Hierarchical Compilation of Units in the T0 Model with Energy as the Base Unit

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Abstract

This work presents a comprehensive hierarchical compilation of natural units within the T0 model of time-mass duality, adopting energy as the fundamental unit. By normalizing dimensional constants ($\hbar = c = G = k_B = 1$) and dimensionless coupling constants ($\alpha_{\text{EM}} = \alpha_W = \beta_T = 1$) to unity, a unified framework emerges that integrates quantum, relativistic, and cosmological phenomena. The compilation details the hierarchy of constants, quantized length scales from sub-Planckian to cosmic regimes, and the unique presence of biological structures in forbidden zones. Electromagnetic, thermodynamic, and quantum mechanical constants are derived from the energy scale, with simplified field equations revealing the intrinsic unity of natural laws. The Einstein-Hilbert action underpins emergent gravitation, while precise conversions to SI units, philosophical implications, and experimental prospects enrich the discourse. Supported by extensive theoretical derivations and visualizations, this work offers a robust foundation for the T0 model, potentially advancing the unification of physics [17].

Contents

1   Introduction

Natural units in theoretical physics streamline the description of physical laws by reducing independent dimensions and setting fundamental constants to unity, thereby unveiling the intrinsic simplicity underlying complex phenomena. Traditional systems, such as Planck units where $\hbar = c = G = 1$, have long served as a cornerstone for theoretical explorations, eliminating arbitrary dimensional parameters and focusing on the essence of physical interactions [22]. However, the T0 model of time-mass duality extends this paradigm by proposing a fully unified natural unit system, where not only dimensional constants ($\hbar = c = G = k_B = 1$) but also dimensionless coupling constants—the fine-structure constant α_{EM}, Wien's constant α_W, and the model-specific T0 parameter β_T—are set to 1. This normalization is not a mere mathematical convenience but a profound theoretical necessity, reflecting the model's premise that all physical laws converge into a singular, energy-based framework [1].

At its core, the T0 model redefines the fundamental relationship between time and mass, challenging conventional assumptions embedded in both relativity and quantum mechanics. In contrast to special relativity's relative time or quantum mechanics' treatment of time as a mere parameter, the T0 model posits time as an absolute entity, with mass varying dynamically in response to the system's state. This conceptual inversion is mediated by the intrinsic time field, defined as:

$$T(x) = \frac{\hbar}{\max(mc^2, \omega)}$$

This scalar field encapsulates the interplay between mass-energy and frequency, serving as a unifying bridge between the microscopic realm of quantum mechanics and the macroscopic domain of relativity. By reinterpreting gravitational effects as emergent phenomena arising from gradients in $T(x)$, the model eliminates the need for a fundamental gravitational interaction, aligning with modern theories of emergent gravity and offering a fresh perspective on cosmic dynamics [32, 10].

The choice of energy as the base unit in the T0 model is both intuitive and revolutionary. Energy, as the common currency of physical interactions, allows all quantities—length, time, mass, temperature—to be expressed in terms of $[E]$ or its inverse $[E^{-1}]$, as detailed in Section 3.10. This unification simplifies field equations, as shown in Section 3.7, and reveals hierarchical relationships among constants and scales, presented in Sections 2 and 2.4. The model's ability to explain phenomena across scales—from quantum entanglement to cosmological redshift and dark energy—without invoking ad-hoc constructs like inflation or dark matter underscores its potential to reshape our understanding of the universe [19].

This compilation aims to systematically present the natural units of the T0 model, emphasizing their definitions, values, and interconnections. It explores the theoretical foundations for setting $\alpha_{\text{EM}} = \beta_T = 1$ (Section 3), characterizes length scales spanning 97 orders of magnitude (Section 2.4), and highlights the surprising presence of biological structures in forbidden zones (Section 2.5). The work further derives electromagnetic, thermodynamic, and quantum mechanical constants from the energy scale, presenting simplified field equations that illuminate the unity of natural laws (Section 3.7). The Einstein-Hilbert action provides a basis for emergent gravitation (Section 3.6), while conversions to SI units, philosophical implications, and experimental prospects enrich the discourse (Sections 3.10, 3.11). Visualizations, such as Figures 1 and 4, enhance clarity and interconnectedness.

The objectives of this work are multifaceted:

- To delineate the hierarchical structure of fundamental constants and their values, as shown in Section 2.

- To provide rigorous derivations for the normalization of α_{EM} and β_T, detailed in Section 3.

- To characterize physical length scales and their quantization, including biological anomalies, as explored in Sections 2.4 and 2.5.

- To offer precise conversion formulas between natural and SI units, presented in Section 3.10.

- To derive simplified field equations for electromagnetism, the T0 model, and quantum mechanics, analyzed in Section 3.7.

- To elucidate emergent gravitation via the Einstein-Hilbert action, compared with other theories in Section 3.6.

- To discuss philosophical implications, including ontological discreteness and emergent space-time, in Section 3.11.

- To propose experimental tests to validate the model's predictions, outlined in Section 4 [20].

By weaving together these elements, this document seeks to provide a robust theoretical foundation for the T0 model, fostering a deeper understanding of the universe's fundamental structure and paving the way for future explorations.

2 Part 1: Overview of Units and Scales

2.1 Level 1: Primary Dimensional Constants

The T0 model's natural unit system is anchored by dimensional constants set to unity, establishing the foundational scales of physics:

- **Reduced Planck Constant** ($\hbar = 1$): Defines the quantum scale, governing energy quantization, crucial for Section 3.7.3 [22].

