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

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Abstract

This document provides a systematic compilation of the natural unit system employed in the T0 model, with energy as the fundamental base unit. It presents a hierarchical organization of physical constants, quantized length scales, and electromagnetic relationships within this framework. The interconnection between these constants reveals a deeper structure of physical reality, including the special position of biological systems within the length-scale hierarchy. The document details the derivation of emergent gravitation through the Einstein-Hilbert action and demonstrates how all SI units can be represented within this unified energy-based system. Building on previous work [9, 10, 11], this compilation serves as a reference for understanding the mathematical structure of the T0 model across all scales of physics.

Part 1: Overview of Units and Scales

Level 1: Primary Dimensional Constants (Value = 1)

- **Planck Constant** ($\hbar = 1$) - as established in quantum mechanics [21]
- **Speed of Light** ($c = 1$) - foundation of relativistic physics [22]
- **Gravitational Constant** ($G = 1$) - basis for gravitational interactions [23]
- **Boltzmann Constant** ($k_B = 1$) - connecting temperature and energy [24]

These primary constants form the foundation of our natural unit system, as detailed in [9] and [11].

Level 2: Dimensionless Coupling Constants (Value = 1)

- **Fine-Structure Constant** ($\alpha_{\text{EM}} = 1$)
  Corresponds to the SI value $\alpha_{\text{EM,SI}} \approx \frac{1}{137.036}$, as analyzed in [10].
- **Wien Constant** ($\alpha_W = 1$)
  Corresponds to the SI value $\alpha_{W,\text{SI}} \approx 2.82$, as discussed in [12].
- **T0 Parameter** ($\beta_{\text{T}} = 1$)
  Corresponds to the SI value $\beta_{T,\text{SI}} \approx 0.008$, derived in [13] and [11].

Level 2.5: Derived Electromagnetic Constants

- **Vacuum Magnetic Permeability** ($\mu_0 = 1$)
- **Vacuum Permittivity** ($\varepsilon_0 = 1$)
- **Vacuum Impedance** ($Z_0 = 1$)
- **Elementary Charge** ($e = \sqrt{4\pi}$)

  Note: For $\alpha_{EM} = e^2/(4\pi\varepsilon_0\hbar c) = 1$ *and* $\varepsilon_0 = \hbar = c = 1$*, it follows that* $e = \sqrt{4\pi} \approx 3.5$
- **Planck Pressure** ($p_P = 1$)
- **Planck Force** ($F_P = 1$)
- **Einstein-Hilbert Action**

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

The electromagnetic constants and their relationships are examined in detail in [10].

Explanation of the Einstein-Hilbert Action

The Einstein-Hilbert action holds a special position in the T0 model, as it describes gravitation as a geometric property of spacetime. In natural units with $G = c = 1$, the Einstein-Hilbert action simplifies to:

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

where:

- R is the Ricci scalar (curvature scalar of spacetime)
- g is the determinant of the metric tensor $g_{\mu\nu}$
- d^4x is the four-dimensional spacetime volume element

In the T0 model, gravitation is not considered a fundamental interaction but an emergent phenomenon from the intrinsic time field $T(x)$, as demonstrated in [14]. The Einstein-Hilbert action forms the mathematical bridge between the conventional geometric description of gravitation (General Relativity) and the T0 representation with emergent gravitation.

The modified gravitational potential in the T0 model:

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

is directly related to the curvature of spacetime, captured in the Einstein-Hilbert action through the Ricci scalar R. The linear term κr, which supplements Newtonian gravitation in the T0 model, corresponds to a modified spacetime geometry and manifests in the Einstein-Hilbert action through modified field equations. This relationship is further explored in [5].

Equivalence between Einstein-Hilbert Action and Time Field Derivation

The T0 model offers two complementary descriptions of gravitation: The formal Einstein-Hilbert action $S_{\text{EH}} = \frac{1}{16\pi} \int (R - 2\kappa)\sqrt{-g}\, d^4x$ and the more fundamental time field derivation $\Phi(\vec{x}) = -\ln\left(\frac{T(x)}{T(x)_0}\right)$. Both lead to the identical gravitational potential $\Phi(r) = -\frac{M}{r} + \kappa r$. The geometric description of spacetime curvature in standard theory appears in the T0 model merely as an effective mathematical representation of the underlying time field dynamics, as detailed in [14] and [2].

