Scientific Research Publishing

Journal of Modern Physics, 2026, 17(8), 953-969
https://www.scirp.org/journal/jmp
ISSN Online: 2153-120X
ISSN Print: 2153-1196

# A Readout-Based Structural Analysis of Empirical CMB Temperature Equations: Macro-Micro Correspondence and Action-Level Framework

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**How to cite this paper:** Miyashita, T. (2026) A Readout-Based Structural Analysis of Empirical CMB Temperature Equations: Macro-Micro Correspondence and Action-Level Framework. *Journal of Modern Physics*, **17**, 953-969.
https://doi.org/10.4236/jmp.2026.178043

**Received:** July 20, 2026
**Accepted:** August 22, 2026
**Published:** August 25, 2026



## Abstract

This report extends our previous studies of empirical equations involving the cosmic microwave background (CMB) temperature by reformulating them within a readout-based structural framework. The empirical relation previously introduced as Equation (12) is reconsidered beyond a purely MKSA-specific numerical adjustment and reorganized in terms of macro-micro correspondence. The framework connects macroscopic reference units, microscopic mass-energy quantities, electromagnetic readouts, and action-level denominators through a branch-resolved table-number rule. The CMB temperature derived under the adopted map is 2.7256307 K, in agreement with the observed value of 2.72548 ± 0.00057 K. The same procedure also provides a gravitational-side calculation. After conversion back to the MKSA reference system, the gravitational value is $6.674184325 \times 10^{-11}$ m$^3$·kg$^{-1}$·s$^{-2}$, close to the reported value of $6.6743 \times 10^{-11}$ m$^3$·kg$^{-1}$·s$^{-2}$. The first and second redefinitions are interpreted as MKSA-derived representations rather than as a universal family of unit systems. The aim is not to present a complete microphysical theory, but to examine whether the CMB-temperature equations and gravitational-side readouts can be organized consistently within a common macro-micro readout framework.

## Keywords

Cosmic Microwave Background Temperature, Minimum Mass, Readout Structure, Macro-Micro Correspondence, Action-Level Denominator, Gravitational Constant

## 1. Introduction

The symbols used in this paper are summarized in Section 2. In previous studies, we proposed a set of empirical equations relating the cosmic microwave background (CMB) temperature to several physical quantities and evaluated them numerically [1]-[5]. In particular, Equations (1)-(3) summarize characteristic CMB-temperature relations that provide the empirical starting point for the present analysis.

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

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

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

We also introduced an empirical expression for the fine-structure constant [6] and examined its consistency with related quantities [7] [8].

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

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

Small deviations from the ideal values of 9/2 and π, respectively, were previously considered as a means of reducing the resulting numerical errors [9]-[14]. The coefficient associated with the dimensional factor $\mathrm{m}^2/\mathrm{s}$ was denoted by $kL$, and by $kL_0$ when expressed explicitly in the meter-kilogram-second-ampere (MKSA) reference system [15] [16]. In the present work, $kL_0$ is treated as a structural readout coefficient associated with the $\mathrm{m}^2/\mathrm{s}$-type branch, rather than as a new dynamical operator or an independently measured transport coefficient.

$$kL\left(\frac{\mathrm{m}^2}{\mathrm{s}}\right) = 1837.94538\left(\frac{\mathrm{m}^2}{\mathrm{s}}\right)_{\mathrm{MKSA}} \equiv kL_0\left(\frac{\mathrm{m}^2}{\mathrm{s}}\right)_{\mathrm{MKSA}} \tag{6}$$

where the subscript "MKSA" denotes the MKSA reference system.

$$3.1327945(\mathrm{V} \cdot \mathrm{m}) = \frac{kL_0 \cdot m_e c^2}{e \cdot c} \tag{7}$$

$$4.4873976\left(\frac{1}{\mathrm{A} \cdot \mathrm{m}}\right) = \frac{q_m \cdot c}{kL_0 \cdot m_p c^2} \tag{8}$$

Applying the first redefinition to the von Klitzing constant returns these coefficients to the ideal values of 9/2 and π [15], yielding Equation (9) and Equation (10).

$$\pi_{unit} = \frac{kL_0 \cdot m_e c^2}{e_{new} \cdot c} \tag{9}$$

$$4.5_{unit} = \frac{q_{m\_new} \cdot c}{kL_0 \cdot m_p c^2} \tag{10}$$

The parameter $kL_0$ is then obtained from Equation (11).

$$kL_0 = \sqrt{\frac{3.1327945}{4.4873976} \cdot \frac{hc^2}{m_p c^2 \cdot m_e c^2}} = \sqrt{\frac{\pi_{unit}}{4.5_{unit}} \cdot \frac{hc^2}{m_p c^2 \cdot m_e c^2}} = 1837.94538 \tag{11}$$

This procedure leads to the following relation.

$$m_p c^2 \cdot m_e c^2 \cdot \frac{4.5_{unit}}{\pi_{unit}} \cdot hc^2 = \left(2\pi(1) \cdot \frac{kT_c}{\alpha}\right)^2 = 1.04985584\text{E}-39 \tag{12}$$

Using this framework, the CMB temperature derived under the adopted map is 2.7256307 K, in agreement with the observed value of 2.72548 ± 0.00057 K. Previous work focused mainly on numerical consistency and readout adjustments within the MKSA reference system [15] [16]. However, the structural meaning of Equation (12), particularly its relationship to the connection between $E = mc^2$ and $E = h\nu$, requires further clarification. Our most recent report [17] examined the structural meaning of these relations in detail.

In the present study, we reconsider these empirical relations from the viewpoint of macro-micro correspondence. The two readout redefinitions are not interpreted as physical changes in fundamental constants, but as changes in their numerical representations. This makes it possible to compare macroscopic reference units with microscopic mass-energy, electromagnetic, and action-related quantities within a single structural framework.

Particular attention is given to the role of $kL_0$, which connects the minimum-mass energy scale with $hc^2$. The same framework is then used to derive the CMB temperature under the adopted map and to examine the gravitational constant, including the role of the human-defined 1 kg reference mass. The purpose is to test the numerical and structural consistency of these relations, rather than to propose a new interaction or a complete microscopic theory.

