Journal of Modern Physics, 2024, 15, 674-689
https://www.scirp.org/journal/jmp
ISSN Online: 2153-120X
ISSN Print: 2153-1196

Ratio of Gravitational Force to Electric Force from Empirical Equations in Terms of the Cosmic Microwave Background Temperature

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How to cite this paper: Miyashita, T. (2024) Ratio of Gravitational Force to Electric Force from Empirical Equations in Terms of the Cosmic Microwave Background Temperature. *Journal of Modern Physics*, **15**, 674-689.
https://doi.org/10.4236/jmp.2024.155031

Received: March 30, 2024
Accepted: April 23, 2024
Published: April 26, 2024

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 × 10^{-11} $m^3 \cdot kg^{-1} \cdot s^{-2}$, respectively. Every equation could be explained in terms of the Compton length of an electron (λ_e), the Compton length of a proton (λ_p) and α. Furthermore, every equation could also be explained in terms of Avogadro's number and the number of electrons in 1 C. However, the ratio of the gravitational force to the electric force cannot be uniquely determined when the unit of the Planck constant (Js) is changed. In this study, we showed that every equation can be described in terms of Planck constant. From the assumption of minimum mass, the ratio of gravitational force to electric force could be elucidated.

Keywords

Ratio of Gravitational Force to Electric Force, Minimum Mass, Temperature of the Cosmic Microwave Background

1. Introduction

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

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

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

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

Next, we derived an empirical equation for the fine-structure constant [6].

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

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

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

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

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

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

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

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

Every equation can be explained in terms of the Compton length of an electron (λ_e), the Compton length of a proton (λ_p) and α [10]. Furthermore, every equation can be explained in terms of Avogadro's number and the number of electrons in 1 C [11]. Using the correspondence principle with the thermodynamic principles in solid-state ionics [12] [13], we propose a canonical ensemble to explain these equations and the concept of the minimum mass. However, the ratio of gravitational force to electric force cannot be uniquely determined when the unit of Planck's constant (Js) is changed. In this study, for the assumption of minimum mass, we show that every equation can be described in terms of the Planck constant. Then, the ratio of the gravitational force to the electric force can be determined.

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 several equations in terms of the Planck constant. In Section 4, using these equations, we explain our main equations. In Section 5, our conclusions are described.

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 value6.673778 $\times 10^{-11}$ in this study)

T_c: CMB temperature: 2.72548 (K) (we used the compensated value 2.726312 K in this study)

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

c: speed of light: 299792458 (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: Rest mass of a proton:$1.6726219059 \times 10^{-27}$ (kg) (we used the compensated value of $1.672621923 \times 10^{-27}$ kg in this study)

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

Rk: 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

$$e_{new} = e \times \frac{4.48852}{4.5} = 1.59809\text{E}-19(\text{C}) \tag{10}$$

$$q_{m\_new} = q_m \times \frac{\pi}{3.13201} = 4.14832\text{E}-15(\text{Wb}) \tag{11}$$

$$h_{new} = e_{new} \times q_{m\_new} = h \times \frac{4.48852}{4.5} \times \frac{\pi}{3.13201} = 6.62938\text{E}-34(\text{J}\cdot\text{s}) \tag{12}$$

$$Rk_{\_new} = \frac{q_{m\_new}}{e_{\_new}} = Rk \times \frac{4.5}{4.48852} \times \frac{\pi}{3.13201} = 25958.0(\Omega) \tag{13}$$

Equation (13) can be rewritten as follows:

$$Rk_{new} = 4.5\left(\frac{1}{\text{A}\cdot\text{m}}\right) \times \pi(\text{V}\cdot\text{m}) \times \frac{m_p}{m_e} = 25957.9966027(\Omega) \tag{14}$$

$$Z_{0\_new} = \alpha \times \frac{2h_{new}}{e_{new}^2} = 2\alpha \times Rk_{new} = Z_0 \times \frac{4.5}{4.48852} \times \frac{\pi}{3.13201} = 378.849(\Omega) \tag{15}$$

Equation (15) can be rewritten as follows:

$$Z_{0\_new} = 4.5\left(\frac{1}{\mathrm{A \cdot m}}\right) \times \pi(\mathrm{V \cdot m}) \times 2\alpha \times \frac{m_p}{m_e} = 378.8493064(\Omega) \quad (16)$$

$$\mu_{0\_new} = \frac{Z_{0\_new}}{c} = \mu_0 \times \frac{4.5}{4.48852} \times \frac{\pi}{3.13201} = 1.26371\mathrm{E}-06\left(\mathrm{N \cdot A^{-2}}\right) \quad (17)$$

$$\varepsilon_{0\_new} = \frac{1}{Z_{0\_new} \times c} = \varepsilon_0 \times \frac{4.48852}{4.5} \times \frac{3.13201}{\pi} = 8.80466\mathrm{E}-12\left(\mathrm{F \cdot m^{-1}}\right) \quad (18)$$

$$c_{\_new} = \frac{1}{\sqrt{\varepsilon_{0\_new}\mu_{0\_new}}} = \frac{1}{\sqrt{\varepsilon_0\mu_0}} = c = 299792458\left(\mathrm{m \cdot s^{-1}}\right) \quad (19)$$

The Compton wavelength (λ) is as follows:

$$\lambda = \frac{h}{mc} \quad (20)$$

This value (λ) should be unchanged since the unit for 1 m is unchanged. However, in Equation (12), Planck's constant is changed. Therefore, the units for the masses of one electron and one proton need to be redefined.