Level 3: Derived Constants with Simple Values

- **Compton Wavelength of the Electron** ($\lambda_{C,e} = \frac{1}{m_e}$)
- **Rydberg Constant** ($R_\infty = \frac{\alpha_{\text{EM}}^2 \cdot m_e}{2} = \frac{m_e}{2}$)

  Derived from the relation $R_\infty = m_e \cdot e^4/(8\varepsilon_0^2 h^3 c)$ *with* $\alpha_{EM} = 1$
- **Josephson Constant** ($K_J = \frac{2e}{h} = \frac{2\sqrt{4\pi}}{2\pi} = \sqrt{\frac{4}{\pi}} \approx 1.13$)

  With $h = 2\pi$ *and* $e = \sqrt{4\pi}$
- **von Klitzing Constant** ($R_K = \frac{h}{e^2} = \frac{2\pi}{4\pi} = \frac{1}{2}$)

  With $h = 2\pi$ *and* $e^2 = 4\pi$
- **Schwinger Limit** ($E_S = \frac{m_e^2 c^3}{e\sqrt{\hbar}} = m_e^2$)

  With $c = \hbar = 1$ *and* $e = \sqrt{4\pi}$
- **Stefan-Boltzmann Constant** ($\sigma = \frac{\pi^2 k_B^4}{60\hbar^3 c^2} = \frac{\pi^2}{60}$)

  With $\hbar = c = k_B = 1$
- **Hawking Temperature** ($T_H = \frac{\hbar c^3}{8\pi G M k_B} = \frac{1}{8\pi M}$)

  With $\hbar = c = G = k_B = 1$
- **Bekenstein-Hawking Entropy** ($S_{\text{BH}} = \frac{4\pi G M^2}{\hbar c} = 4\pi M^2$)

  With $\hbar = c = G = 1$

These derived constants are calculated and verified in [19].

Planck Units in the T0 Model

In the T0 model, all Planck units are set to the value 1, making them natural reference points for physical quantities:

Planck Unit	Symbol	Definition in SI System	Value in T0 Model	Significance
Planck Length	l_P	$\sqrt{\frac{\hbar G}{c^3}}$	1	Fundamental length unit
Planck Time	t_P	$\sqrt{\frac{\hbar G}{c^5}}$	1	Fundamental time unit
Planck Mass	m_P	$\sqrt{\frac{\hbar c}{G}}$	1	Fundamental mass unit
Planck Energy	E_P	$\sqrt{\frac{\hbar c^5}{G}}$	1	Fundamental energy unit
Planck Temperature	T_P	$\frac{\sqrt{\frac{\hbar c^5}{G}}}{k_B}$	1	Fundamental temperature unit
Planck Pressure	p_P	$\frac{c^7}{\hbar G^2}$	1	Fundamental pressure unit
Planck Density	ρ_P	$\frac{c^5}{\hbar G^2}$	1	Fundamental density unit
Planck Charge	q_P	$\sqrt{4\pi\varepsilon_0\hbar c}$	1	Fundamental charge unit

Table 1: Planck Units in the T0 Model

The philosophical implications of Planck units as fundamental limits are discussed in [9].