Section 2 summarizes the symbols and basic relations. Section 3 describes the numerical scaling procedure used in the calculation. Section 4 presents the CMB temperature derived under the adopted map, the macro-micro connection relations, and the gravitational-side results. Section 5 discusses their interpretation, limitations, and remaining open questions. Section 6 summarizes the conclusions.

## 2. Symbol List and Basic Readout Relations

### 2.1. Reference Constants in MKSA Units (Values Taken from Standard Reference Data)

$G$: Gravitational constant: $6.6743 \times 10^{-11}$ ($m^3 \cdot kg^{-1} \cdot s^{-2}$)

(listed for comparison only; not used as an input in the calculation chain.)

$T_c$: CMB temperature: 2.72548 ± 0.00057 (K)

(listed for comparison only; not used as an input in the calculation chain.)

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

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

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

$\varepsilon_0$: Electric constant: $8.8541878128 \times 10^{-12}$ ($N \cdot m^2 \cdot C^{-2}$)

$\mu_0$: 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 is a theoretical value defined by $q_m = h/e$.)

$m_p$: Resting mass of a proton: $1.67262192369 \times 10^{-27}$ (kg)

$m_e$: Resting mass of an electron: $9.1093837015 \times 10^{-31}$ (kg)

$R_k$: von Klitzing constant: 25812.80745 (Ω)

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

$\alpha$: Fine-structure constant: 1/137.035999081.

## 2.2. Symbols and Relations Obtained after the Redefinition Procedure

### 2.2.1. Symbols Obtained after the Redefinition Procedure

In this subsection, symbols carrying the subscript "new" denote quantities expressed under the redefinition scheme adopted in this study. They represent numerically consistent readouts of the corresponding MKSA quantities.

$$e_{new} = e \cdot \frac{4.4873976}{4.5} = 1.5976897 \times 10^{-19} (\mathrm{C}) \tag{13}$$

$$q_{m,new} = q_m \cdot \frac{\pi}{3.1327945} = 4.1472823 \times 10^{-15} (\mathrm{Wb}) \tag{14}$$

$$h_{new} = e_{new} \cdot q_{m\_new} = h \cdot \frac{4.4873976}{4.5} \cdot \frac{\pi}{3.1327945} = 6.62607015\mathrm{E}-34 (\mathrm{J \cdot s}) = h \tag{15}$$

Therefore, the value of Planck's constant remains unchanged.

$$Rk_{\_new} = \frac{q_{m\_new}}{e_{\_new}} = Rk \cdot \frac{4.5}{4.4873976} \cdot \frac{\pi}{3.1327945} = 25957.997 (\Omega) \tag{16}$$

Equation (16) can be rewritten as follows:

$$Rk_{new} = 4.5_{unit} \cdot \pi_{unit} \cdot \frac{m_p}{m_e} = 25957.997 (\Omega) \tag{17}$$

where $4.5_{unit}$ and $\pi_{unit}$ are unit-identification coefficients for the (1/(A·m)) and (V·m) readouts. They represent MKSA readout deviations, not new physical constants.

$$Z_{0\_new} = \alpha \cdot \frac{2h_{new}}{e_{new}^2} = 2\alpha \cdot Rk_{new} = Z_0 \cdot \frac{4.5}{4.4873976} \cdot \frac{\pi}{3.1327945} = 378.84931 (\Omega) \tag{18}$$

Equation (18) can likewise be rewritten as follows:

$$Z_{0\_new} = 4.5_{unit} \cdot \pi_{unit} \cdot 2\alpha \cdot \frac{m_p}{m_e} = 378.84931 (\Omega) \tag{19}$$

$$\mu_{0\_new} = \frac{Z_{0\_new}}{c} = \mu_0 \cdot \frac{4.5}{4.4873976} \cdot \frac{\pi}{3.1327945} = 1.2637053\mathrm{E}-06 \left(\mathrm{N \cdot A^{-2}}\right) \tag{20}$$

$$\varepsilon_{0\_new} = \frac{1}{Z_{0\_new} \cdot c} = \varepsilon_0 \cdot \frac{4.4873976}{4.5} \cdot \frac{3.1327945}{\pi} = 8.8046642\text{E}-12\left(\text{F}\cdot\text{m}^{-1}\right) \quad (21)$$

$$c_{new} = \frac{1}{\sqrt{\varepsilon_{0,ref}\mu_{0,ref}}} = \frac{1}{\sqrt{\varepsilon_0\mu_0}} = c = 299792458\left(\text{m}\cdot\text{s}^{-1}\right) \quad (22)$$

The Compton wavelength, $\lambda$, is then given by

$$\lambda = \frac{h}{mc} \quad (23)$$

Because Planck's constant and the speed of light are fixed, the Compton-wavelength relation connects the length readout to the corresponding mass readout. Equations (24)-(26) are therefore retained.

$$m_{e\_new} = m_e \cdot \frac{4.4873976}{4.5} \cdot \frac{\pi}{3.1327945} = m_e = 9.1093837\text{E}-31\left(\text{kg}\right) \quad (24)$$

$$m_{p\_new} = m_p \cdot \frac{4.4873976}{4.5} \cdot \frac{\pi}{3.1327945} = m_p = 1.6726219\text{E}-27\left(\text{kg}\right) \quad (25)$$

$$kT_{c\_new} = kT_c \cdot \frac{4.4873976}{4.5} \cdot \frac{\pi}{3.1327945} = kT_c = 3.7631393\text{E}-23\left(\text{J}\right) \quad (26)$$

The minimum mass is defined as follows:

$$M_{\min} = 2\pi\frac{kT_c}{\alpha c^2} = 3.605150741\times10^{-37}\left(\text{kg}\right) \quad (27)$$

### 2.2.2. Meaning of the First Redefinition: Ω-Side Normalization

In the first redefinition, macroscopic and microscopic quantities are related through a normalization of the unit Ω. Under this normalization, the unit J·m²/s is fixed as follows:

$$\frac{4.4873976}{3.1327945}\left(\frac{\frac{1}{\text{A}\cdot\text{m}}}{\text{V}\cdot\text{m}}\right) = \frac{4.5}{\pi}\left(\frac{\frac{1}{\text{A}\cdot\text{m}}}{\text{V}\cdot\text{m}} = \frac{1}{\text{J}\cdot\text{m}^2/\text{s}}\right) \quad (28)$$