$$m_{e\_new} = \frac{4.48852}{4.5} \times \frac{\pi}{3.13201} \times m_e = 9.11394\mathrm{E}-31(\mathrm{kg}) \quad (21)$$

$$m_{p\_new} = \frac{4.48852}{4.5} \times \frac{\pi}{3.13201} \times m_p = 1.67346\mathrm{E}-27(\mathrm{kg}) \quad (22)$$

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

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

To simplify the calculation, G_N is defined as follows:

$$G_N = G \times 1\,\mathrm{kg}\left(\mathrm{m^3 \cdot s^{-2}}\right) = 6.673778\mathrm{E}-11\left(\mathrm{m^3 \cdot s^{-2}}\right) \quad (24)$$

Now, the value of G_N value remains unchanged. However, G_N should change [9] as follows:

$$G_{N\_new} = G_N \times \frac{4.5}{4.48852}\left(\mathrm{m^3 \cdot s^{-2}}\right) = 6.69084770\mathrm{E}-11\left(\mathrm{m^3 \cdot s^{-2}}\right) \quad (25)$$

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]:

$$m_{e\_new}c^2 \times \left(\frac{m_p}{m_e} + \frac{4}{3}\right)^2 \left(\frac{\mathrm{J \cdot m^4}}{\mathrm{s^2}}\right)$$

$$= \frac{\pi}{4.5}\left(\mathrm{V \cdot m \cdot A \cdot m} = \frac{\mathrm{J \cdot m^2}}{\mathrm{s}}\right) \times \lambda_p c\left(\frac{\mathrm{m^2}}{\mathrm{s}}\right) = 2.76564\mathrm{E}-07\left(\frac{\mathrm{J \cdot m^4}}{\mathrm{s^2}}\right) = \text{constant} \quad (26)$$

$$e_{new}c\times\left(\frac{m_p}{m_e}+\frac{4}{3}\right)\left(\frac{\text{A}\cdot\text{m}^3}{\text{s}}\right)$$
$$=\frac{1}{4.5}(\text{A}\cdot\text{m})\times\lambda_p c\left(\frac{\text{m}^2}{\text{s}}\right)=8.80330\text{E}-08\left(\frac{\text{A}\cdot\text{m}^3}{\text{s}}\right)=\text{constant} \tag{27}$$

$$m_{p\_new}c^2\times\left(\frac{m_p}{m_e}+\frac{4}{3}\right)^2\left(\frac{\text{J}\cdot\text{m}^4}{\text{s}^2}\right)$$
$$=\frac{\pi}{4.5}\left(\frac{\text{J}\cdot\text{m}^2}{\text{s}}\right)\times\lambda_e c\left(\frac{\text{m}^2}{\text{s}}\right)=5.07814\text{E}-04\left(\frac{\text{J}\cdot\text{m}^4}{\text{s}^2}\right)=\text{constant} \tag{28}$$

$$q_{m\_new}c\times\left(\frac{m_p}{m_e}+\frac{4}{3}\right)\left(\frac{\text{V}\cdot\text{m}^3}{\text{s}}\right)$$
$$=\pi(\text{V}\cdot\text{m})\times\lambda_e c\left(\frac{\text{m}^2}{\text{s}}\right)=2.28516\text{E}-03\left(\frac{\text{V}\cdot\text{m}^3}{\text{s}}\right)=\text{constant} \tag{29}$$

$$kT_{c\_new}\times\frac{2\pi}{\alpha}\times\left(\frac{m_p}{m_e}+\frac{4}{3}\right)^3\left(\frac{\text{J}\cdot\text{m}^6}{\text{s}^3}\right)$$
$$=\frac{\pi}{4.5}\left(\frac{\text{J}\cdot\text{m}^2}{\text{s}}\right)\times\lambda_p c\times\lambda_e c=2.011697\text{E}-10\left(\frac{\text{J}\cdot\text{m}^6}{\text{s}^3}\right)=\text{constant} \tag{30}$$

$$G_{N\_new}\left(\frac{m^3}{s^2}\right)\times\left(\frac{m_p}{m_e}+\frac{4}{3}\right)\left(\frac{\text{m}^2}{\text{s}}\right)$$
$$=\left(\lambda_p c\right)^2\left(\frac{\text{m}^4}{\text{s}^2}\right)\times c\left(\frac{\text{m}}{\text{s}}\right)\times\frac{9\alpha}{8\pi}=1.22943\text{E}-07\left(\frac{\text{m}^5}{\text{s}^3}\right)=\text{constant} \tag{31}$$

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

Avogadro's number (N_A) is 6.02214076 × 10^{23}. This value is related to the following value.

$$N_A=\frac{1g}{m_p}=5.978637\text{E}+23 \tag{32}$$

Using the redefined values, the new definition of Avogadro's number (N_{A_new}) is as follows:

$$N_{A\_new}=\frac{1\,\text{kg}}{m_{p\_new}}=\frac{1\,\text{kg}_{new}}{m_p}=5.975649\text{E}+26\neq\frac{1\,\text{kg}_{new}}{m_{p\_new}} \tag{33}$$

