

# Adjustment of Temperature Units in Natural Units and CMB Measurements

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## Abstract

This paper examines the adjustment of temperature units in natural unit systems, particularly when Wien's constant  $\alpha_W = 1$  is set, analogous to the treatment of the fine-structure constant  $\alpha_{EM} = 1$  in electrodynamics. We analyze the effects on blackbody radiation, CMB measurements, and discuss compatibility with the T0 model of time-mass duality, especially when the T0 parameter  $\beta_T^{\text{nat}} = 1$  is also set. This unified approach reveals fundamental relationships between temperature, energy, and the intrinsic time field  $T(x)$ , but also leads to discrepancies with standard model interpretations, which are critically examined.

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# 1 Introduction

In theoretical physics, it is common to use natural unit systems where fundamental constants such as  $\hbar$ ,  $c$ ,  $k_B$ , and  $G$  are set to 1. This simplification allows for a clearer view of the underlying physical principles by removing artificial unit conventions. Previous work has shown that setting dimensionless constants like the fine-structure constant  $\alpha_{\text{EM}}$  to 1 can be conceptually advantageous [3].

This paper extends this approach to thermodynamic phenomena, particularly to Wien's constant  $\alpha_{\text{W}}$ , which appears in blackbody radiation. To avoid confusion, it's important to distinguish between two different dimensionless constants:

## Important dimensionless constants

- **Fine-structure constant:**  $\alpha_{\text{EM}} = \frac{e^2}{4\pi\epsilon_0\hbar c} \approx \frac{1}{137.036}$
- **Wien's constant:**  $\alpha_{\text{W}} \approx 2.821439$  (numerically determined by maximizing the Planck distribution)

This document explains how temperature measurements and blackbody radiation could be adjusted in a system with  $\alpha_{\text{W}} = 1$ . It also addresses how CMB temperature measurements are currently conducted and whether they are indirectly influenced by constants or coupling factors of the Standard Model. Subsequently, the idea of adjusting the temperature unit with  $\alpha_{\text{W}} = 1$  is discussed in the context of the T0 model of time-mass duality [2], particularly when the parameter  $\beta_{\text{T}}^{\text{nat}} = 1$  is also set [6].

# 2 Fundamentals of Natural Unit Systems

## 2.1 Conventions for $\hbar$ and $h$ in Natural Units

In quantum mechanics, two closely related constants appear: Planck's constant  $h$  and the reduced Planck constant  $\hbar = h/2\pi$ . In natural unit systems, it is conventional to set  $\hbar = 1$ , which implies that  $h = 2\pi$ . This convention has far-reaching implications for formulas originally formulated with  $h$ , such as Wien's displacement law.

The proper handling of  $2\pi$  factors is crucial for system consistency. When  $\hbar = 1$  is set, the following applies:

## Conventions in Natural Units

$$\hbar = 1 \quad (1)$$

$$h = 2\pi \quad (2)$$

$$c = 1 \quad (3)$$

$$k_B = 1 \quad (4)$$

$$G = 1 \text{ (optional)} \quad (5)$$

In the T0 model, where the relationship between mass and the intrinsic time field is given by  $m = \frac{\hbar}{T(x)c^2}$  [2], this convention is particularly relevant and must be considered in all conversions.

## 2.2 Relationship Between Different Natural Unit Systems

There are various possible natural unit systems, depending on which constants are set to 1:

Unit System	$\hbar$	$c$	$k_B$	$G$	$\alpha_{\text{EM}}$	$\alpha_{\text{W}}$	$\beta_{\text{T}}$
Geometrized Units	variable	1	variable	1	variable	variable	variable
Planck Units	1	1	1	1	variable	variable	variable
Electrodynamic NU	1	1	variable	variable	1	variable	variable
Thermodynamic NU	1	1	1	variable	variable	1	variable
T0 Model NU	1	1	1	1	variable	variable	1
Unified NU	1	1	1	1	1	1	1

This work focuses on thermodynamic natural units (with  $\alpha_{\text{W}} = 1$ ) and the unified natural unit system, where both  $\alpha_{\text{W}} = 1$  and  $\beta_{\text{T}}^{\text{nat}} = 1$  are set. The consistency and implications of simultaneously setting  $\alpha_{\text{EM}} = 1$ ,  $\alpha_{\text{W}} = 1$ , and  $\beta_{\text{T}}^{\text{nat}} = 1$  are examined in detail in [7].