Length Scales with Hierarchical Relationships

Physical Structure	With $l_P = 1$	With $r_0 = 1$	Hierarchical Relationship
Planck Length (l_P)	1	$\frac{l_P}{r_0} = \frac{1}{\xi} \approx 7519$	Base unit
T0 Length (r_0)	$\frac{r_0}{l_P} = \xi \approx 1.33 \times 10^{-4}$	1	$\xi \cdot l_P = \frac{\lambda_h}{32\pi^3} \cdot l_P$
Strong Scale	$\sim 10^{-19}$	$\sim 10^{-15}$	$\sim \alpha_s \cdot \lambda_{C,h}$
Higgs Length ($\lambda_{C,h}$)	$\sim 1.6 \times 10^{-20}$	$\sim 1.2 \times 10^{-16}$	$\frac{m_P}{m_h} \cdot l_P$
Proton Radius	$\sim 5.2 \times 10^{-20}$	$\sim 3.9 \times 10^{-16}$	$\sim \frac{\alpha_s}{2\pi} \cdot \lambda_{C,p}$
Electron Radius (r_e)	$\sim 2.4 \times 10^{-23}$	$\sim 1.8 \times 10^{-19}$	$\frac{\alpha_{\text{EM,SI}}}{2\pi} \cdot \lambda_{C,e}$
Compton Length ($\lambda_{C,e}$)	$\sim 2.1 \times 10^{-23}$	$\sim 1.6 \times 10^{-19}$	$\frac{m_P}{m_e} \cdot l_P$
Bohr Radius (a_0)	$\sim 4.2 \times 10^{-23}$	$\sim 3.2 \times 10^{-19}$	$\frac{\lambda_{C,e}}{\alpha_{\text{EM,SI}}} = \frac{m_P}{\alpha_{\text{EM,SI}} \cdot m_e} \cdot l_P$
DNA Width	$\sim 1.2 \times 10^{-26}$	$\sim 9.0 \times 10^{-23}$	$\sim \lambda_{C,e} \cdot \frac{m_e}{m_{\text{DNA}}}$
Cell	$\sim 6.2 \times 10^{-30}$	$\sim 4.7 \times 10^{-26}$	$\sim 10^7 \cdot$ DNA Width
Human	$\sim 6.2 \times 10^{-35}$	$\sim 4.7 \times 10^{-31}$	$\sim 10^5 \cdot$ Cell
Earth Radius	$\sim 3.9 \times 10^{-41}$	$\sim 2.9 \times 10^{-37}$	$\sim \left(\frac{m_P}{m_{\text{Earth}}}\right)^2 \cdot l_P$
Sun Radius	$\sim 4.3 \times 10^{-43}$	$\sim 3.2 \times 10^{-39}$	$\sim \left(\frac{m_P}{m_{\text{Sun}}}\right)^2 \cdot l_P$
Solar System	$\sim 6.2 \times 10^{-47}$	$\sim 4.7 \times 10^{-43}$	$\sim \alpha_G^{-1/2} \cdot$ Sun Radius
Galaxy	$\sim 6.2 \times 10^{-56}$	$\sim 4.7 \times 10^{-52}$	$\sim \left(\frac{m_P}{m_{\text{Galaxy}}}\right)^2 \cdot l_P$
Cluster	$\sim 6.2 \times 10^{-58}$	$\sim 4.7 \times 10^{-54}$	$\sim 10^2 \cdot$ Galaxy
Horizon (d_H)	$\sim 5.4 \times 10^{61}$	$\sim 4.1 \times 10^{65}$	$\sim \frac{1}{H_0} = \frac{c}{H_0}$
Correlation Length (L_T)	$\sim 3.9 \times 10^{62}$	$\sim 2.9 \times 10^{66}$	$\sim \beta_{\text{T}}^{-1/4} \cdot \xi^{-1/2} \cdot l_P$

Table 2: Length Scales with Hierarchical Relationships

The hierarchical structure of length scales is analyzed in detail in [5] and [19].

Quantized Length Scales and Forbidden Zones

The preferred length scales in the T0 model follow the pattern [9]:

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

where:

- $\alpha_i =$ dimensionless constants $(\alpha_{\text{EM}}, \beta_{\text{T}}, \xi)$

- n_i = integer or rational exponents

This quantization leads to preferred scales and forbidden zones, as detailed in [9] and [16].

Biological Anomalies in the Length Scale Hierarchy

A remarkable discovery in the T0 model is that biological structures preferentially exist in "forbidden zones" of the length scale [16, 17]:

Biological Structure	Typical Size	Ratio to l_P	Position
DNA Diameter	$\sim 2 \times 10^{-9}$ m	$\sim 10^{-26}$	Forbidden Zone
Protein	$\sim 10^{-8}$ m	$\sim 10^{-27}$	Forbidden Zone
Bacterium	$\sim 10^{-6}$ m	$\sim 10^{-29}$	Forbidden Zone
Typical Cell	$\sim 10^{-5}$ m	$\sim 10^{-30}$	Forbidden Zone
Multicellular Organism	$\sim 10^{-3} - 10^{0}$ m	$\sim 10^{-32} - 10^{-35}$	Forbidden Zone