The number of electrons in 1 C (N_e) is as follows:

$$N_e=\frac{1\,\text{C}}{e}=6.241509\text{E}+18 \tag{34}$$

Using the redefined values, the new definition of the number of electrons in 1 C (N_{e_new}) is as follows:

$$N_{e\_new}=\frac{1\,\text{C}_{new}}{e}=\frac{1\,\text{C}}{e_{new}}=6.257473\text{E}+18\neq\frac{1\,\text{C}_{new}}{e_{new}} \tag{35}$$

The following equations were proposed in a previous study [11]:

$$m_{p\_new} = \frac{1}{N_{A\_new}} \tag{36}$$

$$m_{e\_new} = \frac{m_e/m_p}{N_{A\_new}} \tag{37}$$

where m_p/m_e (=1836.1526) is not changed after redefinition.

$$e_{new} = \frac{1}{N_{e\_new}} \tag{38}$$

$$q_{m\_new} = \frac{4.5\pi \times m_p/m_e}{N_{e\_new}} = 4.148319\text{E}-15 \tag{39}$$

$$h_{new} = \frac{4.5\pi \times m_p/m_e}{\left(N_{e\_new}\right)^2} = 6.62938382\text{E}-34 \tag{40}$$

$$kT_{c\_new} = \frac{4.5 \times c^3 \times \alpha}{2\pi \times N_{e\_new} \times N_{A\_new}} = 3.7659625\text{E}-23 \tag{41}$$

$$G_{N\_new} = \frac{4.5^3 \times m_p/m_e \times N_{A\_new} \times c^2 \times \alpha}{4 \times N_{e\_new}^3} = 6.6908477\text{E}-11 \tag{42}$$

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

Furthermore, we propose the following four Equations (11):

$$kT_{c\_new}(\text{J}) = \frac{\alpha}{2\pi(1)} \times \frac{1}{\pi}\left(\frac{1}{\text{V}\cdot\text{m}}\right) \times q_{m\_new}c \times m_{e\_new}c^2 = 3.76596254\text{E}-23 \tag{43}$$

$$kT_{c\_new}(\text{J}) = \frac{\alpha}{2\pi(1)} \times 4.5\left(\frac{1}{\text{A}\cdot\text{m}}\right) \times e_{new}c \times m_{p\_new}c^2 = 3.76596254\text{E}-23 \tag{44}$$

In Equations (43) and (44), $2\pi(1)$ is dimensionless. For G, there are two equations, as follows:

$$\begin{aligned} &G_{N\_new}\left(\frac{\text{m}^3\cdot\text{s}^{-2}}{\text{kg}} \times \frac{\text{kg}}{\text{A}\cdot\text{m}} = \frac{\text{m}^2}{\text{C}\cdot\text{s}}\right) \\ &= \frac{\alpha c}{4\pi(1)} \times \left(4.5 \times e_{new}c\right)^2 \times \frac{q_{m\_new}c}{m_{p\_new}c^2} = 6.69084770\text{E}-11 \end{aligned} \tag{45}$$

$$G_{N\_new}\left(\frac{\text{m}^2}{\text{C}\cdot\text{s}}\right) = \frac{\alpha c}{4\pi(1)} \times \left(4.5 \times e_{new}c\right)^3 \times \frac{\pi(\text{V}\cdot\text{m})}{m_{e\_new}c^2} = 6.69084770\text{E}-11 \tag{46}$$

In Equations (45) and (46), $4\pi(1)$ is dimensionless. Importantly, the unit of G_N is different from the usual definition of $G \times 1$ kg.

3. Methods

3.1. Problem in Equation (2)

There is a problem in Equation (2). For convenience, Equation (2) is rewritten as follows:

$$\frac{Gm_p^2}{\left(\frac{e^2}{4\pi\varepsilon_0}\right)} = \frac{4.5}{2\pi} \times \frac{m_e}{e} \times hc \tag{47}$$

According to Equation (47), the ratio of the gravitational force to the electric force should change when the unit of Planck's constant (Js) changes. Therefore, we attempted to explain e, q_m, m_e, m_p and c as a function of h.

3.2. Expressions for e, q_m, m_e, m_p and c as a Function of h

Equation (14) is rewritten as follows:

$$Rk_{new} = 4.5\left(\frac{1}{\text{A}\cdot\text{m}}\right) \times \pi\left(\text{V}\cdot\text{m}\right) \times \frac{m_p}{m_e} = 25957.9966027\left(\Omega\right) \tag{48}$$

where m_p/m_e (=1836.1526) is not changed after redefinition. From Equation 48, the following can be obtained:

$$\frac{h_{new}}{e_{new}^2} = 4.5\pi \times \frac{m_p}{m_e} = 25957.9966027\left(\Omega\right) \tag{49}$$

Therefore, e_{new} and q_{m_new} can be written as follows:

$$e_{new} = \sqrt{\frac{h_{new}}{4.5\pi \times m_p/m_e}} \tag{50}$$

$$q_{m\_new} = Rk_{new} \times e_{new} = \sqrt{h_{new} \times 4.5\pi \times m_p/m_e} \tag{51}$$

Consequently, e_{new} and q_{m_new} can be defined by h_{new}. Next, Equations 8 and 9 are rewritten as follows:

$$m_{e\_new}c = e_{new} \times \pi \times \left(\frac{m_p}{m_e} + \frac{4}{3}\right)^{-1} \tag{52}$$

$$m_{p\_new}c = \frac{q_{m\_new}}{4.5} \times \left(\frac{m_p}{m_e} + \frac{4}{3}\right)^{-1} \tag{53}$$