## 3 Adjustment of the Temperature Unit with $\alpha_{\text{W}} = 1$

The consistent application of the principle of maximum simplification in natural unit systems has profound implications for the interpretation and scaling of thermodynamic quantities. In particular, the relationship between temperature and energy must be reconsidered. Planck's radiation formula, which describes the spectral energy density of blackbody radiation:

$$u(\nu, T) = \frac{2\pi h \nu^3}{c^2} \cdot \frac{1}{e^{h\nu/k_B T} - 1} \quad (6)$$

leads to Wien's displacement law, which relates the frequency of the radiation maximum to temperature:

$$\nu_{\text{max}} = \alpha_{\text{W}} \cdot \frac{k_B T}{h} \quad (7)$$

where  $\alpha_{\text{W}} \approx 2.821439$  is a numerically determined constant. If, in addition to  $k_B = 1$ ,  $h = 2\pi$  (since  $\hbar = 1$ ),  $c = 1$ , we also set  $\alpha_{\text{W}} = 1$ , a direct proportionality between the frequency of the radiation maximum and temperature results:

$$\nu_{\text{max}} = \frac{T}{2\pi} \quad (8)$$

To make this relationship consistent, an adjustment of the temperature unit is required. Kelvin would be inappropriate as a base unit, as temperature would then have to be measured and scaled directly in energy units to match the frequency of the radiation maximum. This adjustment is analogous to the treatment of space and time in relativity theory, where with  $c = 1$ , both can be measured in length units. Setting  $\alpha_{\text{W}} = 1$  is thus a consistent extension of the principle of maximum simplification, but requires a redefinition of the temperature unit. In the context of the T0 model [2], where mass varies with the intrinsic time field  $T(x)$ , this redefinition could align with the model's framework, although temperatures are typically given in Kelvin for practical reasons [5].

## 4 Detailed Adjustment of the Temperature Unit with $\alpha_{\text{W}} = 1$

The document on the fine-structure constant [Natural Units with Fine-structure Constant  \$\alpha = 1\$](#)  [3] proposes an approach that can also be applied to Wien's constant: In natural units with

$k_B = 1$ ,  $h = 2\pi$  (since  $\hbar = 1$ ),  $c = 1$ , and additionally  $\alpha_W = 1$ , temperature directly corresponds to the frequency of the radiation maximum ( $\nu_{\max} = T$ ), when the temperature unit is scaled accordingly. Let's derive this relationship systematically:

## 4.1 Standard Formula

Wien's displacement law in SI units is:

$$\nu_{\max} = \alpha_W \cdot \frac{k_B T}{h}, \quad \alpha_W \approx 2.821439,$$

where  $\alpha_W$  is numerically determined by maximizing the Planck distribution by solving the equation  $3(e^x - 1) = xe^x$ .

## 4.2 Natural Units

With  $k_B = 1$ ,  $h = 2\pi$  (since  $\hbar = 1$ ),  $c = 1$ :

$$\begin{aligned} \nu_{\max} &= \alpha_W \cdot \frac{T}{2\pi}, \\ \nu_{\max} &= \frac{2.821439}{2\pi} T \approx 0.449T. \end{aligned}$$

In natural units,  $\alpha_W \approx 2.821439$  persists as it is a mathematical constant independent of  $h$ ,  $c$ , or  $k_B$ . It represents an intrinsic feature of blackbody radiation, similar to how the fine-structure constant  $\alpha_{\text{EM}}$  is an intrinsic feature of electromagnetic interaction.

## 4.3 Setting $\alpha_W = 1$

If we set  $\alpha_W = 1$ :

$$\nu_{\max} = \frac{T}{2\pi},$$

or, if we absorb the  $2\pi$  factors by appropriate scaling of temperature:

$$T_{\text{scaled}} = 2\pi T,$$

so that:

$$\nu_{\max} = T_{\text{scaled}}.$$

## 4.4 Implications

### Implications of $\alpha_W = 1$

- **New Unit:**  $T$  would no longer be a temperature in the classical sense (Kelvin), but an energy/frequency (e.g., in GeV or Hz, as  $c = 1$  is omitted). This is consistent with the [analogy to relativity theory](#) ( $c = 1$ , space and time in length units).
- **CMB Temperature:** The measured  $T = 2.725$  K would need to be converted. In natural units with  $k_B = 1$ :

$$T = 2.725 \text{ K} \cdot k_B = 2.725 \cdot 1.380649 \times 10^{-23} \text{ J} \approx 3.762 \times 10^{-23} \text{ J}.$$

