Time-Mass Duality Theory (T0 Model): Derivation of Parameters κ, α and β

Johann Pascher

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Introduction

This paper examines the connection between natural unit systems and dimensionless constants in the T0 model of time-mass duality theory. It is argued that the parameter $\beta \approx 0.008$ in the temperature-redshift relation $T(z) = T_0(1+z)(1+\beta\ln(1+z))$ can be set to $\beta = 1$ in natural units, analogous to Wien's constant α_W [2]. Additionally, the parameters κ, α and β of the T0 model are derived in detail and linked to cosmological implications. For a further analysis of the consistency when simultaneously setting the fine structure constant $\alpha_{\text{EM}} = 1$ and the parameter $\beta_{\text{T}} = 1$, see [6].

Contents

1 Dimensionless Parameters in Fundamental Theories

1.1 Historical Development and Principles

Physics shows an evolution towards unit systems in which natural constants are set to 1:

- Maxwell: c as a fundamental constant
- Theory of Relativity: $c = 1$
- Quantum Mechanics: $\hbar = 1$
- Quantum Gravitation: $G = 1$

Dimensionless parameters should be simple (e.g., 1, π). $\beta_{\mathrm{T}}^{\mathrm{SI}} \approx 0.008$ suggests a non-optimal system.

1.2 The Significance of the "Right" Natural Units

Complex values like $\beta_{\mathrm{T}}^{\mathrm{SI}} \approx 0.008$ suggest that the formulation is not fundamental. Historical examples:

- $c = 1$ in appropriate units
- $\hbar = 1$ in quantum units
- $G = 1$ in Planck units

2 The Characteristic Length Scale r_0

2.1 Redefinition of r_0 in Natural Units

The length scale r_0 is defined as $r_0 = \xi \cdot l_P$, where ξ is a dimensionless constant and $l_P = \sqrt{\frac{\hbar G}{c^3}}$ is the Planck length. In natural units ($\hbar = c = G = 1$), $l_P = 1$, thus $r_0 = \xi$.

From $\beta_{\mathrm{T}}^{\mathrm{nat}} = 1$ and:

$$\beta_{\mathrm{T}}^{\mathrm{nat}} = \frac{\lambda_h^2 v^2}{16\pi^3 m_h^2} \cdot \frac{1}{r_0} \tag{1}$$

follows:

$$\xi = \frac{\lambda_h^2 v^2}{16\pi^3 m_h^2} \approx 1.33 \times 10^{-4} \tag{2}$$

$$r_0 \approx \frac{1}{7519} \cdot l_P \tag{3}$$

2.2 Physical Interpretation

r_0 is the interaction length between $T(x)$ and the Higgs field:

- Correlation of fluctuations
- Transition between quantum and classical gravitation
- Coupling to the electroweak sector

This indicates a Planck-scale connection.

2.3 Conversion Between Natural Units and SI Units

$$\begin{aligned} r_{0,\mathrm{SI}} &= \xi \cdot l_{P,\mathrm{SI}} & (4)\\ &= 1.33 \times 10^{-4} \cdot 1.616\,255 \times 10^{-35}\,\mathrm{m} & (5)\\ &\approx 2.15 \times 10^{-39}\,\mathrm{m} & (6) \end{aligned}$$

$$\begin{aligned} \beta_{\mathrm{T}}^{\mathrm{SI}} &= \beta_{\mathrm{T}}^{\mathrm{nat}} \cdot \frac{r_{0,\mathrm{nat}}}{r_{0,\mathrm{SI}}/l_{P,\mathrm{SI}}} & (7)\\ &= 1 \cdot \frac{\xi \cdot l_{P,\mathrm{SI}}}{r_{0,\mathrm{SI}}} & (8)\\ &\approx 0.008 & (9) \end{aligned}$$

2.4 Consistency with the Cosmological Length Scale L_T

$$L_T \sim \frac{M_{\mathrm{Pl}}}{m_h^2 v} \approx 6.3 \times 10^{27}\,\mathrm{m} \tag{10}$$

$$\frac{r_0}{L_T} \sim \frac{\lambda_h^2 v^4}{16\pi^3 M_{\mathrm{Pl}}} \approx 3.41 \times 10^{-67} \tag{11}$$

This ratio is remarkable as it is of the order of $(m_e/M_{Pl})^2$, possibly indicating a deeper connection to the electron mass.