Equations (50) and (52) can be rewritten as follows:

$$m_{e\_new}c = \sqrt{\frac{h_{new} \times \pi \times m_e/m_p}{4.5}} \times \left(\frac{m_p}{m_e} + \frac{4}{3}\right)^{-1} \tag{54}$$

From Equations (51) and (53),

$$m_{p\_new}c = \sqrt{\frac{h_{new} \times \pi \times m_p/m_e}{4.5}} \times \left(\frac{m_p}{m_e} + \frac{4}{3}\right)^{-1} \tag{55}$$

3.3. Values That Should Not Be Changed

Then, we proposed the minimum mass ($M_{\min}$), which is from the canonical ensemble, using the correspondence principle with the thermodynamic principles in solid-state ionics [11], as follows:

$$M_{\min} = \frac{kT_{c\_new}}{\alpha c^2}(\text{kg}) = \frac{h_{new}}{2\pi(1)} \times \frac{m_{e\_new} c}{\pi e_{new}}(\text{kg}) = \frac{h_{new}}{2\pi(1)} \times \left(\frac{m_p}{m_e} + \frac{4}{3}\right)^{-1} \tag{56}$$
$$= 5.74208028\text{E}-38(\text{kg})$$

where $2\pi(1)$ is dimensionless. The ratio between the mass of an electron and the minimum mass is defined as follows:

$$m_e \times \frac{\alpha c^2}{kT_c} = 2\pi(1) \times \frac{\pi}{q_m c} = 1.587219\text{E}+07 \tag{57}$$

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

$$m_p \times \frac{\alpha c^2}{kT_c} = 2\pi(1) \times \frac{1}{4.5} \times \frac{1}{ec} = 2.914376\text{E}+10 \tag{58}$$

These values in Equations 57 and 58 should not change because the value of the mass ratio, such as m_p/m_e (=1836.1526), should not change. However, e and q_m are functions of the number of electrons at 1C. Therefore, when we change the definition of 1C, these values should change.

3.4. Solution for the Unchanged Values

When we defined Planck's constant as (1 Js), the following equation can be used:

$$c_{genaral}\left(\frac{\text{m}_{general}}{\text{s}}\right) = c \times \sqrt{h_{new}(1)} = 299792458 \times \sqrt{6.62938\text{E}-34}$$
$$= 7.71893\text{E}-09\left(\frac{\text{m}_{general}}{\text{s}}\right) \tag{59}$$

where $h_{new}(1)$ (= 6.629383E−34) is dimensionless. $c_{general}$ and 1 $\text{m}_{general}$ are the values for c and 1 m, respectively, after Planck's constant is changed. Thus, the unit of the meter should be changed. Importantly, Equation (59) does not indicate a change in the light speed. Then, we propose the following 7 equations:

$$c_{general} = c \times \sqrt{h_{new}(1)} = 7.71893\text{E}-09\left(\frac{\text{m}_{general}}{\text{s}}\right) \tag{60}$$

$$e_{general} = \sqrt{\frac{1(\text{J}\cdot\text{s})}{4.5\pi \times m_p/m_e}} = 6.20675231\text{E}-03(\text{C}_{general}) \tag{61}$$

$$q_{m\_general} = \sqrt{1(\text{J}\cdot\text{s}) \times 4.5\pi \times m_p/m_e} = 1.61114855\text{E}+02(\text{Wb}_{general}) \tag{62}$$

$$m_{e\_general} = \sqrt{\frac{1(\text{J}\cdot\text{s}) \times \pi \times m_e/m_p}{c_{general}^2 \times 4.5}} \times \left(\frac{m_p}{m_e} + \frac{4}{3}\right)^{-1} = 1.37477924\text{E}+03(\text{kg}_{general}) \tag{63}$$

$$m_{p\_general} = \sqrt{\frac{1(\text{J}\cdot\text{s}) \times \pi \times m_p/m_e}{c_{general}^2 \times 4.5}} \times \left(\frac{m_p}{m_e} + \frac{4}{3}\right)^{-1} = 2.52430455\text{E}+06(\text{kg}_{general}) \tag{64}$$

$$\frac{kT_{c\_general}}{\alpha \times c_{general}^2} = \frac{1(\text{J}\cdot\text{s})}{2\pi(1)} \times \left(\frac{m_p}{m_e} + \frac{4}{3}\right)^{-1} = 8.66155955\text{E}-05(\text{kg}_{general}) \tag{65}$$

$$G_{N\_general} = \frac{\alpha c_{general}^3}{m_p/m_e} \times \frac{4.5^2}{4\pi^2} \times 1(\mathrm{J\cdot s}) \times \left(\frac{m_p}{m_e} + \frac{4}{3}\right) = 1.72273202\mathrm{E}-27\left(\frac{\mathrm{m}_{general}^2}{\mathrm{C}_{general}\cdot \mathrm{s}}\right) \tag{66}$$

where 1 $C_{general}$, 1 $Wb_{general}$, 1 $kg_{general}$, $e_{general}$, $q_{m\_general}$, $m_{e\_general}$, $m_{p\_general}$, $T_{c\_general}$ and $G_{N\_gerneral}$ 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. Importantly, the unit of G_N is different from the usual definition of $G \times$ 1 kg.

4. Results

In this section, using Equations (60)-(66), we establish values that should not be changed and our main three Equations 1, 2 and 3.