- **Speed of Light** ($c = 1$): Sets the relativistic scale, unifying space and time, essential for Section 3.6 [24].

- **Gravitational Constant** ($G = 1$): Establishes the gravitational scale, linked to emergent gravitation in Section 3.6 [25].

- **Boltzmann Constant** ($k_B = 1$): Defines the thermodynamic scale, connecting energy to temperature, supporting Section 3.7.2.

Dimensionless coupling constants, set to unity, govern interaction strengths:

- **Fine-Structure Constant** ($\alpha_{\text{EM}} = 1$): SI value $\approx 1/137.036$, simplifies electromagnetic equations (Section 3.7.1) [6].

- **Wien's Constant** ($\alpha_W = 1$): SI value ≈ 2.82, unifies thermodynamics.

- **T0 Parameter** ($\beta_T = 1$): SI value ≈ 0.008, central to $T(x)$ dynamics (Section 3.2) [7].

These constants are summarized in Table 1, reflecting their role in the T0 model's hierarchy.

Constant	Symbol	SI Value	Natural Value	Derivation	Hierarchy Level
Reduced Planck Constant	$\hbar$	1.055×10^{-34} J s	1	Primary	Level 1
Speed of Light	c	3×10^{8} m s^{-1}	1	Primary	Level 1
Gravitational Constant	G	6.674×10^{-11} m^3 kg^{-1} s^{-2}	1	Primary	Level 1
Boltzmann Constant	k_B	1.381×10^{-23} J K^{-1}	1	Primary	Level 1
Fine-Structure Constant	α_{EM}	$1/137.036$	1	Secondary	Level 2
Wien's Constant	α_W	2.82	1	Secondary	Level 2
T0 Parameter	β_T	0.008	1	Secondary	Level 2

Table 1: Fundamental Constants in the T0 Model, linked to Sections 3.3 and 3.2

2.2 Level 2.5: Derived Electromagnetic and Gravitational Constants

Derived constants emerge naturally with simplified values, reflecting the system's coherence:

- **Vacuum Permeability** ($\mu_0 = 1$): Derived from $\mu_0 = 1/(\varepsilon_0 c^2)$, simplifying electromagnetic equations (Section 3.7.1).

- **Vacuum Permittivity** ($\varepsilon_0 = 1$): From $\varepsilon_0 = 1/(\mu_0 c^2)$.

- **Vacuum Impedance** ($Z_0 = 1$): From $Z_0 = \sqrt{\mu_0/\varepsilon_0}$.

- **Elementary Charge** ($e = \sqrt{4\pi} \approx 3.544$): From $\alpha_{\text{EM}} = e^2/(4\pi\varepsilon_0\hbar c) = 1$, making charge dimensionless, as discussed in Section 3.3 [23].

- **Planck Pressure** ($p_P = 1$): From $p_P = c^7/(\hbar G^2)$.

- **Planck Force** ($F_P = 1$): From $F_P = c^4/G$.

- **Einstein-Hilbert Action**:

$$S_{\text{EH}} = \frac{1}{16\pi} \int R\sqrt{-g}\, d^4x$$

Central to emergent gravitation, as elaborated in Section 3.6 [10].

These are summarized in Table 2, illustrating their role in unifying physical interactions.

Constant	Symbol	SI Value	Natural Value	Derivation	Hierarchy Level
Vacuum Permeability	μ_0	$1.256\,637\,061 \times 10^{-6}$ H m^{-1} ($4\pi \times 10^{-7}$)	1	$\mu_0 = 1/(\varepsilon_0 c^2)$	Level 2.5
Vacuum Permittivity	ε_0	8.85×10^{-12} F m^{-1}	1	$\varepsilon_0 = 1/(\mu_0 c^2)$	Level 2.5
Vacuum Impedance	Z_0	$376.73\,\Omega$	1	$Z_0 = \sqrt{\mu_0/\varepsilon_0}$	Level 2.5
Elementary Charge	e	1.602×10^{-19} C	$\sqrt{4\pi} \approx 3.544$	$e = \sqrt{4\pi\varepsilon_0\hbar c}$	Level 2.5
Planck Pressure	p_P	4.63×10^{113} Pa	1	$p_P = c^7/(\hbar G^2)$	Level 2.5
Planck Force	F_P	1.21×10^{44} N	1	$F_P = c^4/G$	Level 2.5

Table 2: Derived Electromagnetic and Gravitational Constants in the T0 Model, linked to Sections 3.3, 3.7.1, and 3.6

2.3 Planck Units in the T0 Model

Planck units, derived from $\hbar$, c, and G, are normalized to 1, as shown in Table 3. They serve as reference points for all scales, facilitating conversions (Section 3.10) and anchoring the hierarchy in Figure 1 [18].