3 Parameter Derivations in the T0 Model

3.1 Derivation of κ

Theorem 3.1 (Derivation of κ)**.** *In natural units:*

$$\kappa = \beta_T^{nat} \frac{yv}{r_g}, \quad r_g = \sqrt{\frac{M}{a_0}} \tag{12}$$

In SI units:

$$\kappa_{SI} = \beta_T^{SI} \frac{yvc^2}{r_g^2} \approx 4.8 \times 10^{-11}\,\mathrm{m\,s^{-2}} \tag{13}$$

where y is the Yukawa coupling, v the Higgs vacuum expectation value, M the mass, and a_0 an acceleration scale.

3.2 Derivation of α

Theorem 3.2 (Derivation of α)**.** *In natural units:*

$$\alpha = \frac{\lambda_h^2 v}{L_T} \tag{14}$$

In SI units:

$$\alpha_{SI} = \frac{\lambda_h^2 v c^2}{L_T} \approx 2.3 \times 10^{-18}\,\mathrm{m^{-1}} \tag{15}$$

where λ_h is the Higgs self-coupling.

3.3 Derivation of β: From Natural to SI Units

Theorem 3.3 (Derivation of β)**.** *In natural units: $\beta_T^{nat} = 1$. Perturbatively:*

$$\beta_T^{nat} = \frac{\lambda_h^2 v^2}{4\pi^2 \lambda_0 \alpha_0} \tag{16}$$

In SI units:

$$\beta_T^{SI} = \frac{(2\pi)^4 m_h^2}{16\pi^2 v^4 y^2 M_{Pl}^2 \lambda_0^4 \alpha_0} \approx 0.008 \tag{17}$$

where λ_0 is a characteristic wavelength and α_0 a coupling constant of the T0 model.

Here, λ_0 and α_0 are parameters related to the structural constant of the T0 model. It should be noted that α_0 is not necessarily identical to the fine structure constant α_{EM}, although a relationship between the two might exist (see [6]).

3.4 Application: Wavelength-Dependent Redshift and Temperature Evolution

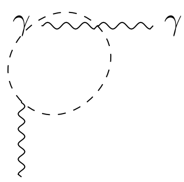
From setting $\beta_{\text{T}}^{\text{nat}} = 1$, the redshift-wavelength relation follows:

$$z(\lambda) = z_0 \left(1 + \beta_{\text{T}}^{\text{SI}} \ln \frac{\lambda}{\lambda_0}\right) \tag{18}$$

And the temperature-redshift relation:

$$T(z) = T_0(1+z)(1 + \beta_{\text{T}}^{\text{SI}} \ln(1+z)) \tag{19}$$

3.4.1 Feynman Diagram Analysis



4 Quantum Theoretical Determination of the Parameter $\beta_{\mathbf{T}}$

The quantum field theoretical analysis of the T0 model yields a perturbative value for the dimensionless parameter $\beta_{\text{T}}^{\text{SI}} \approx 0.008$ in SI units, which is consistent with cosmological observations. This value was derived through a perturbative treatment of the interaction between the intrinsic time field $T(x)$ and matter, with the fundamental time-mass duality $m = \frac{\hbar}{T(x)c^2}$ as a starting point. In particular, it is shown that $\beta_{\text{T}}^{\text{SI}}$ reflects the strength of the coupling between time field fluctuations and cosmic expansion, manifesting in a wavelength-dependent redshift $z(\lambda) = z_0 \left(1 + \beta_{\text{T}} \ln \frac{\lambda}{\lambda_0}\right)$ as well as in modified rotation curves of galaxies. A comprehensive presentation of this derivation, including experimental verifiability through cosmological measurements, can be found in [10], especially in the section "Experimental Tests and Predictions."

