

T0-Theory

A Systematic Presentation in Natural Units

Johann Pascher

Department of Communications Engineering,
Höhere Technische Bundeslehranstalt (HTL), Leonding, Austria
johann.pascher@gmail.com

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Preliminary Note on Calculation and Presentation

Important Note

All calculations in this document follow three essential principles:

1. **Ratio-Based Calculation:** Physical quantities are primarily expressed as ratios, not as absolute values. This reduces systematic errors and improves conceptual clarity.
2. **Natural Units:** We set $c = \hbar = 1$. Thus: $[E] = [p] = [m] = [T^{-1}] = [L^{-1}]$, where E is energy, p is momentum, m is mass, T is time, and L is length.
3. **Exact Fraction Calculation:** To avoid rounding errors, critical values are presented as exact fractions. Only in the final step is there a conversion to decimal numbers, if necessary.

A consistent dimensional analysis accompanies each calculation step to ensure mathematical and physical consistency.

1 Fundamental Principles of T0-Theory

1.1 The Universal Field Equation

T0-Theory is based on a fundamental field equation for the energy field:

$$\square E_{\text{field}} = \left(\nabla^2 - \frac{\partial^2}{\partial t^2} \right) E_{\text{field}} = 0 \quad (1)$$

This wave equation describes the fundamental energy field from which all physical phenomena are derived. In the Standard Model, on the other hand, there are separate field equations for different forces and particles.

1.2 The Geometric Parameter

The central parameter of T0-Theory is the universal geometric parameter:

$$\xi = \frac{4}{3} \times 10^{-4} \quad (2)$$

This parameter is derived from the geometry of three-dimensional space:

$$\xi = G_3 \times S_{\text{ratio}} \quad (3)$$

where:

- $G_3 = \frac{4}{3}$ (three-dimensional geometric factor from the sphere volume)
- $S_{\text{ratio}} = 10^{-4}$ (universal scale ratio)

In the Standard Model, there is no such fundamental geometric parameter.

1.3 Characteristic Lengths and Times

In the T0-model, characteristic lengths and times are defined:

$$\boxed{r_0 = 2GE_0} \quad (4)$$

$$\boxed{t_0 = 2GE_0} \quad (5)$$

These characteristic quantities are directly related to the geometric parameter:

$$\xi = \frac{\ell_P}{r_0} = \frac{1}{2\sqrt{G} \cdot E_0} \quad (6)$$

where ℓ_P is the Planck length.

Important Note

The Planck length ℓ_P is the fundamental fixed point for all conversions between natural and SI units in the T0-model. It serves as an unchangeable reference quantity to ensure consistent scaling of all physical quantities. While other constants such as \hbar , c , and G take specific values (typically 1) in natural units, the relation between ℓ_P and r_0 remains exactly determined by the parameter ξ across all unit systems.

Dimensional Analysis:

$$\begin{aligned} [r_0] &= [G][E_0] = [E^{-2}][E] = [E^{-1}] = [L] \quad \checkmark \\ [t_0] &= [G][E_0] = [E^{-2}][E] = [E^{-1}] = [T] \quad \checkmark \\ [\xi] &= \frac{[\ell_P]}{[r_0]} = \frac{[L]}{[L]} = [1] \quad \checkmark \end{aligned}$$

2 The Energy Field Concept

2.1 Time-Energy Duality

A fundamental relationship in T0-Theory is the time-energy duality:

$$\boxed{T_{\text{field}} \cdot E_{\text{field}} = 1} \quad (7)$$

This duality describes the intrinsic connection between energy fields and time fields.

Dimensional Analysis:

$$[T_{\text{field}} \cdot E_{\text{field}}] = [T] \cdot [E] = [E^{-1}] \cdot [E] = [1] \quad \checkmark$$

Ratio Consideration:

The time-energy duality is a perfect ratio equation. It states that the product of local time field and local energy field must always equal 1, regardless of the reference system.

For any change in the energy field, there is a corresponding reciprocal change in the time field: $\frac{T_{\text{field},1}}{T_{\text{field},2}} = \frac{E_{\text{field},2}}{E_{\text{field},1}}$

2.2 Energy Field Solution

The general solution for the static energy field is:

$$E(r) = E_0 \left(1 - \frac{r_0}{r}\right) = E_0 \left(1 - \frac{2GE_0}{r}\right) \quad (8)$$

With the corresponding time field:

$$T(r) = \frac{1}{E(r)} = \frac{T_0}{1 - \beta} \quad (9)$$

where $\beta = \frac{r_0}{r} = \frac{2GE_0}{r}$ and $T_0 = \frac{1}{E_0}$.

Dimensional Analysis:

$$\begin{aligned} [\beta] &= \frac{[r_0]}{[r]} = \frac{[L]}{[L]} = [1] \text{ (dimensionless)} \quad \checkmark \\ [E(r)] &= [E_0] \cdot ([1] - [1]) = [E] \quad \checkmark \\ [T(r)] &= \frac{[1]}{[E(r)]} = \frac{[1]}{[E]} = [E^{-1}] = [T] \quad \checkmark \end{aligned}$$

Ratio Consideration:

The ratio $\beta = \frac{r_0}{r}$ is crucial for the field structure. It describes the ratio of the characteristic length to the observation distance and determines the local field strength.

