mass. Thus, the definition of the gravitational constant was changed from the relationship between the unit of mass (kg) to the mass ratio of a proton to its minimum mass. We strongly believe that the mass ratio should be explained by the ratio of PVs.

### 5. Conclusions

The normalization methods in our algorithms are used to explain these equations. The normalization methods can be performed in three steps.

Step 1: Redefinition methods.

Step 2: Use the standard value of 1 m and 1 s.

Step 3: Use the standard value of 1 kg.

In Step 1, normalization of the electric constant ( $\epsilon_0$ ) and the magnetic constant ( $\mu_0$ ) is performed. The value in Equation (62) is equal to the value in Equation (17). Clearly, this is not a coincidence. After the redefinition method is applied, the calculated value only slightly changes. This occurred because the definition of the electric current (1 A) by Ampère's force law is highly suitable coincidentally. In more concrete terms, the force ( $2 \text{ dyn} = 2 \text{ g}\cdot\text{cm}/\text{s}^2$ ) was used to define the electric current (1A). Then, the definition of the electric current (1A) was highly suitable.

In Step 2, we defined the standard value of 1 m and 1 s. Then, the light speed using these values was 1 m/s. The unit of  $\text{m}^2/\text{s}$  is 1. The value of 1 J was equivalent to 1 kg,  $\pi$  (Vm) and  $1/4.5$  (Am) remained unchanged. When these values were used, Equations (1), (2), (3) and (10) were correct. Therefore, the ratio of the gravitational force to the electric force should not be changed. However, after the calculation was performed, the ratio changed. This likely occurred because we changed the definition of the gravitational constant from the relationship between the unit of mass to the relationship between the unit of work. This is very important because we strongly believe that gravity should be explained by PVs (Gibbs energy).

In Step 3, we define the normalized value of the mass. Then, the coefficient  $1.837486\text{E}+03$  disappears. Using these values, Equations (1), (2), (3) and (10) were correct. After the calculation, the same problem occurred. The ratio of the gravitational force to the electric force changed. Therefore, we changed the definition of the gravitational constant. We propose Equation (124). Thus, the definition of the gravitational constant was changed from the relationship between the unit of mass (kg) to the mass ratio of a proton to its minimum mass. We strongly believe that the mass ratio should be explained by the ratio of PVs.

## Conflicts of Interest

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

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## Appendix

In this appendix, the interpretation for Equation (22), which seems to be a numerical equation, is explained. For convenience, Equation (22) is rewritten as follows:

$$m_{e\_new} = \frac{4.48852}{4.5} \times \frac{\pi}{3.13201} \times m_e = 9.11394\text{E} - 31(\text{kg}) \quad (\text{A1})$$

Next, for convenience, Equations (6) and (7) are rewritten as follows:

$$3.13201(\text{V} \cdot \text{m}) = \frac{\left(\frac{m_p}{m_e} + \frac{4}{3}\right) m_e c^2}{ec} \quad (\text{A2})$$

$$4.48852\left(\frac{1}{\text{A} \cdot \text{m}}\right) = \frac{q_m c}{\left(\frac{m_p}{m_e} + \frac{4}{3}\right) m_p c^2} \quad (\text{A3})$$

The original concept of 4.5 and  $\pi$  are from the Ted Jacobson homepage.

“I suspect that there are in fact only a finite number of degrees of freedom in any finite volume. It seems difficult to reconcile this hypothesis with local Lorentz invariance, and with ordinary unitary quantum theory”

<https://terpconnect.umd.edu/~jacobson/>.

When we propose the following Equations (A4) and (A5),

$$3.132794486(\text{V} \cdot \text{m}) = \frac{\left(\frac{m_p}{m_e} + \frac{5.378178546}{3}\right) m_{e\_new} c^2}{e_{new} c} \quad (\text{A4})$$

$$4.487397553\left(\frac{1}{\text{A} \cdot \text{m}}\right) = \frac{q_{m\_new} c}{\left(\frac{m_p}{m_e} + \frac{5.378178546}{3}\right) m_{p\_new} c^2} \quad (\text{A5})$$

Equation (A1) becomes as follows.

$$m_{e\_new}(\text{kg}) = \frac{4.487397553}{4.5} \times \frac{\pi}{3.132794486} \times m_e = m_e(\text{kg}) \quad (\text{A6})$$

Then, the mass of an electron is unchanged, which seems to be more suitable. Furthermore, the Boltzmann constant is unchanged. From Equation (57),

$$\begin{aligned} T_{c\_new}(\text{K}) &= \frac{\alpha}{k} \times \frac{1}{2\pi(1)} \times \frac{\pi}{4.5} \times \frac{h}{m_p} \times \frac{h}{m_e} \times \left(\frac{m_p}{m_e} + \frac{5.378178546}{3}\right)^{-3} \\ &= 2.725630704(\text{K}) \end{aligned} \quad (\text{A7})$$

Thus, the CMB temperature is similar with the observed value as 2.72548 (K). However, From Equation (58)

$$\begin{aligned} G_{N\_new} \left(\frac{\text{m}^3}{\text{s}^2}\right) &= \alpha c \frac{4.5(1)}{4\pi(1)} \times \left(\frac{h}{m_p}\right)^2 \times \left(\frac{m_p}{m_e} + \frac{5.378178546}{3}\right)^{-1} \left(\frac{\text{m}^3}{\text{s}^2}\right) \\ &= 6.68917519\text{E} - 11 \end{aligned} \quad (\text{A8})$$

Then, from Equation (26),

$$G_N = G_{N\_new} \times \frac{4.487397553}{4.5} = 6.67044186E-11 \quad (A9)$$

Then, the value is different from  $6.6743 \times 10^{-11} \text{ (m}^3 \cdot \text{kg}^{-1} \cdot \text{s}^{-2}\text{)}$ . The error is  $5.784 \times 10^{-4}$ . Clearly, the compensation is needed.