With  $h = 2\pi\hbar = 6.62607015 \times 10^{-34} \text{ J} \cdot \text{s}$ :

$$\nu_{\max} = \frac{k_B T}{h} \cdot \alpha_W \approx \frac{3.762 \times 10^{-23}}{6.62607015 \times 10^{-34}} \cdot 2.821439 \approx 1.6 \times 10^{11} \text{ Hz}.$$

With  $\alpha_W = 1$ :

$$\nu_{\max} = \frac{T}{2\pi} \approx 6 \times 10^{10} \text{ Hz},$$

and  $T_{\text{scaled}} = 2\pi \cdot 6 \times 10^{10} \approx 3.77 \times 10^{11} \text{ Hz}$ .

- **Relationship to Energy:** In this system, temperature is directly proportional to energy, reducing the fundamental relationship  $E = k_B T$  to  $E = T_{\text{scaled}}$ . This aligns with the perspective of the T0 model that energy is the most fundamental physical quantity [3].

## 4.5 Why Not Common?

- **Observational Practice:** Cosmologists use Kelvin because it directly relates to measured temperatures (e.g., CMB, stellar surfaces). Natural units with  $\alpha_W = 1$  would complicate communication with experimental data, which is why Kelvin is retained in T0 model analyses [5].

## 4.6 Alternative Perspectives on Setting $\alpha_W = 1$

- **Mathematical Nature:** The value  $\alpha_W \approx 2.821439$  arises from solving the transcendental equation  $3(e^x - 1) = xe^x$ . Setting  $\alpha_W = 1$  is conceptually similar to setting  $c = 1$  or  $\hbar = 1$ . It does not change the physical reality, but defines an alternative reference system for thermodynamic quantities, where  $T$  is directly related to the maximum frequency.
- **Dimensional Considerations:** The numerical value of  $\alpha_W$  (like  $\alpha_{\text{EM}} \approx 1/137$ ) influences the magnitude of derived quantities. With  $\alpha_W = 1$ , the numerical values of thermodynamic quantities would change, but this has no physical consequences as long as conversions are consistently applied. This rescaling can offer conceptual advantages for the theoretical formulation of the T0 model, similar to how other natural units simplify theoretical physics.

## 5 Formal Relationship Between $\alpha_W$ and $\beta_T$

A central aspect of this work is the investigation of the relationship between Wien's constant  $\alpha_W$  and the T0 parameter  $\beta_T$ . Both are dimensionless constants that appear in different contexts but exhibit conceptual parallels.

### 5.1 Thermodynamic Interpretation of $\beta_T$

In the T0 model, the parameter  $\beta_T$  describes the coupling between the intrinsic time field  $T(x)$  and other fields. In the temperature-redshift relationship, it appears as:

$$T(z) = T_0(1+z)(1 + \beta_T^{\text{SI}} \ln(1+z)) \quad (9)$$

where the second term represents the deviation from the standard model, which assumes  $T(z) = T_0(1+z)$ .

The derivation of  $\beta_T^{\text{SI}} \approx 0.008$  is perturbative and based on more fundamental parameters [6]:

$$\beta_T^{\text{nat}} = \frac{\lambda_h^2 v^2}{16\pi^3 m_h^2 \xi} \quad (10)$$

where  $\lambda_h$  is the Higgs self-coupling,  $v$  is the Higgs vacuum expectation value,  $m_h$  is the Higgs mass, and  $\xi$  is a dimensionless parameter with  $\xi \approx 1.33 \times 10^{-4}$ , which defines the characteristic length scale  $r_0 = \xi \cdot l_P$  of the model.

### 5.2 Mathematical Relationship and Joint Simplification

While  $\alpha_W$  and  $\beta_T$  describe different physical phenomena, they share a conceptual commonality: Both are dimensionless parameters that could potentially be set to 1 in a more fundamental unit system.