Redefining the macroscopic unit 1 Ω yields the following relations.

$$1(\Omega)_{new} = \frac{1}{1.005624705}\cdot(\Omega)_{\text{MKSA}} = \frac{1}{1.005624705}\cdot\left(\frac{\text{Wb}}{\text{C}}\right)_{\text{MKSA}} \quad (29)$$

$$(e)_{new} = \frac{1.59768967\text{E}-19}{1.60217663\text{E}-19}\cdot(e)_{\text{MKSA}} = \frac{1}{\sqrt{1.005624705}}\cdot(e)_{\text{MKSA}} \quad (30)$$

$$(q_m)_{new} = \frac{4.14728234\text{E}-15}{4.13566770\text{E}-15}\cdot(q_m)_{\text{MKSA}} = \sqrt{1.005624705}\cdot(q_m)_{\text{MKSA}} \quad (31)$$

$$(\varepsilon_0)_{new} = \frac{8.8541878\text{E}-12}{8.8046642\text{E}-12}\cdot(\varepsilon_0)_{\text{MKSA}} = \frac{1}{1.005624705}\cdot(\varepsilon_0)_{\text{MKSA}} \quad (32)$$

$$(\mu_0)_{new} = \frac{1.2637053\text{E}-06}{1.2566370\text{E}-06}\cdot(\mu_0)_{\text{MKSA}} = 1.005624705\cdot(\mu_0)_{\text{MKSA}} \quad (33)$$

$$(Rk)_{new} = \frac{25957.9968739}{25812.807459} = \frac{4.5}{4.4873976}\cdot\frac{\pi}{3.1327945} = 1.005624705\cdot(Rk)_{\text{MKSA}} \quad (34)$$

$$(Z_0)_{new} = \frac{378.8493104}{376.7303137}\cdot(Z_0)_{\text{MKSA}} = 1.005624705\cdot(Z_0)_{\text{MKSA}} \quad (35)$$

### 2.2.3. Readout Relations Used in the Previous Formulation

The following eight relations were used in the previous formulation to connect electromagnetic, mass-energy, and gravitational-side readouts.

$$e_{new} \cdot c\left(\mathrm{A \cdot m}\right) = \frac{1}{4.5_{unit}} \cdot \frac{hc^2}{m_p c^2 \cdot kL_0} = 4.78975317\mathrm{E}-11\left(\mathrm{A \cdot m}\right) \tag{36}$$

$$q_{m\_new} \cdot c\left(\mathrm{V \cdot m}\right) = \pi_{unit} \cdot \frac{hc^2}{m_e c^2 \cdot kL_0} = 1.24332398\mathrm{E}-06\left(\mathrm{V \cdot m}\right) \tag{37}$$

$$m_e c^2 \cdot kL_0 \left(\mathrm{J} \cdot \frac{\mathrm{m}^2}{\mathrm{s}}\right) = \frac{\pi_{unit}}{4.5_{unit}} \cdot \frac{hc^2}{m_p c^2 \cdot kL_0} = 1.50474532\mathrm{E}-10\left(\mathrm{J} \cdot \frac{\mathrm{m}^2}{\mathrm{s}}\right) \tag{38}$$

$$m_p c^2 \cdot kL_0 \left(\mathrm{J} \cdot \frac{\mathrm{m}^2}{\mathrm{s}}\right) = \frac{\pi_{unit}}{4.5_{unit}} \cdot \frac{hc^2}{m_e c^2 \cdot kL_0}\left(\mathrm{J} \cdot \frac{\mathrm{m}^2}{\mathrm{s}}\right) = 2.76294215\mathrm{E}-07\left(\mathrm{J} \cdot \frac{\mathrm{m}^2}{\mathrm{s}}\right) \tag{39}$$

$$hc^2\left(\frac{\mathrm{J \cdot m^2}}{\mathrm{s}}\right) = \frac{\pi_{unit}}{4.5_{unit}} \cdot \frac{hc^2}{m_p c^2 \cdot kL_0} \cdot \frac{hc^2}{m_e c^2 \cdot kL_0}\left(\frac{\mathrm{J \cdot m^2}}{\mathrm{s}}\right) = 5.95521\mathrm{E}-17\left(\frac{\mathrm{J \cdot m^2}}{\mathrm{s}}\right) \tag{40}$$

$$2\pi \cdot \frac{kT_c}{\alpha} \cdot kL_0 = \frac{\pi_{unit}}{4.5_{unit}} \cdot \frac{hc^2}{m_p c^2 \cdot kL_0} \cdot \frac{hc^2}{m_e c^2 \cdot kL_0} = 5.95521\mathrm{E}-17\left(\frac{\mathrm{J \cdot m^2}}{\mathrm{s}}\right) \tag{41}$$

$$R_p\left(m_p\right) \equiv \frac{G_{new}}{c^3} \frac{\left(m_p c^2\right)^2}{\left(\dfrac{\left(e_{new} \cdot c\right)^2}{4\pi\varepsilon_{0\_new} \cdot c}\right)} = \frac{4.5(1)}{2} \cdot \frac{M_{min}}{1\,\mathrm{kg} \cdot c^2} = 8.11158917\mathrm{E}-37 \tag{42}$$

$$\frac{G_{new}}{c^3}\left(\frac{\mathrm{s}}{\mathrm{kg}}\right) = \frac{\alpha}{2\pi} \cdot \frac{4.5(1)}{2} \cdot \left(\frac{4.5_{unit}}{\pi_{unit}} \cdot hc^2\right) \cdot \frac{kL_0}{1\,\mathrm{kg} \cdot c^2} \cdot \left(\frac{m_e}{m_p}\right) = 2.48262121\mathrm{E}-36\left(\frac{\mathrm{s}}{\mathrm{kg}}\right) \tag{43}$$

### 2.2.4. C-Normalization

In this study, physical quantities are expressed in c-normalized form by introducing appropriate factors of the speed of light. This representation allows electromagnetic, mass-energy, and action-type quantities to be compared within a common structural framework.

$$e_{new} \to e_{new} \cdot c \tag{44}$$

$$q_{m\_new} \to q_{m\_new} \cdot c \tag{45}$$

$$\varepsilon_{0\_new} \to \varepsilon_{0\_new} \cdot c \tag{46}$$

$$\mu_{0\_new} \to \mu_{0\_new} \cdot c \tag{47}$$

$$h \to h \cdot c^2 \tag{48}$$

$$\mathrm{kg} \to \mathrm{kg} \cdot c^2 \tag{49}$$

$$G \to \frac{G}{c^3} \tag{50}$$

$$G_N \to \frac{G_N}{c} \tag{51}$$

Here, $G_N$ is defined as the gravitational constant $G$ multiplied by the macroscopic reference mass 1 kg. It is used as an intermediate gravitational-side readout quantity.