4.1. Mathematical Proof for Equations (57) and (58)

The right side of Equation 57 is as follows:

$$2\pi(1)\times\frac{\pi}{q_m c} = \frac{2\pi(1)\times\pi}{q_{m\_general}c_{general}} = \frac{2\pi(1)\times\pi}{\sqrt{1(\mathrm{J\cdot s})\times 4.5\pi\times m_p/m_e}\times c\times\sqrt{h_{new}(1)}} = 1.58721906\mathrm{E}+07 \tag{67}$$

Consequently, the ratio between the mass of an electron and the minimum mass can be constant.

The right side of Equation (58) is as follows:

$$2\pi(1)\times\frac{1}{4.5}\times\frac{1}{ec} = \frac{2\pi(1)}{4.5}\times\frac{1}{\sqrt{\frac{1(\mathrm{J\cdot s})}{4.5\pi\times m_p/m_e}}\times c\times\sqrt{h_{new}(1)}} = 2.91437649\mathrm{E}+10 \tag{68}$$

Consequently, the ratio between the mass of a proton and the minimum mass can be constant.

4.2. Mathematical Proof for $\left(\frac{m_p}{m_e}+\frac{4}{3}\right)$ after the Definition of the Planck Constant Is Changed

We used the following equation after we ensured that the definition of the Planck constant changed:

$$\left(\frac{m_p}{m_e}+\frac{4}{3}\right) = \frac{q_m c}{4.5 m_p c^2} = \frac{\pi e c}{m_e c^2} \tag{69}$$

Then, the following equations can be applied:

$$\frac{q_{m\_general}}{4.5 m_{p\_general}\times c_{general}} = \frac{1.611145\mathrm{E}+02}{4.5\times 2.52430\mathrm{E}+06\times 7.71893\mathrm{E}-09} = 1837.4860 = \frac{m_p}{m_e}+\frac{4}{3} \tag{70}$$

$$\frac{\pi e_{genaral}}{m_{e\_general} c_{genaral}} = \frac{\pi \times 6.20675\text{E}-03}{1.374779\text{E}+03 \times 7.71893\text{E}-09} = 1837.4860 = \frac{m_p}{m_e} + \frac{4}{3} \quad (71)$$

Consequently, Equation (69) is correct after the definition of the Planck constant is changed.

4.3. Explanation of Our Main Three Equations

From this section onward, the values used are those obtained after the definition of the Planck constant is changed. Strictly speaking, m_e should be written as $m_{e\_general}$. However, we omit the subscript "general" to avoid unnecessarily notational complexity.

4.3.1. Explanation of Our First Equation

For convenience, Equation 1 is rewritten as follows:

$$\frac{Gm_p^2}{hc} = \frac{4.5}{2} \times \frac{kT_c}{1\,\text{kg} \times c^2} \quad (72)$$

Therefore, the following can be applied:

$$\frac{G_N m_p^2}{hc} = \frac{4.5}{2} \times \frac{kT_c}{c^2} \quad (73)$$

The left side of Equation (72) is rewritten as follows:

$$\frac{G_N m_p^2}{hc} = \frac{\frac{\alpha c^3}{m_p/m_e} \times \frac{4.5^2}{4\pi^2} \times 1(\text{J}\cdot\text{s}) \times \left(\frac{m_p}{m_e} + \frac{4}{3}\right) \times \frac{1(\text{J}\cdot\text{s}) \times \pi \times m_p/m_e}{c^2 \times 4.5} \times \left(\frac{m_p}{m_e} + \frac{4}{3}\right)^{-2}}{c} \quad (74)$$

Therefore, the following can be applied:

$$\frac{G_N m_p^2}{hc} = \frac{4.5\alpha}{4\pi} \times \left(\frac{m_p}{m_e} + \frac{4}{3}\right)^{-1} \quad (75)$$

The right side of Equation (73) is as follows:

$$\frac{4.5}{2} \times \frac{kT_c}{c^2} = \frac{4.5}{2} \times \alpha \times \frac{1(\text{J}\cdot\text{s})}{2\pi(1)} = \frac{4.5\alpha}{4\pi} \times \left(\frac{m_p}{m_e} + \frac{4}{3}\right)^{-1} \quad (76)$$

Therefore, the following can be obtained:

$$\frac{Gm_p^2}{hc} = \frac{4.5}{2} \times \frac{kT_c}{1\,\text{kg} \times c^2} \quad (77)$$

4.3.2. Explanation of Our Second Equation

For convenience, Equation (2) is rewritten as follows:

$$\frac{Gm_p^2}{\left(\frac{e^2}{4\pi\varepsilon_0}\right)} = \frac{4.5}{2\pi} \times \frac{m_e}{e} \times hc \quad (78)$$

Therefore, the following can be obtained:

$$\frac{G_N m_p^2}{hc} = \frac{4.5}{2\pi} \times \frac{m_e}{e} \times \left(\frac{e^2}{4\pi\varepsilon_0} \right) \tag{79}$$

According to Equation (75), the left side of Equation (79) is as follows:

$$\frac{G_N m_p^2}{hc} = \frac{4.5\alpha}{4\pi} \times \left(\frac{m_p}{m_e} + \frac{4}{3} \right)^{-1} \tag{80}$$

The right side of Equation (79) can be written as follows:

$$\frac{4.5}{2\pi} \times \frac{m_e}{e} \times \left(\frac{e^2}{4\pi\varepsilon_0} \right) = \frac{4.5}{2\pi} \times m_e \times \frac{ec}{4\pi\varepsilon_0 c} = \frac{4.5}{2\pi} \times m_e \times \frac{ec}{4\pi} \times Z_0 \quad 81)$$