In natural units with  $\hbar = c = k_B = 1$ :

$$\alpha_W \approx 2.821439 \quad (\text{empirically determined}) \quad (11)$$

$$\beta_T^{\text{SI}} \approx 0.008 \quad (\text{theoretically derived}) \quad (12)$$

Setting  $\alpha_W = 1$  corresponds to a rescaling of the temperature unit, while  $\beta_T^{\text{nat}} = 1$  implies a rescaling of the characteristic length scale  $r_0$  [6]:

$$r_0 = \xi \cdot l_P \quad \text{with} \quad \xi = \frac{\lambda_h^2 v^2}{16\pi^3 m_h^2} \approx 1.33 \times 10^{-4} \quad (13)$$

A consistent simplification with  $\alpha_W = 1$  and  $\beta_T^{\text{nat}} = 1$  would combine both rescalings and could be represented within a unified theoretical framework, as elaborated in [7].

## 6 Temperature Scaling in the T0 Model with $\alpha_W = 1$ and $\beta_T^{\text{nat}} = 1$

### 6.1 Derivation of the Modified Temperature-Redshift Relationship

In the T0 model, the temperature evolution is described by:

$$T(z) = T_0(1+z)(1 + \beta_T^{\text{SI}} \ln(1+z)) \quad (14)$$

with  $\beta_T^{\text{SI}} \approx 0.008$  [5], reflecting the influence of the intrinsic time field  $T(x)$ . The application of  $\alpha_W = 1$  adjusts the base temperature  $T_0$  to the frequency of the radiation maximum  $\nu_{\text{max}}$ .

In standard practice,  $T_0 = 2.725 \text{ K}$ , but with  $\alpha_W = 1$  and natural units ( $k_B = 1$ ,  $h = 2\pi$ ):

$$\nu_{\text{max}} = \frac{T_0}{2\pi} \approx 6 \times 10^{10} \text{ Hz} \implies T_{0,\text{scaled}} = 2\pi \cdot 6 \times 10^{10} \approx 3.77 \times 10^{11} \text{ Hz}.$$

Setting  $\beta_T^{\text{nat}} = 1$  as an additional simplification in natural units leads to a modified temperature-redshift relationship:

$$T(z) = T_0(1+z)(1+\ln(1+z)).$$

This modification has significant implications for our understanding of the early universe, as it systematically predicts higher temperatures at high redshifts compared to the standard model. These predictions can be tested through observations of products of primordial nucleosynthesis and cosmic microwave background radiation.

## 6.2 Temperature Calculation and Conversion Between Unit Systems

**Basic Premise** If  $\beta_T^{\text{SI}} = 0.008$  and  $\beta_T^{\text{nat}} = 1$  are equivalent representations of the same physical parameter in different unit systems, both calculations must lead to the same physical result after appropriate conversion.

**Calculation in the SI System** Starting from the standard background temperature and applying the temperature-redshift relationship of the T0 model:

$$T(1101) = 2.725 \text{ K} \times 1101 \times (1 + 0.008 \times \ln(1101)) \quad (15)$$

$$= 2.725 \text{ K} \times 1101 \times 1.056 \quad (16)$$

$$= 3.198 \text{ K} \quad (17)$$

**Conversion to Frequency** Converting this temperature to frequency with Wien's displacement law with  $\alpha_W^{\text{SI}} \approx 2.821$ :

$$\nu_{\text{max}} = \alpha_W^{\text{SI}} \cdot \frac{k_B T}{h} \quad (18)$$

$$= 2.821 \cdot \frac{1.381 \times 10^{-23} \times 3.198}{6.626 \times 10^{-34}} \quad (19)$$

$$\approx 3 \times 10^{14} \text{ Hz} \quad (20)$$

**Calculation in the Natural Unit System** Converting the base temperature to natural units with  $\alpha_W = 1$ :

$$T_0^{\text{nat}} = T_0^{\text{SI}} \cdot \frac{k_B}{h} \cdot \frac{\alpha_W^{\text{SI}}}{\alpha_W^{\text{nat}}} \quad (21)$$

$$= 2.725 \text{ K} \cdot \frac{1.381 \times 10^{-23}}{2\pi \cdot 1.055 \times 10^{-34}} \cdot \frac{2.821}{1} \quad (22)$$

$$\approx 7.14 \times 10^{10} \text{ Hz} \quad (23)$$



**Temperature Calculation in Natural Units** In the natural unit system with  $\beta_T^{\text{nat}} = 1$ , we calculate the temperature at redshift  $z = 1101$ :

$$T(1101)^{\text{nat}} = T_0^{\text{nat}} \times 1101 \times (1 + \ln(1101)) \quad (24)$$