#### 2.2.5. Structural Quantities SI, UI, UIP, EI, and EIP

The following structural quantities and their numerical values are introduced.

SI: structural invariant.

$$\mathrm{SI} = \frac{4.5_{unit}}{\pi_{unit}} hc^2 = \left(\frac{M_{\min}}{m_p \cdot m_e}\right)^2 = 8.53021694 \times 10^{-17} \ (\text{dimensionless}) \tag{52}$$

UI: generative action.

$$\mathrm{UI} = hc^2 = \frac{\pi_{unit}}{4.5_{unit}} \left(\frac{M_{\min}}{m_p \cdot m_e}\right)^2 = M_{\min} c^2 \cdot kL_0 = 5.95521486 \times 10^{-17} \left(\mathrm{J} \cdot \mathrm{m}^2 \cdot \mathrm{s}^{-1}\right) \tag{53}$$

UIP: unit-conversion factor.

$$\mathrm{UIP} = \frac{4.5_{unit}}{\pi_{unit}} = 1.432394488 \left(\mathrm{J}^{-1} \cdot \mathrm{m}^{-2} \cdot \mathrm{s}\right) \tag{54}$$

EI: energy-pair quantity.

$$\mathrm{EI} = \left(m_e c^2 \cdot kL_0\right) \cdot \left(m_p c^2 \cdot kL_0\right) = 4.15752428\mathrm{E}-17 \left(\mathrm{J}^2 \cdot \mathrm{m}^4 \cdot \mathrm{s}^{-2}\right) \tag{55}$$

EIP: square-type unit structure.

$$\mathrm{EIP} = \left(\frac{4.5_{unit}}{\pi_{unit}}\right)^2 = 2.051753969 \left(\mathrm{J}^{-2} \cdot \mathrm{m}^{-4} \cdot \mathrm{s}^2\right) \tag{56}$$

The following equations are used as the basic structural relations in the present analysis.

$$\mathrm{SI} = \mathrm{UIP} \cdot \mathrm{UI} = 8.53021694\mathrm{E}-17 \ (\text{dimensionless}) \tag{57}$$

$$\mathrm{SI} = \mathrm{EIP} \cdot \mathrm{EI} = 8.53021694\mathrm{E}-17 \ (\text{dimensionless}) \tag{58}$$

$$\mathrm{EIP} = \mathrm{UIP}^2 \tag{59}$$

## 3. Methods

The present procedure consists of two readout redefinitions. The first redefinition, the initial Ω-side normalization, produces a coherent shell and provides the numerical representation used to derive $kT_c$. The second redefinition, implemented through the calibrated table-number rule, completes the branch-resolved numerical placement required for the MKSA-referenced calculation of $G$. The present procedure is a phenomenological numerical organization under the adopted map; the observed CMB temperature and the reported gravitational constant are used only for comparison and do not enter the calculation chain.

### 3.1. Definition of a Shell with Local Macroscopic-Microscopic Unit Correspondence

In this study, a shell $S$ is a coherent numerical-readout set consisting of a macroscopic unit, its corresponding microscopic reference quantity, and the representative number that relates them. The shell-local representatives are

$$N_{1,S} := (1\,C)_S / e_S = 6.24151\mathrm{E}+18. \tag{60}$$

$$N_{2,S} := (1\,\mathrm{Wb})_S / q_{m,S} = 2.41799\mathrm{E}+14. \tag{61}$$

$$N_{3,S} := (1\,\mathrm{kg})_S / M_{\min,S} = 2.773809\mathrm{E}+36\,. \tag{62}$$

within each shell, the macroscopic unit is set to one and the representative is preserved, so the paired microscopic quantity has the same local readout as in the MKSA shell. By contrast, its readout changes when expressed relative to the macroscopic unit of the MKSA shell.

### 3.2. Second Redefinition: Table-Number Assignment and Readout-Transfer Rule

For the numerical calculations in this study, each readout quantity $X$ is assigned a table number $A(X)$, which is converted into a readout-transfer factor according to

$$A(X) \mapsto J_{\mathrm{tab}}^{A(X)}. \tag{63}$$

here, $A$ is a covector assigning the table number $A(X)$ to each readout quantity $X$; thus, $A(c)=0$ means zero table-number weight for $c$, not the $c$-normalization introduced in Section 2.2.4. A positive table number multiplies the readout by $J_{\mathrm{tab}}^{A(X)}$ when $A(X)>0$, whereas a negative table number divides the readout by $J_{\mathrm{tab}}^{|A(X)|}$ when $A(X)<0$; a zero value leaves the readout unchanged. The assignments used in the calculations are listed in **Table 1** and applied in Section 4. The common scale is calibrated by $J_{\mathrm{tab}}^{5} = \pi/\pi_{unit,\mathrm{MKSA}} = 4.5/4.5_{unit,\mathrm{MKSA}}$; under the adopted single-parameter net map, the relative split (−1, +1) gives $\lambda = J_{\mathrm{tab}}$ and net assignments (+4, +6). Its physical necessity and uniqueness are discussed in Section 5.