For convenience, Equation (16) is rewritten as follows:

$$Z_0 = 4.5 \times 2\pi \times \alpha \times \frac{m_p}{m_e} = 9\pi \times \alpha \times \frac{m_p}{m_e} \tag{82}$$

Therefore, the following can be obtained:

$$\frac{4.5}{2\pi} \times \frac{m_e}{e} \times \left(\frac{e^2}{4\pi\varepsilon_0} \right) = \frac{4.5}{2\pi} \times m_e \times \frac{ec}{4\pi} \times 9\pi \times \alpha \times \frac{m_p}{m_e} = \frac{4.5^2 \alpha}{4\pi} \times m_p \times ec \times \alpha \tag{83}$$

Hence, the following can be obtained:

$$\begin{aligned} \frac{4.5^2 \alpha}{4\pi} \times ec \times m_p &= \frac{4.5^2 \alpha}{4\pi} \times \sqrt{\frac{1(\mathrm{J \cdot s})}{4.5\pi \times m_p / m_e}} \sqrt{\frac{1(\mathrm{J \cdot s}) \times \pi \times m_p / m_e}{c^2 \times 4.5}} \times \left(\frac{m_p}{m_e} + \frac{4}{3} \right)^{-1} \\ &= \frac{4.5\alpha}{4\pi} \times \left(\frac{m_p}{m_e} + \frac{4}{3} \right)^{-1} \end{aligned} \tag{84}$$

From Equations (80) and (84), we obtain the following:

$$\frac{G_N m_p^2}{hc} = \frac{4.5}{2\pi} \times \frac{m_e}{e} \times \left(\frac{e^2}{4\pi\varepsilon_0} \right) \tag{85}$$

Therefore, the following can be obtained:

$$\frac{G m_p^2}{\left(\frac{e^2}{4\pi\varepsilon_0} \right)} = \frac{4.5}{2\pi} \times \frac{m_e}{e} \times hc \tag{86}$$

4.3.3. Explanation of Our Third Equation

For convenience, Equation (3) is rewritten as follows:

$$\frac{m_e c^2}{e} \times \left(\frac{e^2}{4\pi\varepsilon_0} \right) = \pi \times kT_c \tag{87}$$

The left side of Equation (87) can be written as follows:

$$m_e c^2 \times \frac{e}{4\pi\varepsilon_0} = m_e c^2 \times \frac{ec}{4\pi\varepsilon_0 c} = m_e c^2 \times \frac{ec}{4\pi} \times Z_0 \tag{88}$$

Therefore, using Equation (16), we obtain the following:

$$m_e c^2 \times \frac{ec}{4\pi} \times Z_0 = m_e c^2 \times \frac{ec}{4\pi} \times 9\pi \times \alpha \times \frac{m_p}{m_e} = m_p c^2 \times ec \times \frac{9}{4} \alpha \tag{89}$$

Therefore, the following can be obtained:

$$m_p c^2 \times ec \times \frac{9}{4}\alpha = \frac{9}{4}\alpha c^3 \times \sqrt{\frac{1(\mathrm{J \cdot s}) \times \pi \times m_p / m_e}{c^2 \times 4.5}} \times \left(\frac{m_p}{m_e} + \frac{4}{3}\right)^{-1} \times \sqrt{\frac{1(\mathrm{J \cdot s})}{4.5\pi \times m_p / m_e}} \quad (90)$$

Thus, the following can be obtained:

$$m_p c^2 \times ec \times \frac{9}{4}\alpha = \frac{1}{2}\alpha c^2 \times 1(\mathrm{J \cdot s}) \times \left(\frac{m_p}{m_e} + \frac{4}{3}\right)^{-1} \quad (91)$$

The right side of Equation (87) can be written as follows:

$$\pi \times kT_c = \frac{kT_c}{\alpha \times c^2} \times \pi\alpha c^2 = \frac{1(\mathrm{J \cdot s})}{2\pi(1)} \times \left(\frac{m_p}{m_e} + \frac{4}{3}\right)^{-1} \times \pi\alpha c^2 \quad (92)$$

From Equations (91) and (92), we obtain the following equation:

$$m_e c^2 \times \frac{e}{4\pi\varepsilon_0} = \pi \times kT_c \quad (93)$$

4.4. Mathematical Proof for the Ratio of Gravitational Force to Electric Force

Equation (2) is rewritten as follows:

$$\frac{Gm_p^2}{hc} = \frac{4.5}{2} \times \frac{kT_c}{1\,\mathrm{kg} \times c^2} \quad (94)$$

The fine-structure constant is defined as follows:

$$\frac{e^2}{4\pi\varepsilon_0} = \frac{\alpha hc}{2\pi} = 2.30823131\mathrm{E}-28(\mathrm{J \cdot m}) \quad (95)$$

Therefore, the following can be obtained:

$$\frac{Gm_p^2}{\left(\frac{e^2}{4\pi\varepsilon_0}\right)}\left(\frac{1}{\mathrm{A \cdot m}}\right) = \frac{4.5\left(\frac{1}{\mathrm{A \cdot m}}\right) \times \pi(1) \times \frac{kT_{c\_general}}{\alpha \times c_{general}^2}\left(\mathrm{kg}_{general}\right)}{1\,\mathrm{kg}} \quad (96)$$

