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

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Introduction

This work explores the connection between natural unit systems and dimensionless constants in the T0 model of the 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 consistency when simultaneously setting the fine-structure constant $\alpha_{\text{EM}} = 1$ and the parameter $\beta_{\text{T}} = 1$, refer to [6].

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1 Dimensionless Parameters in Fundamental Theories

1.1 Historical Development and Principles

Physics shows a progression toward unit systems where natural constants are set to 1:

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

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 Importance of the "Right"Natural Units

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

- $c = 1$ in suitable 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 ($\hbar = c = G = 1$), $l_P = 1$, so $r_0 = \xi$.

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

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

it 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 gravity
- Coupling to the electroweak sector

This suggests a connection to the Planck scale.

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 on 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 is the Higgs vacuum expectation value, M is the mass, and a_0 is 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 is a coupling constant of the T0 model.

Here, λ_0 and α_0 are parameters related to the structure constant of the T0 model. Note that α_0 is not necessarily identical to the fine-structure constant α_{EM}, though a relationship may exist (see [6]).

3.4 Application: Wavelength-Dependent Redshift and Temperature Evolution

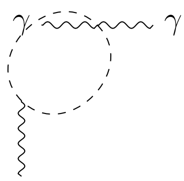
From setting $\beta_{\mathrm{T}}^{\mathrm{nat}} = 1$, the redshift-wavelength relation follows:

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

And the temperature-redshift relation:

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

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 $\beta_{\mathrm{T}}^{\mathrm{SI}} \approx 0.008$ in SI units, consistent with cosmological observations. This value was derived through a perturbative treatment of the interaction between the intrinsic time field $T(x)$ and matter, using the fundamental time-mass duality $m = \frac{\hbar}{T(x)c^2}$ as a starting point. Specifically, $\beta_{\mathrm{T}}^{\mathrm{SI}}$ reflects the strength of the coupling between time field fluctuations and cosmic expansion, manifesting in a wavelength-dependent redshift $z(\lambda) = z_0 \left(1 + \beta_{\mathrm{T}} \ln \frac{\lambda}{\lambda_0}\right)$ and modified galaxy rotation curves. A comprehensive presentation of this derivation, including experimental testability through cosmological measurements, is found in [10], particularly in the section "Experimental Tests and Predictions."

A deeper theoretical consideration reveals that in natural units ($\hbar = c = 1$), the parameter $\beta_{\mathrm{T}}^{\mathrm{nat}} = 1$ is equivalent. This equivalence arises from the scaling property of 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 dimensioned constants like $\hbar$ and c, giving β_T a universal significance. In [10], section "Natural Units in the T0 Model," it is shown that this shift is not merely a mathematical simplification but uncovers fundamental relationships between time, mass, and gravity. For example, the field equation

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

in natural units directly links the mass density $\rho(\vec{x})$ to the gradients of the time field, generating emergent gravity.

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 remove this scaling, presenting β_T as a unified coupling constant. This duality of representation has far-reaching implications: while $\beta_\mathrm{T}^\mathrm{SI}$ directly ties to observable quantities like cosmic acceleration and galaxy dynamics, $\beta_\mathrm{T}^\mathrm{nat}$ provides a theoretical foundation for unifying the T0 model with other physical theories, such as the Higgs mechanism or entropic gravity, as further elaborated in [10]. Future work could aim to refine the quantum theoretical derivation of β_T using 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 unit system choice. They represent fundamental aspects of the theory and may hint at 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

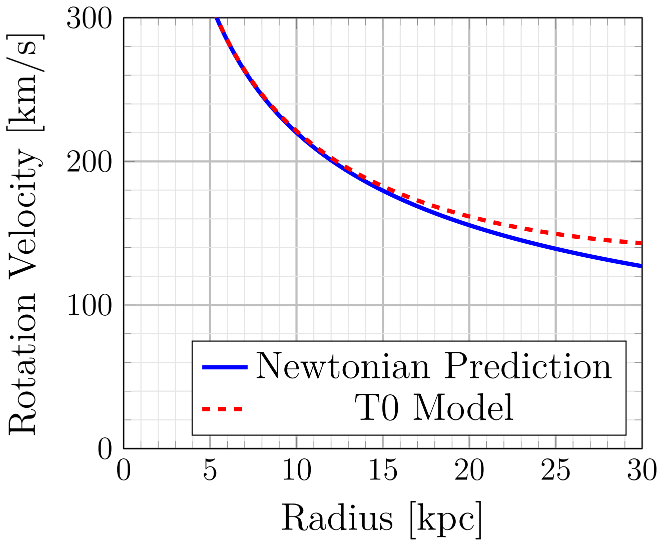


Abbildung 1: Rotation curves with κ_{SI}.

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 rule:

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

This is analogous to $c = 1$ in 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 Reevaluation of Measurements

The redshift discrepancy between predictions with $\beta_{\mathrm{T}}^{\mathrm{nat}} = 1$ and current "measured" values might suggest a standard model bias in interpreting cosmological data. Note that:

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

The quantitative impacts of this reevaluation are analyzed in detail in [6].

8 Integration into the Time-Mass Duality Theory

8.1 Consistency with Core Principles

Setting $\beta_{\mathrm{T}}^{\mathrm{nat}} = 1$ aligns with the core principles of the time-mass duality theory:

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

8.2 Implications for Other Parameters

Setting $\beta_{\mathrm{T}}^{\mathrm{nat}} = 1$ affects other parameters of the T0 model, particularly:

- κ: Direct dependence via 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 a perfect blackbody spectrum could provide clues about the true form of the temperature-redshift relation.
- **Search for Signatures of Higher Temperatures in Early Cosmic History:** Examining isotope distributions from primordial nucleosynthesis could indicate higher temperatures.
- **Direct Temperature Measurements at Intermediate Redshifts:** The divergence between models grows with z and could be measurable at intermediate redshifts.

9.2 Indirect Tests and Cosmological Parameters

- **Hubble Tension:** Reinterpreting CMB data with $\beta_{\mathrm{T}}^{\mathrm{nat}} = 1$ could resolve the Hubble tension problem.
- **Baryon Acoustic Oscillations (BAO):** The altered temperature-redshift relation would affect 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, refer to [6], where specific predictions and comparisons with the standard model are presented.

10 Conclusions

Setting $\beta_{\mathrm{T}}^{\mathrm{nat}} = 1$ in the natural units of the T0 model represents a conceptually elegant and physically motivated simplification, analogous to setting $c = 1$ in relativity or $\hbar = 1$ in quantum mechanics. This simplification requires a specific interpretation of the characteristic length scale r_0 as $r_0 \approx 1.33 \times 10^{-4} \cdot l_P$, corresponding to a particular 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 overly influenced by the paradigmatic framework of the standard model. This opens the door to new perspectives and experimental tests that could distinguish between different cosmological models.

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

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