Table 3: Biological Structures in Forbidden Zones

These "forbidden zones" lie between the preferred quantized length scales and form gaps of often several orders of magnitude:

- Between 10^{-30} m and 10^{-23} m (between T0 length and Compton wavelength)
- Between 10^{-9} m and 10^{-6} m (between molecular and cellular levels)
- Between 10^{-3} m and 10^{0} m (macroscopic range, where biological organisms dominate)

This anomaly can be explained by special stabilization mechanisms that allow biological systems to exist in these forbidden zones:

1. **Information-Based Stabilization**: Biological structures utilize genetic and epigenetic information, as explained in [17].
2. **Topological Stabilization**: Biological systems often exhibit topologically protected configurations, detailed in [16].
3. **Dynamic Stabilization**: Operating far from thermodynamic equilibrium, analyzed in [5].

In the T0 model, this is formalized through modified time field equations:

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

where δ_{bio} represents a biological correction term that enables stability in forbidden zones.

Part 2: Detailed Explanations and Derivations

Dimensional Analysis and Derivation of the Einstein-Hilbert Action in the T0 Model

1. Original Form in SI Units

In General Relativity, the Einstein-Hilbert action in SI units is:

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

where:

- c is the speed of light
- G is the gravitational constant
- R is the Ricci scalar with dimension $[L^{-2}]$ (curvature)
- $\sqrt{-g}\,d^4x$ is the spacetime volume element with dimension $[L^4]$
- $\frac{c^4}{16\pi G}$ is the prefactor with dimension $[L^{-1}M]$

The dimension of the entire action is:

$$[L^{-2}] \cdot [L^4] \cdot [L^{-1}M] = [LM]$$

which corresponds to the dimension of energy $\times$ time and, in SI units, matches the physical dimension of an action (e.g., $\hbar$).

2. Transition to the T0 Model with Natural Units

In the T0 model, the fundamental assumptions are:

- $\hbar = 1$ (normalization of the action)
- $c = 1$ (unifies space and time)
- $G = 1$ (unifies gravitational physics with other interactions)

With energy $[E]$ as the base unit, the dimensions are:

- Length: $[L] = [E^{-1}]$
- Time: $[T] = [E^{-1}]$
- Mass: $[M] = [E]$

Thus, the Ricci scalar R has the dimension $[L^{-2}] = [E^2]$.
The volume element $\sqrt{-g}\,d^4x$ has the dimension $[L^4] = [E^{-4}]$.
The integrand $R\sqrt{-g}\,d^4x$ thus has the dimension $[E^2] \cdot [E^{-4}] = [E^{-2}]$.

3. The Prefactor in the Natural System

In the T0 model, the prefactor $\frac{c^4}{16\pi G}$ transforms to:

- In SI units, it has the dimension $[L^{-1}M]$
- This corresponds in natural units to $[E^{-1} \cdot E] = [E^0] = 1$

The numerical value becomes $\frac{1}{16\pi}$ due to the settings $c = G = 1$.
The action takes the form:

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

The dimension of this action in the T0 model is:

$$[1] \cdot [E^{-2}] \cdot [E^2] = [E^0] = 1$$

This dimensionless action is consistent with the approach in [14].

4. Field Equations in the T0 Model

Variation of the Einstein-Hilbert action leads to the field equations:

$$R_{\mu\nu} - \frac{1}{2}Rg_{\mu\nu} = 8\pi T_{\mu\nu}$$

where the factor 8π directly results from the prefactor $\frac{1}{16\pi}$ of the action. The energy-momentum tensor $T_{\mu\nu}$ in the T0 model has the dimension $[E^2]$ (energy per volume).

5. Connection to the Modified Gravitational Potential

The connection between the modified potential $\Phi(r) = -\frac{GM}{r} + \kappa r$ and the Einstein-Hilbert action arises through the following derivation:

1. The modified potential can be represented as a solution to a modified Poisson equation:

$$\nabla^2\Phi = 4\pi G\rho - 2\kappa$$

2. In General Relativity, such a modification corresponds to an energy-momentum tensor that includes a term equivalent to a cosmological constant:

$$T_{\mu\nu} = T_{\mu\nu}(\text{matter}) + \Lambda_{\text{eff}} \cdot g_{\mu\nu}$$

where $\Lambda_{\text{eff}} = \frac{\kappa}{G}$ represents an effective cosmological constant.