**Table 1.** Table-number assignments used in the present calculation.

| Readout quantity | Symbol | Table number $A(X)$ | Numerical operation |
|---|---|---|---|
| Electric-charge readout branch | $ec$ | −4 | divide by $J_{\mathrm{tab}}^{4}$ |
| Magnetic-charge readout branch | $q_m c$ | +6 | multiply by $J_{\mathrm{tab}}^{6}$ |
| Resistance branch | Ω | +10 | multiply by $J_{\mathrm{tab}}^{10}$ |
| Action branch | J·s | +2 | multiply by $J_{\mathrm{tab}}^{2}$ |
| Mass-energy branches | $m_e c^2$, $m_p c^2$, $kT_c$ | +3 | multiply by $J_{\mathrm{tab}}^{3}$ |
| Action-product center | $hc^2$ | +2 | multiply by $J_{\mathrm{tab}}^{2}$ |
| Length-time branch | $kL_0$ | −1 | divide by $J_{\mathrm{tab}}^{1}$ |
| Coefficient branch | $4.5_{unit}$ | +4 | multiply by $J_{\mathrm{tab}}^{4}$ |
| Coefficient branch | $\pi_{unit}$ | +6 | multiply by $J_{\mathrm{tab}}^{6}$ |
| Unit-conversion branch | UIP | −2 | divide by $J_{\mathrm{tab}}^{2}$ |
| Speed-of-light branch | $c$ | 0 | unchanged |
| Primary gravitational readout | $G_N/c$ | −1 | divide by $J_{\mathrm{tab}}^{1}$ |
| Gravitational readout branch | $G/c^3$ $(=kL_0/(\mathrm{kg}\cdot c^2))$ | −4 | divide by $J_{\mathrm{tab}}^{4}$ |
| $G_{new}(m_p)^2 \Big/ \left(\dfrac{(e_{new})^2}{4\pi\varepsilon_{0\_new}}\right)$ | $R_p(m_p)$ | 0 | unchanged |

The quantities summarized in Table 2 are not introduced as additional independent assignments. They are reconstructed from the seed values $A(\mathrm{C}) = -4$, $A(\mathrm{Wb}) = +6$, $A(s) = -1$, and $A(c) = 0$, together with $A(m) = A(s)$ and the shell-local correspondences $A(e) = A(\mathrm{C})$ and $A(q_m) = A(\mathrm{Wb})$. The detailed interpretation and limitations of this electromagnetic reconstruction are discussed in Section 5.

**Table 2.** Conditional electromagnetic reconstruction of the derived unit, field, circuit, action, and landing branches.

| Sector | Reconstructed quantity | Relation used | $A(X)$ | Status/role |
|---|---|---|---|---|
| Seed | Coulomb branch C | adopted seed | −4 | Input |
| Seed | Weber branch Wb | adopted seed | +6 | Input |
| Seed | Time branch $s$ | adopted time gate | −1 | Input |
| Seed | Speed of light $c$ | fixed-$c$ condition | 0 | Input |
| Length-time | Length branch $m$ | $c = m/s$ | −1 | Derived |
| Basic EM unit | Voltage $V$ | $V = \mathrm{Wb}/s$ | +7 | Derived |
| Basic EM unit | $c$-normalized voltage $V/c$ | $A(c)=0$ | +7 | Derived landing branch |
| Basic EM unit | Current $A_{\mathrm{amp}}$ | $A_{\mathrm{amp}} = \mathrm{C}/s$ | −3 | Derived |
| Basic EM unit | $c$-normalized current $A_{\mathrm{amp}}/c$ | $A(c)=0$ | −3 | Derived landing branch |
| Resistance | Resistance Ω | $\Omega = V/A_{\mathrm{amp}} = \mathrm{Wb}/\mathrm{C}$ | +10 | Derived resistance center |
| Conductance | Conductance $S_{\mathrm{cond}}$ | $S_{\mathrm{cond}} = 1/\Omega$ | −10 | Derived |
| Capacitance | Farad $F_{\mathrm{cap}}$ | $F_{\mathrm{cap}} = \mathrm{C}/\mathrm{V} = s/\Omega$ | −11 | Derived |
| Capacitance | Inverse farad $F_{\mathrm{cap}}^{-1}$ | $F_{\mathrm{cap}}^{-1} = \mathrm{V}/\mathrm{C} = \Omega/s$ | +11 | Derived upper span |
| Inductance | Henry $H_{\mathrm{ind}}$ | $H_{\mathrm{ind}} = \mathrm{Wb}/A_{\mathrm{amp}} = \Omega s$ | +9 | Derived lower span |
| Time constant | RC time | $\Omega F_{\mathrm{cap}} = s$ | −1 | Recovers time gate |
| Time constant | L/R time | $H_{\mathrm{ind}}/\Omega = s$ | −1 | Recovers time gate |
| Oscillation | LC product | $H_{\mathrm{ind}} F_{\mathrm{cap}} = s^2$ | −2 | Derived |
| Oscillation | Frequency $\nu$ or $\omega$ | $1/s$ | +1 | Derived |
| Oscillation | Resonance scale | $1/\sqrt{H_{\mathrm{ind}} F_{\mathrm{cap}}}$ | +1 | Derived |
| Impedance | Inductive impedance $Z_L$ | $Z_L = \omega H_{\mathrm{ind}}$ | +10 | Returns resistance branch |
| Impedance | Capacitive impedance $Z_C$ | $Z_C = 1/(\omega F_{\mathrm{cap}})$ | +10 | Returns resistance branch |
| Vacuum constant | Electric constant $\varepsilon_0$ | $\varepsilon_0 = F_{\mathrm{cap}}/m$ | −10 | Derived |
| Vacuum constant | Magnetic constant $\mu_0$ | $\mu_0 = H_{\mathrm{ind}}/m$ | +10 | Derived |
| Vacuum closure | Light-speed relation | $c^{-2} = \mu_0 \varepsilon_0$ | 0 | Consistency closure |
| Wave branch | Vacuum impedance $Z_0$ | $Z_0 = \sqrt{\mu_0/\varepsilon_0} = \mu_0 c$ | +10 | Resistance-equivalent branch |
| Wave branch | Vacuum admittance $Y_0$ | $Y_0 = 1/Z_0$ | −10 | Derived |
| Field | Electric field $E$ | $E = V/m$ | +8 | Derived |
| Field | Magnetic flux density $B$ | $B = \mathrm{Wb}/m^2$ | +8 | Derived dual field |
| Field | Electric displacement $D$ | $D = \varepsilon_0 E = \mathrm{C}/m^2$ | −2 | Derived |