$$= 7.14 \times 10^{10} \text{ Hz} \times 1101 \times (1 + 7.0) \quad (25)$$

$$= 7.14 \times 10^{10} \text{ Hz} \times 1101 \times 8.0 \quad (26)$$

$$\approx 6.29 \times 10^{14} \text{ Hz} \quad (27)$$

**Frequency Normalization** The calculated frequency must be normalized to account for the difference between  $\alpha_W^{\text{SI}} = 2.821$  and  $\alpha_W^{\text{nat}} = 1$ :

$$\nu_{\text{max}}^{\text{normalized}} = \frac{\nu_{\text{max}}^{\text{nat}}}{\alpha_W^{\text{SI}}} \times \alpha_W^{\text{nat}} \quad (28)$$

$$= \frac{6.29 \times 10^{14} \text{ Hz}}{2.821} \times 1 \quad (29)$$

$$\approx 2.23 \times 10^{14} \text{ Hz} \quad (30)$$

**Conversion Back to SI Temperature** Converting this frequency back to temperature in the SI system:

$$T_{\text{final}} = \frac{h \cdot \nu_{\text{max}}^{\text{normalized}}}{k_B \cdot \alpha_W^{\text{SI}}} \quad (31)$$

$$= \frac{6.626 \times 10^{-34} \times 2.23 \times 10^{14}}{1.381 \times 10^{-23} \times 2.821} \quad (32)$$

$$\approx 4.36 \text{ K} \quad (33)$$

**Interpretation** The calculation shows a fundamental ratio between the T0 model prediction and the standard model value:

$$\frac{T_{\text{T0-Model}}}{T_{\text{Standard}}} = \frac{4.36 \text{ K}}{2.725 \text{ K}} \approx 1.6 \quad (34)$$

**Physical Significance** This ratio of 1.6 is not an arbitrary correction, but represents the fundamental difference between:

- The standard model's interpretation of expansion-based redshift and its effect on temperature
- The T0 model's interpretation of redshift as energy loss through interaction with the intrinsic time field

### 6.3 Derivation of the Energy Loss and Time Dilation Model

**Standard Model Time Dilation Equation** In the standard cosmology model, time dilation is described by the Lorentz factor:

$$\gamma = \frac{1}{\sqrt{1 - v^2/c^2}} \quad (35)$$

The redshift-time relationship is typically expressed as:

$$t_{\text{observed}} = t_{\text{emitted}} \cdot \gamma = t_{\text{emitted}} \cdot \frac{1}{\sqrt{1 - v^2/c^2}} \quad (36)$$

**T0 Model Energy Loss Equation** In contrast, the T0 model describes redshift as energy loss through interaction with the intrinsic time field:

$$z(\lambda) = z_0 \left( 1 + \beta_T^{\text{nat}} \ln \frac{\lambda}{\lambda_0} \right) \quad (37)$$

With  $\beta_T^{\text{nat}} = 1$  in natural units, this simplifies to:

$$z(\lambda) = z_0 \left( 1 + \ln \frac{\lambda}{\lambda_0} \right) \quad (38)$$

**Reconciliation and Derivation of the Correction Factor** The factor of 1.6 arises from the different physical interpretations of redshift:

1. **Standard Model:** Interprets redshift as purely kinematic, affecting temperature as  $T \propto (1 + z)$
2. **T0 Model:** Interprets redshift as energy loss, affecting temperature as  $T \propto (1 + z)(1 + \ln(1 + z))$

For a redshift of  $z = 1101$  (CMB), the correction factor is:

$$\frac{(1 + z)(1 + \ln(1 + z))}{(1 + z)} = (1 + \ln(1 + z)) \approx 8.0 \quad (39)$$

When normalized by the ratio of  $\alpha_W$  values ( $2.821/1$ ) and considering the conversion between temperature and frequency, we obtain the final factor of 1.6.

**Physical Interpretation** This correction factor of 1.6 represents the systematic difference between:

- The time dilation interpretation of the standard model
- The energy loss mechanism of the T0 model

It shows that the T0 model predicts higher primordial temperatures than the standard model at the same observed redshift, with potentially significant implications for early universe processes and structure formation.

## 7 Future Research: Recalibration of Cosmological Parameters in the T0 Model

### 7.1 The Need for Fundamental Recalibration

The comparative calculations between the standard cosmology model and the T0 model presented in this work have used the conventionally accepted redshift value  $z = 1101$  for the recombination epoch. However, it is important to recognize that this value itself is derived

within the framework of the  $\Lambda$ CDM model and incorporates its assumptions about cosmic expansion, dark energy, and dark matter.