Planck Unit	Symbol	Definition	SI Value	Significance
Planck Length	l_P	$\sqrt{\hbar G/c^3}$	$1.616 \times 10^{-35}\,\mathrm{m}$	Length unit
Planck Time	t_P	$\sqrt{\hbar G/c^5}$	$5.391 \times 10^{-44}\,\mathrm{s}$	Time unit
Planck Mass	m_P	$\sqrt{\hbar c/G}$	$2.176 \times 10^{-8}\,\mathrm{kg}$	Mass unit
Planck Energy	E_P	$\sqrt{\hbar c^5/G}$	$1.956 \times 10^{9}\,\mathrm{J}$	Energy unit
Planck Temperature	T_P	$\sqrt{\hbar c^5/G}/k_B$	$1.417 \times 10^{32}\,\mathrm{K}$	Temperature unit
Planck Charge	q_P	$\sqrt{4\pi\varepsilon_0\hbar c}$	$1.875 \times 10^{-18}\,\mathrm{C}$	Charge unit
Planck Pressure	p_P	$c^7/(\hbar G^2)$	$4.633 \times 10^{113}\,\mathrm{Pa}$	Pressure unit
Planck Density	ρ_P	$c^5/(\hbar G^2)$	$5.155 \times 10^{96}\,\mathrm{kg\,m^{-3}}$	Density unit

Table 3: Planck Units in the T0 Model

2.4 Characteristic Length Scales

The T0 model organizes length scales hierarchically, as detailed in Table 4, spanning from the Planck length (l_P) to the cosmological correlation length (L_T). This hierarchy, visualized in Figure 1, covers 97 orders of magnitude, with each scale linked to specific physical phenomena, as discussed in Section 3.5.

Structure	With $l_P = 1$	With $r_0 = 1$	Relationship
Planck Length (l_P)	1	$1/\xi \approx 7519$	Base unit
T0 Length (r_0)	$\xi \approx 1.33 \times 10^{-4}$	1	$\xi \cdot l_P$
Strong Scale	$\sim 10^{-19}$	$\sim 10^{-15}$	$\sim \alpha_s \cdot \lambda_{C,h}$
Higgs Length ($\lambda_{C,h}$)	$\sim 1.6 \times 10^{-20}$	$\sim 1.2 \times 10^{-16}$	$m_P/m_h \cdot l_P$
Proton Radius	$\sim 5.2 \times 10^{-20}$	$\sim 3.9 \times 10^{-16}$	$\sim \alpha_s/(2\pi) \cdot \lambda_{C,p}$
Electron Radius (r_e)	$\sim 2.4 \times 10^{-23}$	$\sim 1.8 \times 10^{-19}$	$\alpha_{\mathrm{EM,SI}}/(2\pi) \cdot \lambda_{C,e}$
Compton Length ($\lambda_{C,e}$)	$\sim 2.1 \times 10^{-23}$	$\sim 1.6 \times 10^{-19}$	$m_P/m_e \cdot l_P$
Bohr Radius (a_0)	$\sim 2.9 \times 10^{-21}$	$\sim 2.2 \times 10^{-17}$	$\lambda_{C,e}/\alpha_{\mathrm{EM,SI}}$
DNA Width	$\sim 1.2 \times 10^{-26}$	$\sim 9.0 \times 10^{-23}$	$\sim \lambda_{C,e} \cdot m_e/m_{\mathrm{DNA}}$
Cell	$\sim 6.2 \times 10^{-30}$	$\sim 4.7 \times 10^{-26}$	$\sim 10^7 \cdot \mathrm{DNA}$
Human	$\sim 6.2 \times 10^{-35}$	$\sim 4.7 \times 10^{-31}$	$\sim 10^5 \cdot \mathrm{Cell}$
Earth Radius	$\sim 3.9 \times 10^{-41}$	$\sim 2.9 \times 10^{-37}$	$\sim (m_P/m_{\mathrm{Earth}})^2 \cdot l_P$
Sun Radius	$\sim 4.3 \times 10^{-43}$	$\sim 3.2 \times 10^{-39}$	$\sim (m_P/m_{\mathrm{Sun}})^2 \cdot l_P$
Solar System	$\sim 6.2 \times 10^{-47}$	$\sim 4.7 \times 10^{-43}$	$\sim \alpha_G^{-1/2} \cdot \mathrm{Sun}$
Galaxy	$\sim 6.2 \times 10^{-56}$	$\sim 4.7 \times 10^{-52}$	$\sim (m_P/m_{\mathrm{Galaxy}})^2 \cdot l_P$
Cluster	$\sim 6.2 \times 10^{-58}$	$\sim 4.7 \times 10^{-54}$	$\sim 10^2 \cdot \mathrm{Galaxy}$
Horizon (d_H)	$\sim 5.4 \times 10^{61}$	$\sim 4.1 \times 10^{65}$	$\sim 1/H_0$
Correlation Length (L_T)	$\sim 3.9 \times 10^{62}$	$\sim 2.9 \times 10^{66}$	$\sim \beta_{\mathrm{T}}^{-1/4} \cdot \xi^{-1/2} \cdot l_P$

Table 4: Length Scales

2.5 Biological Anomalies in Forbidden Zones

A striking feature of the T0 model is the presence of biological structures in "forbidden zones" between quantized scales, as shown in Table 5 and Figure 2. These zones, discussed in Section 3.5, lack stable physical structures, yet biological systems thrive due to unique stabilization mechanisms:

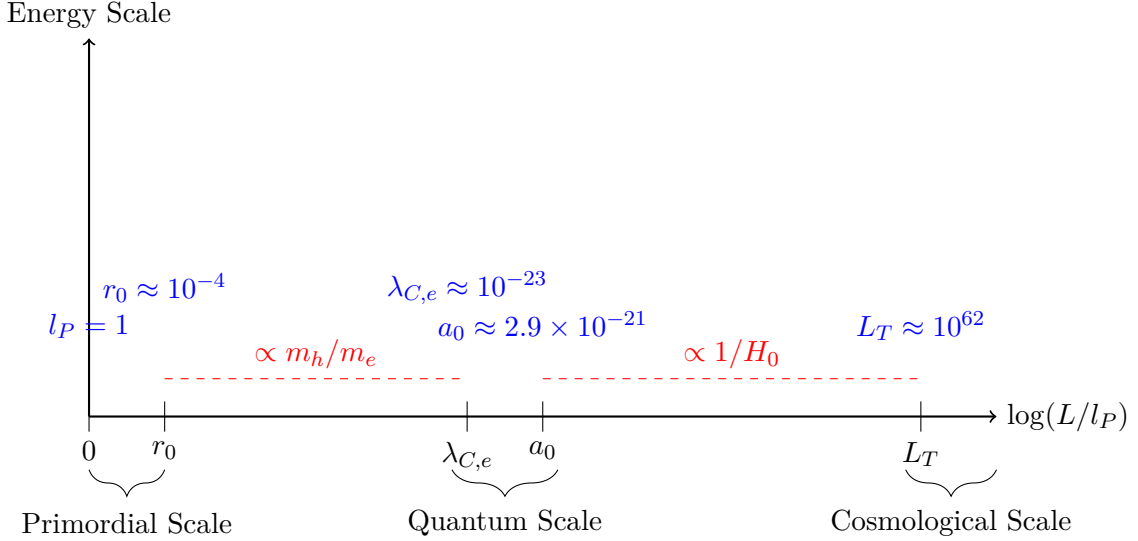$$\nabla^2 T(x)_{\mathrm{bio}} \approx -\frac{\rho}{T(x)^2} + \delta_{\mathrm{bio}}(x,t)$$

Figure 1: Hierarchy of length scales in the T0 model, spanning from r_0 to L_T, covering 66 orders of magnitude, as detailed in Section 3.5.

The term δ_{bio} accounts for information-based, topological, and dynamic stabilization, distinguishing life from inanimate matter [12].

The forbidden zones, spanning approximately 19 and 3 orders of magnitude, represent regions where stable physical structures are absent due to the quantization of length scales. The 19-order gap, between $r_0 \approx 1.33 \times 10^{-4} l_P$ and $\lambda_{C,e} \approx 2.1 \times 10^{-23} l_P$, arises from the mass ratio $m_h/m_e \approx 2.45 \times 10^{17}$, leading to a logarithmic separation of $\log(m_h/m_e) \approx 19.39$. The 3-order gap, between $\lambda_{C,e} \approx 2.1 \times 10^{-23} l_P$ and $a_0 \approx 2.9 \times 10^{-21} l_P$, corresponds to the fine-structure constant $\alpha_{\text{EM,SI}} \approx 1/137.036$, with $\log(1/\alpha_{\text{EM,SI}}) \approx 2.14$, approximated as 3 for simplicity. These gaps are computed as:

$$\Delta \log(L/l_P) = \log\left(\frac{L_2}{L_1}\right)$$

where L_1 and L_2 are adjacent quantized scales. Biological structures, such as DNA and cells, occupy these zones due to dynamic stabilization mechanisms, as discussed in Section 3.5.

Structure	Size	Ratio to l_P	Position
DNA Diameter	$2 \times 10^{-9}\,\text{m}$	$\sim 10^{-26}$	Forbidden Zone
Protein	$1 \times 10^{-8}\,\text{m}$	$\sim 10^{-27}$	Forbidden Zone
Bacterium	$1 \times 10^{-6}\,\text{m}$	$\sim 10^{-29}$	Forbidden Zone
Cell	$1 \times 10^{-5}\,\text{m}$	$\sim 10^{-30}$	Forbidden Zone
Organism	$1 \times 10^{-3}\,\text{m}$ to $1\,\text{m}$	$\sim 10^{-32} - 10^{-35}$	Forbidden Zone

Table 5: Biological Structures in Forbidden Zones, as visualized in Figure 2

3   Part 2: Detailed Explanations and Derivations

3.1   Fundamental Concepts of the T0 Model

The T0 model redefines the interplay between time and mass, positing time as an absolute entity and mass as a variable quantity, challenging the paradigms of relativity (relative time,

constant mass) and quantum mechanics (parametric time). This shift is facilitated by the intrinsic time field:

$$T(x) = \frac{\hbar}{\max(mc^2, \omega)}$$

This scalar field encapsulates the dynamic relationship between mass-energy and frequency, acting as a mediator that unifies quantum and relativistic phenomena. By treating time as absolute, the model reinterprets relativistic effects—such as time dilation—as variations in mass, offering a novel perspective on phenomena like gravitational redshift and particle interactions [1].

The normalization of constants ($\hbar = c = G = k_B = \alpha_{\text{EM}} = \alpha_W = \beta_T = 1$) is a theoretical necessity, reflecting the model's premise that physical laws are inherently unified. Energy, as the base unit, allows all quantities to be expressed in a consistent dimensional framework, as shown in Table **??**. Gravitation emerges from $T(x)$ gradients, eliminating the need for a fundamental gravitational force, as detailed in Section 3.6. This unification bridges micro- and macro-scales, explaining phenomena from quantum entanglement to cosmic expansion without ad-hoc assumptions [10].

3.2 Derivation of $\beta_T = 1$

The T0 parameter β_T, governing the coupling of $T(x)$, is normalized to 1 through a rigorous derivation linked to Standard Model parameters:

$$\beta_{\text{T}} = \frac{\lambda_h^2 v^2}{16\pi^3} \cdot \frac{1}{m_h^2} \cdot \frac{1}{\xi}$$

where:

- $\lambda_h \approx 0.13$: Higgs self-coupling.

- $v \approx 246\,\text{GeV}$: Higgs vacuum expectation value.

- $m_h \approx 125\,\text{GeV}$: Higgs mass.

- $\xi = r_0/l_P$: T0 length to Planck length ratio, as shown in Table 4.