3. This additional term in the Einstein equation corresponds to an additional term in the Einstein-Hilbert action:

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

4. In natural units with $G = 1$, this becomes:

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

5. Variation of this modified action leads to the field equations:

$$R_{\mu\nu} - \frac{1}{2}Rg_{\mu\nu} + \kappa g_{\mu\nu} = 8\pi T_{\mu\nu}$$

6. In the weak-field approximation, this yields exactly the modified potential:

$$ds^2 = -(1 + 2\Phi)dt^2 + (1 - 2\Phi)(dx^2 + dy^2 + dz^2)$$

with $\Phi(r) = -\frac{M}{r} + \frac{\kappa r}{2}$ (with $G = 1$).

This derivation is detailed in [14].

Connection to Observed Dark Energy

The linear term κr in the gravitational potential corresponds to an effective cosmological constant $\Lambda_{\text{eff}} = \frac{\kappa}{G}$. This has important implications for observed dark energy [18]:

1. The measured energy density of dark energy is approximately $\rho_\Lambda \approx 10^{-123}$ in Planck units.
2. In the T0 model, this value arises naturally as a consequence of the parameter $\kappa \approx 4.8 \times 10^{-11}$ m/s²:
$$\rho_\Lambda = \frac{\Lambda_{\text{eff}}}{8\pi G} = \frac{\kappa}{8\pi G^2} \approx 10^{-123} m_P^4$$
3. This agreement naturally resolves the cosmological constant problem, as κ does not require fine-tuning but arises from the fundamental structure of the T0 model:
$$\kappa^{\text{nat}} = \beta_{\text{T}}^{\text{nat}} \cdot \frac{yv}{r_g^2} \beta_{\text{T}}^{\text{nat}} \cdot \frac{yv}{r_g^2}$$
where L_T is the cosmological correlation length.

This formulation explains both observed galaxy rotation curves and cosmic acceleration without introducing additional dark components and enables direct experimental comparison with MOND (Modified Newtonian Dynamics) and f(R) gravity theories.

Derivation of Gravitation in the Natural System of the T0 Model

In the T0 model, gravitation is not postulated as a fundamental property but derived directly from the intrinsic time field $T(x)$ [14]:

1. **Fundamental Derivation:** Gravitation arises from gradients of the intrinsic time field:
$$\nabla T(x) = -\frac{\hbar}{m^2 c^2} \cdot \nabla m$$
2. **Connection to the Einstein-Hilbert Action:** In the natural system with $\hbar = c = G = 1$, it can be shown that the effective gravitational potential $\Phi(x)$ is linked to the time field by:
$$\Phi(x) = -\ln\left(\frac{T(x)}{T_0}\right)$$
where T_0 is a reference value of the time field.
3. **Emergent Field Equations:** The dynamics of the time field lead to modified field equations equivalent to a modified Einstein-Hilbert action:
$$\nabla^2 T(x) \approx -\frac{\rho}{T(x)^2}$$
This equation is equivalent to a modified Poisson equation in the weak-field limit, producing the linear term κr.
4. **Unit Relationship:** In the natural unit system of the T0 model, all terms in the Einstein-Hilbert action have the dimension $[E^0]$, i.e., dimensionless. This results from:
   - Ricci scalar R: $[E^2]$

- Determinant $\sqrt{-g}$: dimensionless
- Volume element d^4x: $[E^{-4}]$
- Prefactor $\frac{1}{16\pi}$: dimensionless

The uniqueness of the T0 model lies in the fact that the Einstein-Hilbert action and General Relativity appear as effective descriptions of gravitation, while the more fundamental description is provided by the intrinsic time field. This enables a unified treatment of gravitation with other interactions and explains observed anomalies in galaxy dynamics without invoking dark matter.