A deeper theoretical consideration reveals, however, that in natural units ($\hbar = c = 1$), the parameter $\beta_{\text{T}}^{\text{nat}} = 1$ is equivalent. This equivalence arises from the scaling property of the time-mass duality, which enables a unified representation of physical quantities in natural units. In the T0 model, mass is defined as an inverse function of the time field, and the choice of natural units eliminates dimensionful constants such as $\hbar$ and c, giving β_{T} a universal meaning. In [10], section "Natural Units in the T0 Model," it is shown that this transition is not merely a mathematical simplification, but also reveals fundamental connections between time, mass, and gravitation. For example, the field equation

$$\boldsymbol{\nabla}^2 T(x) = -\kappa\rho(\vec{x})T(x)^2 \tag{20}$$

in natural units leads to a direct connection between the mass density $\rho(\vec{x})$ and the gradients of the time field that generate emergent gravitation.

The discrepancy between $\beta_{\mathrm{T}}^{\mathrm{SI}} \approx 0.008$ and $\beta_{\mathrm{T}}^{\mathrm{nat}} = 1$ is thus not a contradiction, but an artifact of the chosen unit systems. In SI units, β_{T} is scaled by the specific values of $\hbar$, c, and other constants, while natural units eliminate this scaling and present β_{T} as a unified coupling constant. This duality of representation has far-reaching implications: While $\beta_{\mathrm{T}}^{\mathrm{SI}}$ is directly linked to observable quantities such as cosmic acceleration and galaxy dynamics, $\beta_{\mathrm{T}}^{\mathrm{nat}}$ provides a theoretical foundation for the unification of the T0 model with other physical theories, such as the Higgs mechanism or entropic gravitation, as further elaborated in [10]. Future work could aim to refine the quantum theoretical derivation of β_{T} through non-perturbative methods to further substantiate the consistency between these two values.

5 Interpretation and Coherence of Natural Parameters

5.1 Hierarchy of Units and Dimensionless Constants

1. Natural constants: $c = \hbar = G = k_B = 1$
2. Dimensionless parameters: $\alpha_{\mathrm{EM}} \approx 1/137$, $\alpha_W \approx 2.82$ [2], $\beta_{\mathrm{T}}^{\mathrm{nat}} = 1$
3. Length scales: $r_0 = \xi \cdot l_P$, $\xi \approx 1.33 \times 10^{-4}$; $L_T = \zeta \cdot l_P$, $\zeta \sim 10^{62}$

5.2 Ratios Between Length Scales in the T0 Model

- $l_{P,\mathrm{SI}} \approx 1.616 \times 10^{-35}\,\mathrm{m}$
- $\lambda_h \approx 1.576 \times 10^{-18}\,\mathrm{m}$
- $r_{0,\mathrm{SI}} \approx 2.15 \times 10^{-39}\,\mathrm{m}$
- $L_T \approx 6.3 \times 10^{27}\,\mathrm{m}$

$$\frac{r_0}{l_P} \approx 1.33 \times 10^{-4} \tag{21}$$

$$\frac{\lambda_h}{l_P} \approx 9.75 \times 10^{16} \tag{22}$$

$$\frac{L_T}{l_P} \approx 3.9 \times 10^{62} \tag{23}$$

These ratios are purely dimensionless and independent of the choice of unit system. They represent fundamental aspects of the theory and could indicate deeper structures.

5.3 Conversion Between Unit Systems

Conversion Scheme

1. Length scales: $L_{\text{SI}} = L_{\text{nat}} \cdot l_{P,\text{SI}}$
2. Energy scales: $E_{\text{SI}} = E_{\text{nat}} \cdot \sqrt{\frac{\hbar c^5}{G}}$
3. Dimensionless parameters: $\beta_{\text{T}}^{\text{SI}} = \beta_{\text{T}}^{\text{nat}} \cdot \frac{\xi \cdot l_{P,\text{SI}}}{r_{0,\text{SI}}}$

5.4 Application: Calculation of κ

The modified gravitational potential in the T0 model is:

$$\Phi(r) = -\frac{GM}{r} + \kappa r \tag{24}$$

In natural units with $\beta_{\text{T}}^{\text{nat}} = 1$:

$$\kappa_{\text{nat}} = \frac{yv}{r_g} \tag{25}$$

In SI units with $\beta_{\text{T}}^{\text{SI}} \approx 0.008$:

$$\kappa_{\text{SI}} = \beta_{\text{T}}^{\text{SI}} \frac{yvc^2}{r_g^2} \approx 4.8 \times 10^{-11}\,\text{m}\,\text{s}^{-2} \tag{26}$$