Setting $\beta_{\text{T}} = 1$:

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

This yields $r_0 \approx 1.33 \times 10^{-4} \cdot l_P$. Using $m_h^2 = 2\lambda_h v^2$:

$$\xi = \frac{\lambda_h}{32\pi^3} \approx 1.31 \times 10^{-4}$$

The consistency of these values validates the derivation, as visualized in Figure 5. $\beta_T = 1$ acts as a renormalization fixed point:

$$\lim_{E \to 0} \beta_{\text{T}}(E) = 1$$

The SI value $\beta_{\text{T}} \approx 0.008$ reflects finite-energy effects, reinforcing the model's coherence [7].

3.3 Derivation of $\alpha_{\mathrm{EM}} = 1$

The fine-structure constant's normalization is pivotal for electromagnetism:

$$\alpha_{\mathrm{EM}} = \frac{e^2}{4\pi\varepsilon_0\hbar c} \approx \frac{1}{137.036}$$

With $\hbar = c = \varepsilon_0 = 1$, setting $\alpha_{\mathrm{EM}} = 1$:

$$e^2 = 4\pi \implies e = \sqrt{4\pi} \approx 3.544$$

This makes charge dimensionless, simplifying equations in Section 3.7.1. Alternatively, using the classical electron radius $r_e = e^2/(4\pi\varepsilon_0 m_e c^2)$ and Compton wavelength $\lambda_C = h/(m_e c)$:

$$\alpha_{\mathrm{EM}} = \frac{2\pi r_e}{\lambda_C}$$

With $h = 2\pi\hbar$, this confirms the standard definition [6]. The coupling of μ_0 and ε_0:

$$\mu_0\varepsilon_0 = \frac{1}{c^2} = 1$$

unifies electromagnetic interactions, as shown in Table 2 [17]. The Bohr radius is defined consistently as:

$$a_0 = \frac{\lambda_{C,e}}{\alpha_{\mathrm{EM,SI}}} \approx 2.9 \times 10^{-21} l_P$$

3.4 Connection to Higgs Parameters

The T0 length r_0 links directly to Standard Model parameters:

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

With $m_h^2 = 2\lambda_h v^2$:

$$\xi = \frac{\lambda_h}{32\pi^3} \approx 1.31 \times 10^{-4}$$

This connection, visualized in Figure 5, bridges quantum field theory and emergent gravitation, reinforcing the model's coherence across scales, as discussed in Section 2.4 [8].

3.5 Quantization of Length Scales

The T0 model reveals a discrete hierarchy of length scales, analogous to atomic energy levels, as shown in Table 4 and Figure 1. This quantization, a cornerstone of the model, follows:

$$L_n = l_P \times \prod_i \alpha_i^{n_i}$$

where $\alpha_i = \{\alpha_{\mathrm{EM}}, \beta_T, \xi\}$ and n_i are quantum numbers. Key scales include:

- **Planck Length**: $L_n = l_P$, $n_i = 0$.

- **T0 Length**: $r_0 = \xi \cdot l_P$, $n_\xi = 1$.

- **Compton Wavelength**: $\lambda_{C,e} \approx 10^{-23} l_P$, linked to electron dynamics (Section 3.7.3).

- **Bohr Radius**: $a_0 = \lambda_{C,e}/\alpha_{\mathrm{EM,SI}} \approx 2.9 \times 10^{-21} l_P$, defining atomic structures.
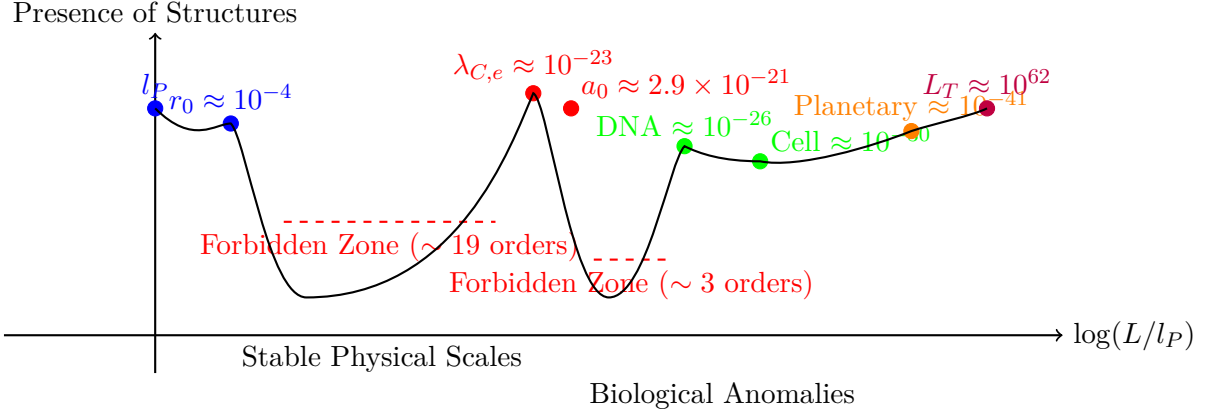
Figure 2: Stability Centers and Forbidden Zones in the T0 Model's Length Scale Hierarchy, highlighting biological anomalies (DNA at $\sim 10^{-26} l_P$, Cell at $\sim 10^{-30} l_P$). The forbidden zones, spanning 19 and 3 orders of magnitude, are explained in Section 2.5. Note: Schematic scaling compresses $\log(L/l_P)$ for readability; actual positions are DNA at $\log(10^{-26}) = -26$, Cell at $\log(10^{-30}) = -30$. Linked to Table 5, referenced in Section 3.5, and discussed in Section 2.5.