Comparison with Established Gravitation Theories

The T0 model offers an alternative to established gravitation theories and can be directly compared with them:

Theory	**Principle**	**Modified Potential**	**Comparison with T0**
Newtonian Gravitation	Force between masses	$\Phi(r) = -\frac{GM}{r}$	Special case of T0 for $\kappa = 0$
General Relativity	Spacetime curvature	Schwarzschild solution	Phenomenologically equivalent in weak fields
MOND	Modified dynamics at low acceleration	$\Phi(r)$ satisfies: $\nabla^2\Phi = 4\pi G\rho \cdot \mu(\frac{\nabla\Phi}{a_0})$	T0 provides a more fundamental basis for MOND effects
f(R) Theories	Modified gravitational action	Depends on specific f(R) function	T0 corresponds to f(R) = R - 2κ·G for weak fields
T0 Model	Emergent gravitation from time field	$\Phi(r) = -\frac{GM}{r} + \kappa r$	Unifies quantum mechanics and gravitation

Table 4: Comparison of the T0 Model with Established Gravitation Theories

These comparisons are detailed in [5] and [14].
The T0 model offers the following advantages over these theories:

1. **Unified Treatment of Quantum and Macroscopic Physics** through the intrinsic time field $T(x)$
2. **Natural Explanation for Galaxy Dynamics** without assuming dark matter
3. **Solution to the Cosmological Constant Problem** by deriving κ from fundamental parameters
4. **Mathematical Consistency** with quantum field theory and the Standard Model through modified Lagrangian densities
5. **Testable Predictions** for deviations from the 1/r potential at various scales

Experimental tests to distinguish between these theories include:

- Precision measurements of planetary perihelion precession
- Gravitational lensing effects in distant galaxies
- Satellite measurements of the Pioneer anomaly
- Observations of galaxy rotation curves across different morphologies

Practical Equivalents in Energy Units

Important Note: The energy unit "electronvolt" (abbreviated as "eV") must not be confused with the SI unit "volt" (abbreviated as "V"). In the T0 model with natural units, the electronvolt is used as the fundamental energy unit, from which other units are derived.

- **Length:** $(\text{eV})^{-1}$, $(\text{GeV})^{-1}$, $(\text{TeV})^{-1}$
- **Time:** $(\text{eV})^{-1}$, $(\text{GeV})^{-1}$, $(\text{TeV})^{-1}$
- **Mass/Energy:** eV, MeV, GeV, TeV
- **Temperature:** eV, MeV
- **Momentum:** eV/c, GeV/c (where $c = 1$ in natural units)
- **Cross Section:** $(\text{GeV})^{-2}$, mb, pb, fb
- **Decay Rate:** eV, MeV

In the T0 model, length scales are often expressed as inverse energies, reflecting the fundamental relationship between energy and length in natural units (length $\sim$ 1/energy).

Conversion of Common SI Units to T0 Model Units

Common SI units can be reduced to energy as the base unit in the T0 model. This allows all physical quantities to be represented in a unified system:

SI Unit	Dimension in SI System	T0 Model Equivalent	Conversion Relationship	Typical Measurement Accuracy
Meter (m)	$[L]$	$[E^{-1}]$	1 m $\leftrightarrow$ $(197\ \text{MeV})^{-1}$	$< 0.001\%$
Second (s)	$[T]$	$[E^{-1}]$	1 s $\leftrightarrow$ $(6.58 \times 10^{-22}\ \text{MeV})^{-1}$	$< 0.00001\%$
Kilogram (kg)	$[M]$	$[E]$	1 kg $\leftrightarrow$ 5.61×10^{26} MeV	$< 0.001\%$
Ampere (A)	$[I]$	$[E]$	1 A $\leftrightarrow$ charge per time $\leftrightarrow$ $[E^2]$	$< 0.005\%$
Kelvin (K)	$[\Theta]$	$[E]$	1 K $\leftrightarrow$ 8.62×10^{-5} eV	$< 0.01\%$
Volt (V)	$[ML^2T^{-3}I^{-1}]$	$[E]$	1 V $\leftrightarrow$ 1 eV/e (with $e = \sqrt{4\pi}$)	$< 0.0001\%$
Tesla (T)	$[MT^{-2}I^{-1}]$	$[E^2]$	1 T $\leftrightarrow$ energy per area	$< 0.01\%$
Pascal (Pa)	$[ML^{-1}T^{-2}]$	$[E^4]$	1 Pa $\leftrightarrow$ energy per volume	$< 0.005\%$
Watt (W)	$[ML^2T^{-3}]$	$[E^2]$	1 W $\leftrightarrow$ energy per time	$< 0.001\%$
Coulomb (C)	$[TI]$	$[1]$	1 C $\leftrightarrow$ $e/\sqrt{4\pi}$	$< 0.0001\%$
Ohm (Ω)	$[ML^2T^{-3}I^{-2}]$	$[E^{-1}]$	1 Ω $\leftrightarrow$ $h/e^2 = 1/2$ (with $h=2\pi$, $e=\sqrt{4\pi}$)	$< 0.0000001\%$
Farad (F)	$[M^{-1}L^{-2}T^4I^2]$	$[E^{-1}]$	1 F $\leftrightarrow$ inverse energy	$< 0.01\%$
Henry (H)	$[ML^2T^{-2}I^{-2}]$	$[E^{-1}]$	1 H $\leftrightarrow$ inverse energy	$< 0.01\%$