Therefore, using Equation (65), we can obtain the following:

$$\frac{Gm_p^2}{\left(\frac{e^2}{4\pi\varepsilon_0}\right)}\left(\frac{1}{\mathrm{A \cdot m}}\right) = \frac{\frac{4.5}{2}\left(\frac{1}{\mathrm{A \cdot m}}\right) \times \pi(1) \times \left(\frac{m_p}{m_e} + \frac{4}{3}\right)^{-1}\left(\mathrm{kg}_{general}\right)}{1\,\mathrm{kg}}$$
$$= 3.84688\mathrm{E}-03\left(\frac{1}{\mathrm{A \cdot m}} \times \frac{\mathrm{kg}_{general}}{1\,\mathrm{kg}}\right) \quad (97)$$

Then, the following can be obtained:

$$\frac{\mathrm{kg}_{general}}{1\,\mathrm{kg}} = \frac{m_{p\_general}}{m_{p\_new}} = \frac{2.52430455\mathrm{E}+06}{1.6734583781\mathrm{E}-27} = 6.629384\mathrm{E}-34 = h(1) \quad (98)$$

where $h(1)$ is dimensionless. Thus, the following can be defined:

$$1\,\text{kg} = \frac{\text{kg}_{general}}{h(1)} \tag{99}$$

From Equations (97) and (99), the following can be obtained:

$$\frac{Gm_p^2}{\left(\frac{e^2}{4\pi\varepsilon_0}\right)}\left(\frac{1}{\text{A}\cdot\text{m}}\right) = 3.84688\text{E}-03 \times 6.629384\text{E}-34\left(\frac{1}{\text{Am}}\right)$$
$$= 8.11767475\text{E}-37\left(\frac{1}{\text{A}\cdot\text{m}}\right) \tag{100}$$

Consequently, the ratio of the gravitational force to the electric force can be explained.

4.5. Theoretical Meaning of Equation (3)

Equation (3) is written as follows:

$$\frac{m_e c^2}{e} \times \left(\frac{e^2}{4\pi\varepsilon_0}\right) = \pi \times kT_c \tag{101}$$

Equation (101) is equal to Equation (92). Therefore,

$$M_{\min}\left(\text{kg}_{general}\right) = \frac{kT_c}{\alpha \times c^2} = \frac{1(\text{J}\cdot\text{s})}{2\pi} \times \left(\frac{m_p}{m_e} + \frac{4}{3}\right)^{-1} \tag{102}$$

Consequently, Equation 3 indicates the existence of a minimum mass.

4.6. Easiest Explanation for the Minimum Mass

The total energy ($T.E.$) is the sum of the potential energy ($P.E.$) and the kinetic energy ($K.E.$). Under the activation energy (Ea), these values should change. When Ea is kT_c/α,

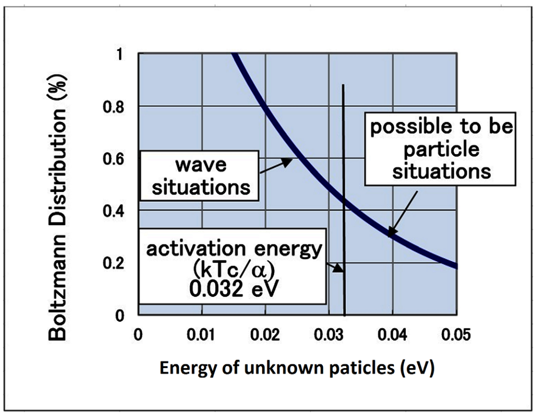
$$T.E = K.E. + P.E. \tag{103}$$

$$K.E._{particle} = K.E._{wave} - \frac{kT_c}{\alpha} > 0 \tag{104}$$

$$P.E._{particle} = P.E._{wave} + \frac{kT_c}{\alpha} \tag{105}$$

where $K.E._{particle}$, $K.E._{wave}$, $P.E._{paricle}$ and $K.E._{wave}$ are $K.E.$ in the particle situation, $K.E.$ in the wave situation, $P.E.$ in the particle situation and $K.E.$ in the wave situation, respectively. Strictly speaking, the energy in the particle situations should be defined by the Gibbs energy.

Regarding the correspondence principle with the thermodynamic principles in solid-state ionics [11], the wave situation corresponds to the ions in the vacancies. The particle situations correspond to the ions during hopping. The correct canonical ensemble for explaining these equations is shown in **Figure 1**. In a previous report [11], we considered the wave situation to correspond to the ions during hopping as "the moving situation", which should be corrected and is different in this report.



Figurer 1. Correct canonical ensemble from the correspondence principle with solid-state ionics. There should be unknown particles that are not related to the photon.

The minimum mass is not related to the photon. There should be unknown particles.

5. Conclusions

Using the correspondence principle with the thermodynamic principles in solid-state ionics, we propose a canonical ensemble to explain these equations and the concept of the minimum mass. From the assumption of minimum mass, we show that every equation can be explained in terms of Planck's constant. Then, the ratio of the gravitational force to the electric force can be explained.