6 Cosmological Implications

- κ_{SI}: Explains rotation curves without dark matter
- α_{SI}: Describes expansion without dark energy
- $\beta_{\text{T}}^{\text{SI}}$: Wavelength-dependent redshift, testable with JWST

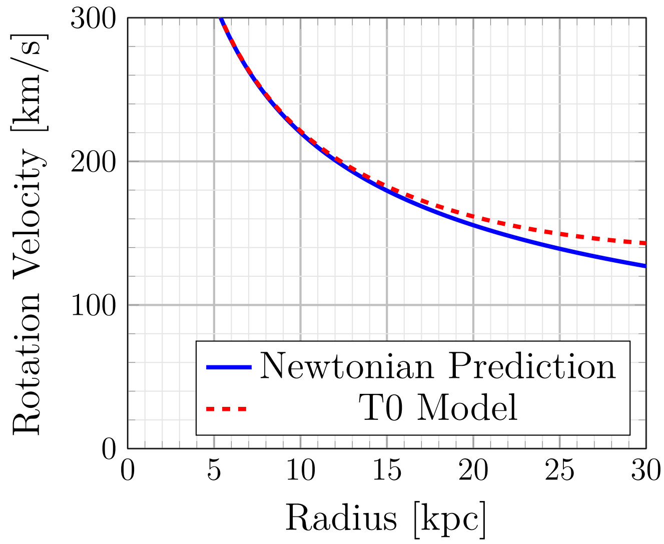


Figure 1: Rotation curves with κ_{SI}.

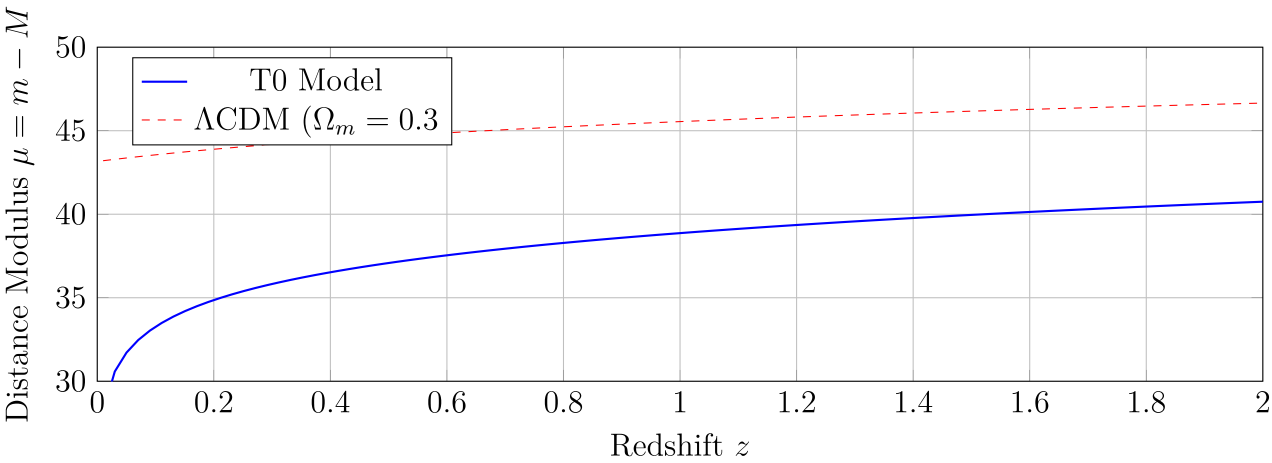


Figure 2: Distance modulus vs. redshift comparing the T0 model prediction (solid blue) with the ΛCDM prediction (dashed red) for $H_0 = 70$ km/s/Mpc. The models show a distinctive pattern: initially far apart at low redshifts, they gradually converge at higher redshifts, providing a clear observational test.