Continued

| | | | | |
|---|---|---|---|---|
| Field | Magnetic field strength $\boldsymbol{H}$ | $\boldsymbol{H} = B/\mu_0 = A_{\text{amp}}/m$ | −2 | Derived dual field |
| Source | Charge density $\rho$ | $\rho = \text{C}/m^3$ | −1 | Derived |
| Source | Current density $\boldsymbol{J}$ | $\boldsymbol{J} = A_{\text{amp}}/m^2$ | −1 | Derived |
| Maxwell relation | Gauss electric branch | $\nabla \cdot \boldsymbol{D} = \rho$ | −1 = −1 | Exponent consistency only |
| Maxwell relation | Faraday induction branch | $\nabla \times \boldsymbol{E} = -\partial \boldsymbol{B}/\partial t$ | +9 = +9 | Exponent consistency only |
| Maxwell relation | Ampère-Maxwell branch | $\nabla \times \boldsymbol{H} = \boldsymbol{J} + \partial \boldsymbol{D}/\partial t$ | −1 = −1 | Exponent consistency only |
| Conservation | Charge continuity | $\partial \rho/\partial t + \nabla \cdot \boldsymbol{J} = 0$ | 0=0 | Exponent consistency only |
| Power | Electromagnetic power $P$ | $P = VA_{\text{amp}}$ | +4 | Derived |
| Energy | Electromagnetic energy $E_{\text{em}}$ | $E_{\text{em}} = V\text{C} = \text{Wb}A_{\text{amp}}$ | +3 | Mass-energy landing scale |
| Force | Electromagnetic force $F$ | $F = eE = E_{\text{em}}/m$ | +4 | Derived |
| Energy density | Electromagnetic energy density $u_{\text{em}}$ | $u_{\text{em}} = \boldsymbol{E} \cdot \boldsymbol{D} = \boldsymbol{B} \cdot \boldsymbol{H}$ | +6 | Derived |
| Energy flux | Poynting vector $\boldsymbol{S}_P$ | $\boldsymbol{S}_P = \boldsymbol{E} \times \boldsymbol{H}$ | +6 | Derived |
| Stress | Maxwell stress $T_{ij}$ | $[T_{ij}] = [u_{\text{em}}]$ | +6 | Exponent consistency |
| Action | Action $h$ or J·s | $\text{C} \cdot \text{Wb} = \text{J} \cdot \text{s}$ | +2 | Derived action center |
| Action | $hc^2$ branch | $A(c) = 0$ | +2 | Derived action-product center |
| Photon landing | $h\nu$ | $A(h) + A(\nu)$ | +3 | Energy branch |
| Wavelength landing | $hc/\lambda$ | $A(h) - A(\lambda)$ | +3 | Energy branch |
| Momentum | Momentum $p$ | $p = h/\lambda$ | +3 | $c$-normalized energy-compatible branch |
| Electron landing | $eV$ | $(ec)(V/c) = eV$ | +3 | Electron mass-energy landing |
| Proton landing | $q_m A_{\text{amp}}$ | $(q_m c)(A_{\text{amp}}/c) = q_m A_{\text{amp}}$ | +3 | Proton mass-energy landing |
| Dual action | $X_e = e^2/(\varepsilon_0 c)$ | $2A(e) - A(\varepsilon_0)$ | +2 | Electric action branch |
| Dual action | $X_m = q_m^2/(\mu_0 c)$ | $2A(q_m) - A(\mu_0)$ | +2 | Magnetic action branch |
| Dual action closure | $\sqrt{X_e X_m}$ | $\sqrt{X_e X_m} = h$ | +2 | Symmetric action closure |

# 4. Results

## 4.1. Branch-Resolved Readouts Obtained from the Table-Number Rule

The table-number rule in Equation (63) was applied to the MKSA reference readouts using $J_{\text{tab}} = 1.00056105184$. Table 3 summarizes the principal transferred values used in the subsequent calculations.

Equation (12) gives $T_c = 2.7256307\ \text{K}$. Table 3 lists the transferred readout after $A(kT_c) = +3$; dividing that entry by $k_B$ yields the intermediate display 2.73022088 K, which is not the final comparison value. The signs of the assigned table numbers determine only whether the corresponding factor is multiplied or divided; their structural interpretation is reserved for Section 5. The transferred electromagnetic product is consistent with the transferred action-product center: $(ec)(q_m c) = hc^2$ within the numerical precision used in the calculation. Table 3 also includes the transferred $kT_c$ readout used in the gravitational-side calculation in Section 4.4.

Table 3. Principal branch-resolved readouts used in the present calculation.

| Readout quantity | Symbol | $A(X)$ | Calculated/transferred readout |
|---|---|---|---|
| Electric-charge readout | $ec$ | −4 | $4.79244043 \times 10^{-11}$ A·m |
| Magnetic-charge readout | $q_m c$ | +6 | $1.24402154 \times 10^{-6}$ V·m |
| Electron mass-energy | $m_e c^2$ | +3 | $8.20089368 \times 10^{-14}$ J |
| Proton mass-energy | $m_p c^2$ | +3 | $1.50580929 \times 10^{-10}$ J |
| Transferred CMB thermal energy | $kT_c$ | +3 | $3.76947673 \times 10^{-23}$ J |
| Action-product center | $hc^2$ | +2 | $5.96189911 \times 10^{-17}$ J·m²·s⁻¹ |
| Length-time branch | $kL_0$ | −1 | $1.83691478 \times 10^{3}$ m²·s⁻¹ |
| Coefficient readout | $4.5_{unit}$ | +4 | 4.49747668 A⁻¹·m⁻¹ |
| Coefficient readout | $\pi_{unit}$ | +6 | 3.14335525 V·m |
| Unit-conversion readout | UIP | −2 | 1.43078854 J⁻¹·m⁻²·s |

## 4.2. Numerical Consistency of the Four Macro-Micro Connection Equations

The branch-resolved readouts were substituted into the four macro-micro connection equations, and the results are summarized in Table 4. The first pair compares coefficient-normalized electromagnetic readouts with minimum-mass coordinates, while the second pair compares coefficient-wrapped electromagnetic readouts with the corresponding mass-energy-$kL_0$ products. All four equations agree within approximately $1.1 \times 10^{-9}$ in relative terms, confirming numerical consistency without establishing a completed physical mechanism or electromagnetic-mass representative-count equality.