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

$$c_{general} = c \times \sqrt{h_{new}(1)} = 7.71893\text{E}-09\left(\frac{\text{m}_{general}}{\text{s}}\right) \tag{106}$$

$$e_{general} = \sqrt{\frac{1(\text{J}\cdot\text{s})}{4.5\pi \times m_p/m_e}} = 6.20675231\text{E}-03\left(\text{C}_{general}\right) \tag{107}$$

$$q_{m\_general} = \sqrt{1(\text{J}\cdot\text{s}) \times 4.5\pi \times m_p/m_e} = 1.61114855\text{E}+02\left(\text{Wb}_{general}\right) \tag{108}$$

$$m_{e\_general} = \sqrt{\frac{1(\text{J}\cdot\text{s}) \times \pi \times m_e/m_p}{c_{general}^2 \times 4.5}} \times \left(\frac{m_p}{m_e} + \frac{4}{3}\right)^{-1} = 1.37477924\text{E}+03\left(\text{kg}_{general}\right) \tag{109}$$

$$m_{p\_general} = \sqrt{\frac{1(\text{J}\cdot\text{s}) \times \pi \times m_p/m_e}{c_{general}^2 \times 4.5}} \times \left(\frac{m_p}{m_e} + \frac{4}{3}\right)^{-1} = 2.52430455\text{E}+06\left(\text{kg}_{general}\right) \tag{110}$$

$$\frac{kT_{c\_general}}{\alpha \times c_{general}^2} = \frac{1(\text{J}\cdot\text{s})}{2\pi(1)} \times \left(\frac{m_p}{m_e} + \frac{4}{3}\right)^{-1} = 8.66155955\text{E}-05\left(\text{kg}_{general}\right) \tag{111}$$

$$\begin{aligned} G_{N\_general} &= \frac{\alpha c_{general}^3}{m_p/m_e} \times \frac{4.5^2}{4\pi^2} \times 1(\text{J}\cdot\text{s}) \times \left(\frac{m_p}{m_e} + \frac{4}{3}\right) \\ &= 1.72273202\text{E}-27\left(\frac{\text{m}_{general}^2}{\text{C}_{general}\cdot\text{s}}\right) \end{aligned} \tag{112}$$

The minimum mass is as follows:

$$M_{\min}\left(kg_{general}\right)=\frac{kT_c}{\alpha\times c^2}=\frac{1(\mathrm{J}\cdot\mathrm{s})}{2\pi}\times\left(\frac{m_p}{m_e}+\frac{4}{3}\right)^{-1} \tag{113}$$

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

$$m_{e\_general}\times\frac{\alpha c_{general}^2}{kT_{c\_general}}=2\pi(1)\times\frac{\pi}{q_{m\_general}c_{general}}=1.587219\mathrm{E}+07 \tag{114}$$

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

$$m_{p\_general}\times\frac{\alpha c_{general}^2}{kT_{c\_general}}=2\pi(1)\times\frac{1}{4.5}\times\frac{1}{e_{general}c_{general}}=2.914376\mathrm{E}+10 \tag{115}$$

The ratio of the gravitational force to the electric force is as follows:

$$\begin{aligned}\frac{Gm_p^2}{\left(\frac{e^2}{4\pi\varepsilon_0}\right)}\left(\frac{1}{\mathrm{A}\cdot\mathrm{m}}\right)&=\frac{\frac{4.5}{2}\left(\frac{1}{\mathrm{Am}}\right)\times\pi(1)\times\left(\frac{m_p}{m_e}+\frac{4}{3}\right)^{-1}\left(\mathrm{kg}_{general}\right)}{1\,\mathrm{kg}}\\&=8.11767475\mathrm{E}-37\left(\frac{1}{\mathrm{A}\cdot\mathrm{m}}\right)\end{aligned} \tag{116}$$

We already have various lists for the three equations shown in Section 2. The compatibility among these lists will be explained in a future study.

Conflicts of Interest

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

References

[1] Miyashita, T. (2020) *Journal of Modern Physics*, **11**, 1180-1192. https://doi.org/10.4236/jmp.2020.118074

[2] Miyashita, T. (2021) *Journal of Modern Physics*, **12**, 623-634. https://doi.org/10.4236/jmp.2021.125040

[3] Miyashita, T. (2021) *Journal of Modern Physics*, **12**, 859-869. https://doi.org/10.4236/jmp.2021.127054

[4] Miyashita, T. (2020) *Journal of Modern Physics*, **11**, 1159. https://doi.org/10.4236/jmp.2020.118074

[5] Miyashita, T. (2021) *Journal of Modern Physics*, **12**, 1160-1161. https://doi.org/10.4236/jmp.2021.128069

[6] Miyashita, T. (2022) *Journal of Modern Physics*, **13**, 336-346. https://doi.org/10.4236/jmp.2022.134024

[7] Miyashita, T. (2018) *Journal of Modern Physics*, **9**, 2346-2353. https://doi.org/10.4236/jmp.2018.913149

[8] Miyashita, T. (2023) *Journal of Modern Physics*, **14**, 160-170. https://doi.org/10.4236/jmp.2023.142011

[9] Miyashita, T. (2023) *Journal of Modern Physics*, **14**, 432-444. https://doi.org/10.4236/jmp.2023.144024

[10] Miyashita, T. (2023) *Journal of Modern Physics*, **14**, 1217-1227. https://doi.org/10.4236/jmp.2023.148068

[11] Miyashita, T. (2024) *Journal of Modern Physics*, **15**, 51-63. https://doi.org/10.4236/jmp.2024.151002

[12] Jarzynski, C. (1997) *Physical Review Letters*, **78**, 2690. https://doi.org/10.1103/PhysRevLett.78.2690

[13] Miyashita, T. (2017) *Journal of the Electrochemical Society*, **164**, E3190-E3199. https://doi.org/10.1149/2.0251711jes