7 Consequences of Setting $\beta = 1$

7.1 Theoretical Elegance

- Simplicity of the temperature-redshift relation
- Coherence of dimensionless parameters
- Clarity of relationships between fundamental quantities

7.2 Conversion to SI Units

The conversion formula:

$$\beta_{\mathrm{T}}^{\mathrm{SI}} = \beta_{\mathrm{T}}^{\mathrm{nat}} \cdot \frac{\xi \cdot l_{P,\mathrm{SI}}}{r_{0,\mathrm{SI}}} \tag{27}$$

This is analogous to $c = 1$ in the theory of relativity, where we can switch between the theoretical formulation with $c = 1$ and the experimental measurement with $c = 3 \times 10^8\,\mathrm{m\,s^{-1}}$.

7.3 Reassessment of Measurements

The redshift discrepancy between predictions with $\beta_{\mathrm{T}}^{\mathrm{nat}} = 1$ and current "measured" values could indicate a standard model bias in the interpretation of cosmological data. It should be noted that:

- Cosmological measurements are typically calibrated within the framework of the ΛCDM model
- The "measured" values may contain implicit assumptions
- A complete reassessment within the framework of the T0 model with $\beta_{\mathrm{T}}^{\mathrm{nat}} = 1$ could lead to a consistent interpretation

The quantitative effects of this reassessment are analyzed in detail in [6].

8 Integration into the Time-Mass Duality Theory

8.1 Consistency with the Basic Principles

Setting $\beta_T^{nat} = 1$ is consistent with the basic principles of the time-mass duality theory:

- Time is absolute: The fundamental time scale is determined by the intrinsic time field $T(x)$
- Mass varies: $m = \frac{\hbar}{T(x)c^2}$, whereby the variation is mediated by the Higgs field
- Emergent gravitation: Gravitation arises from the gradients of $T(x)$

8.2 Implications for Other Parameters

Setting $\beta_T^{nat} = 1$ affects other parameters of the T0 model, in particular:

- κ: Direct dependence through the equation $\kappa = \frac{yv}{r_g}$
- α: Connection through the characteristic length scales r_0 and L_T

9 Experimental Tests and Perspectives

9.1 Direct Tests of Setting $\beta = 1$

- **Precision measurements of the CMB spectrum:** A detailed analysis of deviations from the perfect blackbody spectrum could provide indications of the true form of the temperature-redshift relation.
- **Search for signatures of higher temperatures in the early cosmic history:** The investigation of isotope distributions from primordial nucleosynthesis could provide evidence for higher temperatures.
- **Direct temperature measurements at medium redshifts:** The deviation between the models increases with z and could already be measurable at medium redshifts.

9.2 Indirect Tests and Cosmological Parameters

- **Hubble tension:** A reinterpretation of the CMB data with $\beta_T^{nat} = 1$ could solve the Hubble tension problem.
- **Baryon Acoustic Oscillations (BAO):**
The modified temperature-redshift relation would influence the interpretation of BAO measurements.
- **Galaxy formation:** Higher temperatures in the early universe would influence structure and galaxy formation.

For a detailed quantitative analysis of these tests, see [6], where specific predictions and comparisons with the standard model are presented.

10 Conclusions

Setting $\beta_T^{nat} = 1$ in natural units of the T0 model represents a conceptually elegant and physically motivated simplification, analogous to setting $c = 1$ in the theory of relativity or $\hbar = 1$ in quantum mechanics. This simplification requires a specific interpretation of the characteristic length scale r_0 as $r_0 \approx 1.33 \times 10^{-4} \cdot l_P$, which corresponds to a specific ratio to the Planck length.

The resulting discrepancy with current "measurements" can be understood as an indication that our interpretation of cosmological data may be too strongly influenced by the paradigmatic framework of the standard model. This opens the door for new perspectives and experimental tests that could distinguish between different cosmological models.

For practical application and comparison with experimental data, all results can be easily translated back into SI units. The conceptual elegance of a theory with simple dimensionless parameters ($\beta_{\mathrm{T}}^{\mathrm{nat}} = 1$) versus complex values ($\beta_{\mathrm{T}}^{\mathrm{SI}} \approx 0.008$) supports a deeper investigation of this possibility, especially in the context of the time-mass duality theory, which already proposes fundamental reinterpretations of physical concepts.

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