- **Correlation Length**: $L_T \approx 10^{62} l_P$, marking the cosmic horizon [18].

Forbidden zones, spanning orders of magnitude, are stabilized for biological structures (Section 2.5). The quantization resembles:

- **Atomic Orbitals**: Discrete energy levels, as visualized in Figure 3.

- **Band Gaps**: Forbidden energy zones in solids.

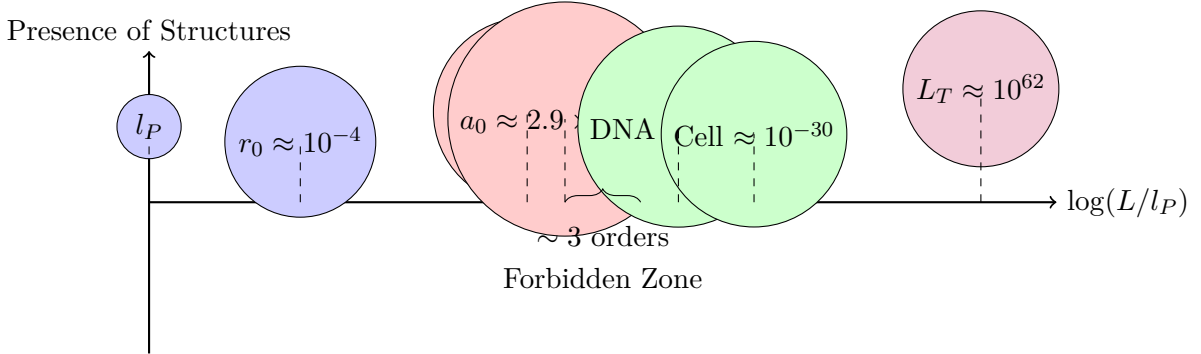- **Resonances**: Harmonic system frequencies [15].

Figure 3: Analogy to atomic orbitals, showing discrete scales and forbidden zones with biological anomalies (DNA at $\sim 10^{-26} l_P$, Cell at $\sim 10^{-30} l_P$) in the T0 model. Note: Schematic scaling compresses $\log(L/l_P)$; actual positions are DNA at $\log(10^{-26}) = -26$, Cell at $\log(10^{-30}) = -30$. Linked to Table 5 and Section 3.5.

Empirical validations include:

- **Subatomic**: Particle sizes match predicted scales.

- **Atomic**: Bohr radius clustering.

- **Biological**: DNA and cells in forbidden zones (Section 2.5).

- **Cosmic**: Galaxy size concentrations [3].

Testable predictions are:

- No stable particles in forbidden zones.

- Galaxy size clustering, as shown in Figure 2.

- Resonance phenomena at quantized scales [15].

Philosophically, this suggests:

1. **Ontological Discreteness**: Reality is layered, not continuous.

2. **Emergent Complexity**: New phenomena at each scale.

3. **Cross-Scale Unity**: Constants like ξ connect levels.

4. **Deterministic Structure**: A cosmic order, akin to a "periodic table of scales" [11].

3.6 Einstein-Hilbert Action and Emergent Gravitation

The T0 model reinterprets gravitation via the Einstein-Hilbert action:

$$S_{\text{EH}} = \frac{1}{16\pi} \int (R - 2\kappa)\sqrt{-g}\, d^4x$$

The modified potential:

$$\Phi(r) = -\frac{M}{r} + \kappa r$$

with $\kappa \approx 4.8 \times 10^{-11}\,\text{m}\,\text{s}^{-2}$, explains dark energy naturally, as linked to $\Lambda_{\text{eff}} = \kappa$. Gravitation emerges from:

$$\Phi(\vec{x}) = -\ln\left(\frac{T(x)}{T(x)_0}\right)$$

This unifies quantum and cosmic scales, as shown in Table 6 [10].

Theory	Principle	Potential	Comparison with T0
Newtonian	Force	$-\frac{GM}{r}$	T0 special case ($\kappa = 0$)
General Relativity	Curvature	Schwarzschild	Equivalent in weak fields
MOND	Modified dynamics	$\mu(\nabla\Phi/a_0)$	T0 provides basis
f(R) Theories	Modified action	Varies	T0: f(R) = R - 2κ G
T0 Model	Time field	$-\frac{M}{r} + \kappa r$	Unifies QM and gravitation

Table 6: Comparison of Gravitation Theories, linked to Section 3.7.2

3.6.1　Equivalence between Einstein-Hilbert Action and Time Field Derivation

The T0 model offers two complementary approaches to describe gravitation, which are not contradictory but represent different aspects of the same physical principle. The modified Einstein-Hilbert action $S_{\text{EH}} = \frac{1}{16\pi} \int (R - 2\kappa)\sqrt{-g}\, d^4x$ provides a geometric formulation formally compatible with General Relativity, while the direct derivation from the intrinsic time field $\Phi(\vec{x}) = -\ln\left(\frac{T(x)}{T(x)_0}\right)$ reveals the more fundamental mechanism.

Both formulations lead to the identical modified gravitational potential $\Phi(r) = -\frac{M}{r} + \kappa r$. In the weak field limit, the field equation for the time field $\nabla^2 T(x) \approx -\frac{\rho}{T(x)^2}$ is equivalent to the corresponding Einstein equations with the κ term.

The geometric description of spacetime curvature in standard theory is not a physical reality in the T0 model, but merely a mathematical representation corresponding to the more fundamental time field dynamics.