Table 4. Numerical comparison of the four macro-micro connection equations.

| Connection equation | Left-hand side | Right-hand side | Relative difference |
|---|---|---|---|
| $4.5_{unit}(ec) = M_{\min}/m_p$ | $2.15538891 \times 10^{-10}$ | $2.15538891 \times 10^{-10}$ | $1.24 \times 10^{-10}$ |
| $(q_m c)/\pi_{unit} = M_{\min}/m_e$ | $3.95762311 \times 10^{-7}$ | $3.95762311 \times 10^{-7}$ | $9.13 \times 10^{-10}$ |
| $\pi_{unit}(ec) = m_e c^2 kL_0$ | $1.50643428 \times 10^{-10}$ | $1.50643428 \times 10^{-10}$ | $3.88 \times 10^{-11}$ |
| $(q_m c)/4.5_{unit} = m_p c^2 kL_0$ | $2.76604333 \times 10^{-7}$ | $2.76604333 \times 10^{-7}$ | $1.08 \times 10^{-9}$ |

## 4.3. Preservation of SI and the Composite Readouts

The transferred quantities were also evaluated through the three composite forms of SI used in the present framework. The first form combines UIP with the action-product readout $hc^2$. The second combines the square-pair quantity EIP with the energy-pair quantity EI. The third is the mass-side composite formed from the minimum-mass and electron–proton mass-energy readouts. Table 5 summarizes the calculated results.

The three independently displayed forms agree within the numerical precision of the calculation. Accordingly, the table-number transfer preserves the same dimensionless SI readout across the action-product, energy-pair, and mass-side composite representations.

Table 5. Comparison of the SI composite readouts.

| Composite form | Numerical value |
|---|---|
| UIP·$hc^2$ | $8.53021694 \times 10^{-17}$ |
| EIP·EI | $8.53021694 \times 10^{-17}$ |
| $(M_{\min}c^2)^2/[(m_e c^2)(m_p c^2)]$ | $8.53021694 \times 10^{-17}$ |

## 4.4. Gravitational-Side Calculation from $R_p(m_p)$ to $G$ and $G_N$

Using the branch-resolved readouts and the transferred $kT_c$ value listed in Table 3, the proton-side force-ratio readout is obtained. In the present framework, $G_N$ is treated as the primary gravitational-side quantity. The macroscopic reference mass 1 kg is a human-defined reference setting used to express the corresponding gravitational readout as $G$. Accordingly, 1 kg/$M_{\min}$ is interpreted as a kg-reference mass-ratio representative, not as an Avogadro-type count. From Equation (42),

$$R_p\left(m_p\right) = \frac{9}{4}\cdot\frac{\left(M_{\min}/s\right)_{\text{readout}}}{\left(1\,\text{kg}/s\right)_{\text{MKSA}}} \tag{64}$$

The resulting numerical readout is

$$R_p\left(m_p\right) = \frac{8.111589\times 10^{-37}}{J_{\text{tab}}^{4}} = 8.093411\times 10^{-37} \tag{65}$$

The factor $J_{\text{tab}}^{-4}$ belongs to the mixed-shell $\text{kg}/kL_0$ denominator-side projection, not to the zero-allocation quantity $R_p\left(m_p\right)$ itself. The corresponding gravitational-side readouts are summarized in Table 6. Here, $G_N = G \times 1$ kg retains the macroscopic reference mass explicitly, whereas $G$ is the corresponding readout projected onto the human-defined 1 kg reference setting. Table 6 summarizes the gravitational-side readouts, with $G_N$ shown as an intermediate readout, $G_{\text{MKSA}}$ as the reverse-transferred MKSA value, and $6.6743 \times 10^{-11}$ m$^3$·kg$^{-1}$·s$^{-2}$ used only for comparison. The detailed interpretation of the mass-ratio display, reference-mass setting, and denominator-side readout is discussed in Section 5.

Table 6. Principal gravitational-side readouts obtained from $R_p(m_p)$.

| Readout quantity | Calculated value |
|---|---|
| $G/c^3$ | $2.48262121 \times 10^{-36}$ s·kg$^{-1}$ |
| $G_{\text{readout}}$ (before reverse transfer) | $6.68917519 \times 10^{-11}$ m$^3$·kg$^{-1}$·s$^{-2}$ |
| $G_N = G \times 1$ kg (divide by $J_{\text{tab}}^{1}$) | $6.68542432 \times 10^{-11}$ m$^3$·s$^{-2}$ |
| $G_{\text{MKSA}}$ (divide by $J_{\text{tab}}^{3}$) | $6.674184325 \times 10^{-11}$ m$^3$·kg$^{-1}$·s$^{-2}$ |

## 5. Discussions

The numerical results in Section 4 show that the adopted table-number rule preserves the branch-resolved relations and completes the MKSA-referenced gravitational display. The discussion therefore focuses on seven points: shell-local macro-micro correspondence; the distinct roles of the first and second redefinitions; coefficient allocation and common length-gate routing; electromagnetic reconstruction and the status of the table-number rule; the external MKSA 1 kg reference in the gravitational projection; the interpretation of the 9/4 coefficient; and the remaining interpretive boundary.

### 5.1. Shell-Local Macro-Micro Correspondence

In each shell, the macroscopic unit is normalized to 1 and the branch-local representative $N_X$ is preserved, so the paired microscopic reference quantity retains the same shell-local readout. The table-number map does not change this local macro-micro correspondence.

What changes is only the numerical display relative to the corresponding MKSA macroscopic unit. A negative table number means that the MKSA-referenced readout is smaller by the corresponding power of $J_{\text{tab}}$, whereas a positive table number means that it is larger. These are purely cross-shell display changes, not changes in the physical quantity or in its shell-local readout. The representatives are therefore shell-local macro-micro coordinates, not literal particle counts.

### 5.2. Roles of the First and Second Redefinitions

The first redefinition produces a coherent normalized shell and provides the numerical representation used to calculate $kT_c$. This shell is internally consistent, but it does not by itself complete the MKSA-referenced numerical display required for the gravitational-side calculation.