A more fundamental approach would require direct recalibration of cosmological parameters within the T0 model framework. This represents a significant future research direction that could provide insights beyond the simple comparison of temperature-redshift formulas.

## 7.2 Proposed Framework for Parameter Recalibration

While a comprehensive recalibration exceeds the scope of the current work, we outline here a methodological framework for such an undertaking:

1. **Reformulation of Cosmological Evolution Equations:** The Boltzmann equations and cosmological evolution equations should be reformulated within the T0 model, replacing expansion-based dynamics with energy loss mechanisms mediated by the intrinsic time field  $T(x)$ .
2. **Reconsideration of the Recombination Process:** The physical conditions of recombination (mainly temperature and matter density) should be analyzed in the context of the T0 model, focusing on how the intrinsic time field affects ionization equilibrium.
3. **Direct Fitting to CMB Data:** Instead of adopting derived parameters from the standard model, spectral CMB data should be directly fitted to the mathematical framework of the T0 model, potentially leading to different values for fundamental cosmological parameters.
4. **Redetermination of the Recombination Redshift:** Using the conditions for recombination ( $T \approx 3000$  K) and the temperature-redshift relationship of the T0 model  $T(z) = T_0(1+z)(1 + \beta_T^{\text{SI}} \ln(1+z))$ , a revised value for the recombination redshift can be derived.

A preliminary estimate suggests that the recombination redshift in the T0 model might be closer to  $z \approx 950$  than  $z \approx 1101$ , but a rigorous determination requires the complete analysis outlined above.

## 7.3 Implications for Cosmological Tensions

This recalibration could have significant implications for current cosmological tensions:

- **Hubble Tension:** The discrepancy between measurements of the Hubble constant in the early and late universe could be addressed by reinterpreting redshift in the T0 model.
- **Structure Formation:** The timeline for structure formation might need revision in the T0 model, potentially mitigating tensions between observed structures and simulation predictions.
- **Dark Energy and Dark Matter:** The modified gravitational potential of the T0 model  $\Phi(r) = -\frac{GM}{r} + \kappa r$  could, with proper calibration of parameters, reduce or eliminate the need for dark components.

## 7.4 Experimental Approaches to Model Discrimination

To empirically distinguish between the standard and T0 models, several experimental approaches are proposed:

1. **Precision Spectroscopy of High-Redshift Sources:** Multi-frequency observations to detect the logarithmic wavelength dependence of redshift predicted by the T0 model.
2. **Temperature-Redshift Relationship at Multiple Redshifts:** Measurements of temperature indicators across different cosmic epochs to test the modified temperature scaling.
3. **Galaxy Dynamics without Dark Matter:** Testing whether the modified gravitational potential with parameter  $\kappa^{\text{SI}} \approx 4.8 \times 10^{-11} \text{ m/s}^2$  can explain observed galaxy dynamics without dark matter.

This comprehensive recalibration and testing program represents an ambitious but necessary future direction to fully evaluate the T0 model as a viable alternative to the standard cosmological paradigm.

## 7.5 Challenges in Interpreting Physical Theories

A fundamental challenge in theoretical physics is distinguishing between mathematical representation and physical content. The parameters  $\beta_{\text{T}}^{\text{SI}} = 0.008$  and  $\beta_{\text{T}}^{\text{nat}} = 1$  describe the same physical content in different unit systems. The choice of unit system does not affect observable phenomena, but offers different conceptual perspectives:

- **Conceptual Clarity:** The natural unit system with  $\beta_{\text{T}}^{\text{nat}} = 1$  and  $\alpha_{\text{W}} = 1$  highlights the fundamental role of energy as the basic physical quantity in the T0 model and reveals potential deeper connections between different interactions.
- **Connection to Standard Physics:** The SI formulation with  $\beta_{\text{T}}^{\text{SI}} = 0.008$  facilitates comparison with established theories and interpretation of experimental data in the context of familiar physical quantities.
- **Mathematical Elegance:** The unified representation with dimensionless parameters equal to 1 corresponds to the principle of maximum simplicity, often seen as an indicator of fundamental theories, as emphasized in [4].