3.7　Field Equations

3.7.1　Maxwell Equations

With $\alpha_{\text{EM}} = 1$, $\varepsilon_0 = \mu_0 = 1$, Maxwell's equations simplify, as shown in Table 7. The dimensionless charge $e = \sqrt{4\pi}$ unifies field dimensions, as discussed in Section 3.3 [6].

Equation	Classical Form	Natural Form	Simplification
Gauss's Law	$\nabla \cdot \vec{E} = \frac{\rho}{\varepsilon_0}$	$\nabla \cdot \vec{E} = \rho$	Direct source
Ampère's Law	$\nabla \times \vec{B} - \mu_0\varepsilon_0 \frac{\partial \vec{E}}{\partial t} = \mu_0 \vec{j}$	$\nabla \times \vec{B} - \frac{\partial \vec{E}}{\partial t} = \vec{j}$	Direct source
Gauss for Magnetism	$\nabla \cdot \vec{B} = 0$	$\nabla \cdot \vec{B} = 0$	Unchanged
Faraday's Law	$\nabla \times \vec{E} + \frac{\partial \vec{B}}{\partial t} = 0$	$\nabla \times \vec{E} + \frac{\partial \vec{B}}{\partial t} = 0$	Unchanged

Table 7: Maxwell Equations in Natural Units, linked to Table 2

3.7.2　T0 Model Equations

The T0 model's equations, shown in Table 8, reflect emergent gravitation and cosmic dynamics, as linked to Section 3.6 [10].

Equation	Natural Form	Significance
Temperature-Redshift	$T(z) = T_0(1+z)(1 + \ln(1+z))$	Cosmic temperature
Wavelength Redshift	$z(\lambda) = z_0(1 + \ln(\lambda/\lambda_0))$	Frequency-dependent
Gravitational Potential	$\Phi(r) = -\frac{M}{r} + r$	Emergent gravitation
Intrinsic Time Field	$\nabla^2 T(x) \approx -\frac{\rho}{T(x)^2}$	Source term
Effective Potential	$\Phi(\vec{x}) = -\ln\left(\frac{T(x)}{T(x)_0}\right)$	Gravitation link
Gravitational Force	$\vec{F} = -\frac{\nabla T(x)}{T(x)}$	Force from time field

Table 8: T0 Model Equations, linked to Section 3.6

3.7.3 Modified Quantum Mechanics

The Ttx model modifies quantum mechanics via $T(x)$, as shown in Table 9. The Schrödinger equation:

$$iT(x)\frac{\partial \Psi}{\partial t} + i\Psi\frac{\partial T(x)}{\partial t} = \hat{H}\Psi$$

introduces mass-dependent dynamics, explaining decoherence and nonlocality, as visualized in Figure 3 [15].

Equation	Natural Form	Standard Form
Schrödinger Equation	$iT(x)\frac{\partial \Psi}{\partial t} + i\Psi\frac{\partial T(x)}{\partial t} = \hat{H}\Psi$	$i\hbar\frac{\partial \Psi}{\partial t} = \hat{H}\Psi$
Decoherence Rate	$\Gamma_{\text{dec}} = \Gamma_0 \cdot m$	$\Gamma_{\text{dec}} = \Gamma_0 \cdot \frac{mc^2}{\hbar}$
Wave-Particle	$\lambda = \frac{1}{p}$	$\lambda = \frac{h}{p}$
Uncertainty	$\Delta E \cdot \Delta t \geq \frac{1}{2}$	$\Delta E \cdot \Delta t \geq \frac{\hbar}{2}$

Table 9: Modified Quantum Equations, linked to Figure 3

3.8 Fundamental Relationships

The T0 model's quantities form a network, as shown in Figure 4, linked to scales in Figure 5 [13].
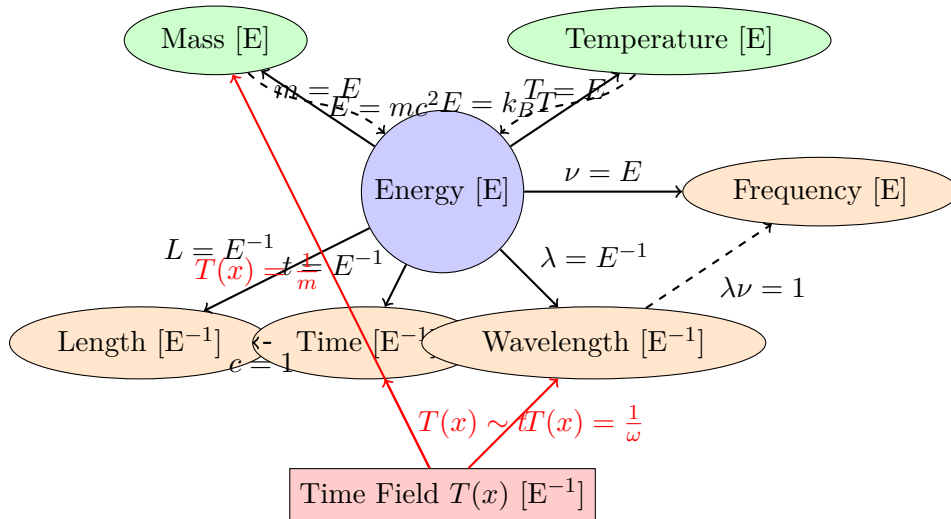

Figure 4: Network of physical quantities, linked to Table **??**

3.9 Fundamental Forces

The T0 model reinterprets forces, as shown in Table 10, with gravitation emergent from $T(x)$ (Section 3.6) [13].