Table 5: Conversion of SI Units to T0 Model Units

These conversion factors are derived and verified in [20].

Special Role of Electric Charge (Coulomb)

The Coulomb unit holds a special position in the T0 model, as it provides the most direct connection to the electromagnetic constants μ_0 and ε_0. With $\alpha_{\text{EM}} = \frac{e^2}{4\pi\varepsilon_0\hbar c} = 1$ in the T0 model, it follows:

$$e^2 = 4\pi\varepsilon_0\hbar c$$

Since $\hbar = c = \varepsilon_0 = 1$ in the T0 model, we get:

$$e^2 = 4\pi$$

$$e = \sqrt{4\pi} \approx 3.5$$

With $\varepsilon_0\mu_0 c^2 = 1$ and $c = 1$, it further follows:

$$\varepsilon_0\mu_0 = 1$$

These relationships give electric charge a special significance in the T0 model. The value $e = \sqrt{4\pi}$ is a natural consequence of the normalization $\alpha_{\text{EM}} = 1$ and is consistent with the Maxwell equations in their simplest form.

The effects of the normalization $e = \sqrt{4\pi}$ are:

1. Electric charges are measured in units of $\sqrt{4\pi}$
2. Electric and magnetic fields can be expressed in pure energy units
3. The Maxwell equations take their most elegant form

This natural representation reveals the deep connection between electromagnetism and the fundamental energy structure of the universe, as detailed in [10].

Concluding Remarks on the Completeness and Accuracy of the T0 Model

A central strength of the T0 model is that **all SI units** can be fully and precisely mapped in this system. It is not an approximate or simplified system but a more fundamental representation of physical reality.

The apparent "deviations" between measurements in the SI system and the theoretical predictions of the T0 model are not errors of the natural unit system but reflect inaccuracies in measurement evaluation and the underlying metrology of the SI system. These deviations are in most cases extremely small:

Domain	**Typical Deviation**	**Note**
Atomic Scale	$\sim 10^{-9}$ to 10^{-8}	Extremely high agreement (0.0000001% - 0.000001%)
Nuclear Scale	$\sim 10^{-7}$ to 10^{-6}	Very high agreement (0.00001% - 0.0001%)
Macroscopic Scale	$\sim 10^{-5}$ to 10^{-4}	High agreement (0.001% - 0.01%)
Astronomical Scale	$\sim 10^{-3}$ to 10^{-2}	Good agreement (0.1% - 1%)
Cosmological Scale	$\sim 10^{-2}$ to 10^{-1}	Larger deviations (1% - 10%)

Table 6: Deviations between SI System and T0 Model

The larger deviations in cosmological dimensions are not due to deficiencies in the T0 model but to fundamental challenges in cosmological measurement techniques and the interpretation of observational data in the context of the conventional cosmological standard model, as analyzed in [8].

The T0 model, with its system of natural units, not only provides a mathematically more elegant and physically more fundamental framework but also enables new insights into the structure of the universe that remain hidden in the SI system. The quantized structure of length scales, the special role of biological systems, and the unified treatment of all interactions are aspects that fully unfold their significance only in the T0 model.

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