Whether the T0 model or another theory better describes physical reality can ultimately only be determined through experimental verification, with both unit systems leading to identical predictions. The elegance of the unified unit system ( $\alpha_{\text{W}} = \beta_{\text{T}}^{\text{nat}} = 1$ ) could, however, offer a conceptual advantage by revealing fundamental relationships between different physical phenomena that might remain hidden in other representations, as discussed in [7].

# 8 Conclusion and Outlook

## 8.1 Theoretical Significance

The unification of natural units by simultaneously setting  $\alpha_{\text{W}} = 1$  and  $\beta_{\text{T}}^{\text{nat}} = 1$  remains a fascinating theoretical concept that could indicate deeper connections between thermodynamics, electrodynamics, and the dynamics of the intrinsic time field. This unification corresponds to

the fundamental principle that a complete physical theory should contain as few free parameters as possible.

Moreover, a conceptual elegance emerges from the fact that in this unified system, thermodynamic, electromagnetic, and gravitational interactions can be described by simple relationships. This suggests a deeper unity of natural forces, mediated in the T0 model by the intrinsic time field  $T(x)$ , as investigated in [8].

## 8.2 Connection to the Fine-Structure Constant $\alpha_{\text{EM}}$

A particularly fascinating perspective arises from the joint consideration of  $\alpha_{\text{W}} = 1$ ,  $\beta_{\text{T}}^{\text{nat}} = 1$ , and  $\alpha_{\text{EM}} = 1$ . As discussed in [3] and [7], setting  $\alpha_{\text{EM}} = 1$  leads to a unification of electromagnetic phenomena, where electric charges become dimensionless and all electromagnetic quantities can be reduced to energy.

The joint consideration of all three simplifications ( $\alpha_{\text{W}} = \beta_{\text{T}}^{\text{nat}} = \alpha_{\text{EM}} = 1$ ) would result in a maximally unified unit system, where energy is the only fundamental dimension to which all other physical quantities can be reduced:

### Fully Unified Unit System

- **Length:**  $[L] = [E^{-1}]$
- **Time:**  $[T] = [E^{-1}]$
- **Mass:**  $[M] = [E]$
- **Temperature:**  $[T_{\text{emp}}] = [E]$
- **Electric Charge:**  $[Q] = [1]$  (dimensionless)
- **Intrinsic Time:**  $[T(x)] = [E^{-1}]$

This complete unification could pave the way for a more fundamental theory that describes electrodynamics, thermodynamics, and gravitation within a common framework, as proposed in [10].

## 8.3 Practical Implications for Cosmological Analyses

On a practical level, reinterpreting cosmological data within the T0 model with  $\alpha_{\text{W}} = \beta_{\text{T}}^{\text{nat}} = 1$  could lead to a significant reassessment of cosmic history. In particular, the following aspects could be reinterpreted:

- **Cosmic Temperature History:** Systematically higher temperatures in the early universe would influence primordial nucleosynthesis and the recombination epoch.
- **Cosmological Redshifts:** The wavelength dependence of redshift would lead to a reassessment of distance measurements and expansion history.
- **Dark Energy:** The apparent cosmic acceleration could be partially or completely explained by the modified temperature-redshift relationship, eliminating the need for additional components like dark energy.
- **Hubble Tension:** The current discrepancy between different measurements of the Hubble constant could be reinterpreted within the unified T0 model framework.

These implications are discussed in detail in [5] and [2], which show how the T0 model provides a more economical explanation for cosmological observations without requiring dark matter or dark energy.

## 8.4 Future Research Directions

The unification of natural units by simultaneously setting  $\alpha_W = 1$  and  $\beta_T^{\text{nat}} = 1$  remains a fascinating theoretical concept that could indicate deeper connections between thermodynamics, electrodynamics, and the dynamics of the intrinsic time field. The full development of this concept and its application to the interpretation of cosmological data could open new perspectives on the fundamental structure of the universe and potentially lead to a more comprehensive unification theory.

While we grapple with the practical challenges posed by the significant deviation of  $\beta_T^{\text{nat}} = 1$  from current observations, we should not underestimate the theoretical elegance and conceptual power of this approach. The history of physics teaches us that discrepancies between elegant theoretical formulations and empirical observations often pave the way for fundamental breakthroughs. Thus, the tension between  $\beta_T^{\text{nat}} = 1$  and  $\beta_T^{\text{SI}} = 0.008$  could ultimately be the key to a deeper understanding of cosmic structure and evolution, as suggested in [7].

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