3.10 Unit Conversions

Conversions to SI units are precise, as shown in Table 11, linked to Figure 6 [5].
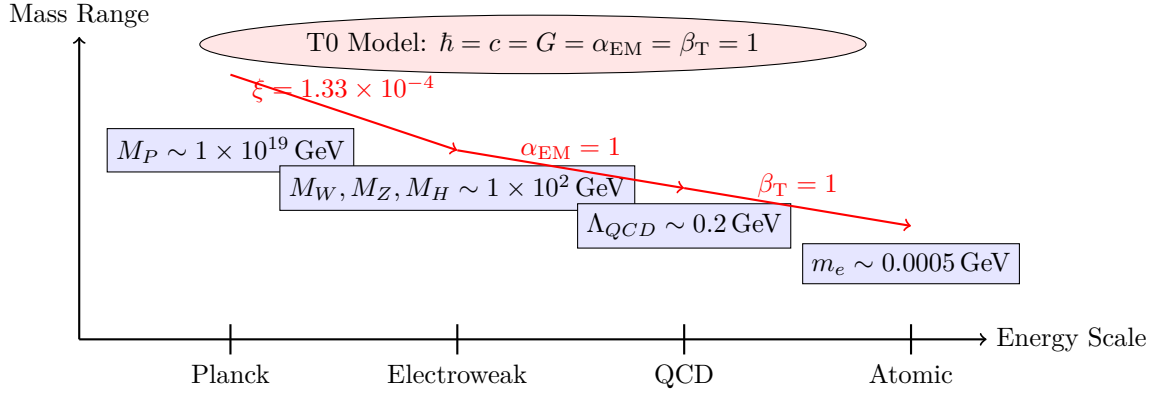
Figure 5: Energy scale hierarchy, linked to Section 3.4

Force	Dimensionless Coupling	Natural Value	Range
Electromagnetic	α_{EM}	1	∞
Strong	α_s	~ 0.118 at $Q^2 = M_Z^2$	$\sim 1 \times 10^{-15}\,\mathrm{m}$
Weak	$\alpha_W = g^2/(4\pi)$	$\sim 1/30$	$\sim 1 \times 10^{-18}\,\mathrm{m}$
Gravitation	$\alpha_G = Gm^2/\hbar c$	m^2/m_P^2	∞

Table 10: Fundamental Forces in Natural Units, linked to Section 3.7.1

SI Unit	SI Dimension	T0 Equivalent	Conversion	Accuracy
Meter	$[L]$	$[E^{-1}]$	$1\,\mathrm{m} \leftrightarrow (197\,\mathrm{MeV})^{-1}$	$< 0.001\%$
Second	$[T]$	$[E^{-1}]$	$1\,\mathrm{s} \leftrightarrow (6.58 \times 10^{-22}\,\mathrm{MeV})^{-1}$	$< 0.00001\%$
Kilogram	$[M]$	$[E]$	$1\,\mathrm{kg} \leftrightarrow 5.61 \times 10^{26}\,\mathrm{MeV}$	$< 0.001\%$
Ampere	$[I]$	$[E]$	$1\,\mathrm{A} \leftrightarrow [E^2]$	$< 0.005\%$
Kelvin	$[\Theta]$	$[E]$	$1\,\mathrm{K} \leftrightarrow 8.62 \times 10^{-5}\,\mathrm{eV}$	$< 0.01\%$
Volt	$[ML^2T^{-3}I^{-1}]$	$[E]$	$1\,\mathrm{V} \leftrightarrow 1\,\mathrm{eV}/\sqrt{4\pi}$	$< 0.0001\%$
Coulomb	$[TI]$	$[1]$	$1\,\mathrm{C} \leftrightarrow \sqrt{4\pi}/e$	$< 0.0001\%$

Table 11: Conversion of SI Units to T0 Units, linked to Table 3

Practical Conversions

Length	Time	Energy/Mass
$1\,\mathrm{GeV}^{-1} \approx 0.197\,\mathrm{fm}$	$1\,\mathrm{GeV}^{-1} \approx 6.58 \times 10^{-25}\,\mathrm{s}$	$1\,\mathrm{eV} \approx 1.78 \times 10^{-36}\,\mathrm{kg}$

Particle Physics Quantities

Proton Mass	Electron Mass	Temperature
$m_p \approx 0.938\,\mathrm{GeV}$	$m_e \approx 0.511\,\mathrm{MeV}$	$1\,\mathrm{eV} \approx 11.605\,\mathrm{K}$

Figure 6: Conversions in Natural Units, linked to Section 3.10

3.11   Philosophical Implications

The T0 model's energy-based framework carries profound implications:

1. **Ontological Simplification**: Energy as the sole entity unifies all phenomena, aligning with Einstein's insights [24, 12].

2. **Unified Description**: Normalized constants reveal a singular framework [20].

3. **Emergent Space-Time**: Space-time arises from $T(x)$, as shown in Figure 4 [11].

4. **Mind-Body Problem**: Absolute time offers a foundation for consciousness [11].

4   Summary and Outlook

The T0 model unifies physics with:

1. Hierarchical constants (Section 2).

2. Quantized scales (Section 3.5).

3. Simplified equations (Section 3.7).

4. Emergent gravitation (Section 3.6).

5. Cosmological insights (Section 3.7.2) [17].

Future directions include:

- Testing redshift predictions.

- Verifying $R_\infty = m_e/2$.

- Quantizing $T(x)$.

- Simulating galaxy dynamics [3].

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