The second redefinition, implemented through the calibrated table-number rule, transfers the coherent shell to the final branch-resolved numerical representation required for the calculation of $G$.

### 5.3. From the Coefficient Pair to the Voltage-Current Landings

The shell-local representatives can be used to rewrite the two coefficient branches without removing the macro-micro structure. Under the adopted mapping, the $4.5_{unit}$ branch contains the representative allocation $N_1/N_3$, whereas the $\pi_{unit}$ branch contains $N_3/N_2$. The common mass representative $N_3$ therefore connects the two branches while cancelling from their product. The common length gate then routes the two coefficient branches into the corresponding voltage- and current-type landing coordinates. This gives the branch-local composite relations $e_S V_{e,S} = m_{e,S} c^2$ and $q_{m,S} A_{p,S} = m_{p,S} c^2$. These relations show how the coefficient pair, shell-local representatives, and length-time branch participate in one coherent routing structure.

Why the numerical anchors are specifically 4.5 and $\pi$ remains unexplained. Nevertheless, within the present framework, other anchor values do not reproduce the present calculations of $T_c$ and $G$.

### 5.4. Electromagnetic Reconstruction and the Status of the Table-Number Rule

Table 2 shows that the voltage, current, resistance, capacitance, inductance, field, action, and dual mass-energy landing branches can be reconstructed from the adopted seed assignments through standard electromagnetic unit relations. If the seed exponents were independently derived, the table-number rule could be interpreted as a compact encoding of the electromagnetic unit structure. In the present framework, however, this reconstruction remains conditional on the adopted seeds. The table-number rule may therefore serve as an operational substitute for repeating the branch-by-branch electromagnetic reconstruction, but it does not replace electromagnetic theory or independently explain the physical origin of the seed exponents. This reconstruction is consistent with the table-number map used in the present calculations of $T_c$ and $G$, but this agreement does not constitute a first-principles derivation of that map.

### 5.5. Gravitational Readout and the MKSA 1 kg Reference

In the gravitational-side calculation, $G_N$ is treated as the primary readout quantity, whereas $G$ is obtained by projection onto the external MKSA mass reference:

$$G_{\text{MKSA}} = \frac{G_N}{(1\,\text{kg})_{\text{MKSA}}}. \tag{66}$$

The factor $(1\,\text{kg})_{\text{MKSA}}$ is therefore a macroscopic reference placement in the numerical display of $G$, not an intrinsic component of $G_N$. The first redefinition produces a coherent intermediate shell, but the second redefinition is required to complete the MKSA-referenced numerical representation used in this projection. The relation may also be written as

$$G_{\text{MKSA}} = \frac{G_N}{N_{\text{MKSA}} M_{\min}}. \tag{67}$$

$$N_{\text{MKSA}} := \frac{(1\,\text{kg})_{\text{MKSA}}}{M_{\min}}. \tag{68}$$

here, $N_{\text{MKSA}}$ is a macro-micro representative associated with the external 1 kg reference. It is not interpreted as a literal particle count.

### 5.6. Algebraic Role of the 9/4 Coefficient

The proton-side force-ratio relation is

$$R_p\left(m_p\right) = \frac{9}{4}\frac{M_{\min}}{1\,\text{kg}}. \tag{69}$$

Using

$$M_{\min}c^2 = \frac{2\pi}{\alpha}kT_c, \tag{70}$$

This relation becomes

$$R_p\left(m_p\right) = 4.5\pi\frac{kT_c/\alpha}{\left(1\,\text{kg}\right)c^2}. \tag{71}$$

thus, the factor 9/4, together with the factor 2π in the minimum-mass relation, gives rise to the coefficient 4.5π in the thermal representation of $R_p\left(m_p\right)$. In the present representation, $kT_c/\alpha$ may be interpreted as an activation-energy-like scale in the phenomenological context of thermally activated and nonequilibrium processes [18] [19]. However, no microscopic activation barrier, dissipation mechanism, or gravitational thermodynamic origin is derived in the present work.

### 5.7. Present Interpretation and Boundary

The present framework clarifies the coherent-shell interpretation, the distinct roles of the two redefinitions, the preservation of shell-local representatives, the coefficient-to-landing routing, the external MKSA 1 kg projection of $G_N$, and the algebraic appearance of 4.5π and $kT_c/\alpha$. These results establish structural organization and internal numerical consistency under the adopted map, but not a completed microscopic mechanism. The first-principles origins of the table-number base weights, the fifth-root order $n = 5$, the anchors 4.5 and π, the branch orientation, and the physical necessity of the second redefinition remain unresolved.

## 6. Conclusion

This study reorganized the empirical CMB-temperature equations within a branch-resolved macro-micro readout framework. The adopted table-number rule preserved the four macro-micro connection equations and the equivalent SI composite displays within the numerical precision of the calculation. After conversion back to the MKSA reference system, the gravitational value is 6.674184325 × $10^{-11}$ $\text{m}^3\cdot\text{kg}^{-1}\cdot\text{s}^{-2}$. A shell was interpreted as a coherent numerical-readout set consisting of a macroscopic unit, its corresponding microscopic reference quantity, and their shell-local representative. The first redefinition establishes a coherent normalized shell, whereas the second completes the branch-resolved placement required for the MKSA-referenced gravitational calculation. The coefficient branches are routed through the shell-local representatives and the common length gate to the electron-side voltage and proton-side current landings. Once the seed exponents are specified, the electromagnetic unit and landing sectors can also be reconstructed from standard electromagnetic unit relations. This establishes conditional consistency with the electromagnetic unit structure, but does not independently derive the seed values or the fifth-root calibration topology. On the gravitational side, $G_N$ is treated as the primary readout, while $G$ is expressed through the external MKSA 1 kg reference. The factor 9/4, together with the 2π factor in the minimum-mass relation, produces 4.5π. In the adopted representation, $kT_c/\alpha$ has an activation-energy-like form, but no microscopic activation process or dissipation mechanism is derived in the present work. The physical origins of the table-number base weights, the fifth-root order $n=5$, the anchors 4.5 and π, the branch orientation, and the necessity of the second redefinition remain unexplained. The present framework therefore provides a coherent structural organization, but not a completed microscopic mechanism.

## Conflicts of Interest

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

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