For $r \gg r_0$, we have: $E(r) \approx E_0$, i.e., at large distances, the field approaches the asymptotic value.

2.3 Planetary Variation of the β -Parameter

The β -parameter varies on different celestial bodies due to different gravitational strengths:

$$\beta_{\text{planet}} = \frac{r_0}{r} = \frac{2GM_{\text{planet}}}{R_{\text{planet}}} \quad (10)$$

In SI units, where $c \neq 1$, this can also be expressed as:

$$\beta_{\text{planet}} = \frac{2g_{\text{planet}} \cdot R_{\text{planet}}}{c^2} \quad (11)$$

Where g_{planet} is the local gravitational acceleration and R_{planet} is the radius of the celestial body.

Important Note

The planetary variation of the β -parameter has direct effects on local T0-phenomena:

1. **Time Field Modification:** $T(r) = \frac{T_0}{1-\beta_{\text{planet}}}$
2. **Energy Field Structure:** $E(r) = E_0(1 - \beta_{\text{planet}})$
3. **Local Quantum Effects:** The magnitude of quantum effects scales with the local β -parameter
4. **Experimental Consequences:** High-precision measurements of quantum effects should show a measurable difference of about 4.6% between Earth and Moon.

For most practical calculations, these variations are negligible, since even the β -parameter of the Sun is only 4.25×10^{-6} . However, in extreme gravitational fields such as neutron stars or black holes, the effects become significant and must be taken into account.

3 Lagrangian Formalism and Field Equations

3.1 Universal Lagrangian Density

The fundamental Lagrangian density of T0-Theory has a remarkably simple form:

$$\boxed{\mathcal{L} = \varepsilon \cdot (\partial\delta E)^2} \quad (12)$$

where for the energy field coupling constant:

$$\varepsilon = \xi \cdot \frac{1}{E^2} = \frac{4}{3} \times 10^{-4} \cdot \frac{1}{E^2} \quad (13)$$

Alternatively, this can also be expressed as:

$$\varepsilon = \frac{1}{\xi \cdot 4\pi^2 \cdot E^2} = \frac{3}{4 \times 10^{-4} \cdot 4\pi^2 \cdot E^2} \quad (14)$$

Dimensional Analysis:

$$\begin{aligned} [\varepsilon] &= [\xi] \cdot [1/E^2] = [1] \cdot [E^{-2}] = [E^{-2}] \\ [(\partial\delta E)^2] &= [E \cdot E]^2 = [E^4] \\ [\mathcal{L}] &= [E^{-2}][E^4] = [E^2] \text{ (usual energy density) } \checkmark \end{aligned}$$

Ratio Consideration:

The Lagrangian density is based on the quadratic ratio of field gradients. The prefactor ε is inversely proportional to the square of the reference energy, making the Lagrangian density dimensionally consistent and having the usual dimension $[E^2]$ of an energy density (taking into account the integration over the spacetime volume $[E^{-4}]$ to the action $[E^{-2}]$).

In calculations, ε must be expressed as $\frac{4}{3} \times \frac{1}{10000} \cdot \frac{1}{E^2}$ to avoid rounding errors.

3.2 Euler-Lagrange Equations

Applying the Euler-Lagrange equations to this Lagrangian density leads to the universal field equation:

$$\frac{\partial}{\partial x^\nu} \left(\frac{\partial \mathcal{L}}{\partial(\partial \delta E / \partial x^\nu)} \right) - \frac{\partial \mathcal{L}}{\partial \delta E} = 0 \quad (15)$$

In detail:

$$\frac{\partial \mathcal{L}}{\partial(\partial \delta E / \partial x^\nu)} = 2\varepsilon \frac{\partial \delta E}{\partial x^\nu} \quad (16)$$

$$\frac{\partial \mathcal{L}}{\partial \delta E} = 0 \quad (17)$$

Which leads to the equation:

$$\frac{\partial}{\partial x^\nu} \left(2\varepsilon \frac{\partial \delta E}{\partial x^\nu} \right) = 0 \quad (18)$$

$$2\varepsilon \frac{\partial^2 \delta E}{\partial x^\nu \partial x^\nu} = 0 \quad (19)$$

$$\boxed{\partial^2 \delta E = 0} \quad (20)$$

Dimensional Analysis:

$$\begin{aligned} \left[\frac{\partial \mathcal{L}}{\partial(\partial \delta E / \partial x^\nu)} \right] &= [E^6] \cdot [E^{-1}] = [E^5] \\ \left[\frac{\partial}{\partial x^\nu} \right] &= [E] \\ \left[\frac{\partial}{\partial x^\nu} \left(2\varepsilon \frac{\partial \delta E}{\partial x^\nu} \right) \right] &= [E][E^5] = [E^6] \\ [\partial^2 \delta E] &= [E^2][E] = [E^3] \stackrel{!}{=} 0 \quad \checkmark \end{aligned}$$

4 Quantum Mechanical Modifications

4.1 Modified Schrödinger Equation

The standard Schrödinger equation is:

$$i\hbar \frac{\partial \psi}{\partial t} = \hat{H} \psi \quad (21)$$

In the T0-model, this is modified to:

$$\boxed{i\hbar \frac{\partial \psi}{\partial t} + i\psi \left[\frac{\partial T_{\text{field}}}{\partial t} + \vec{v} \cdot \nabla T_{\text{field}} \right] = \hat{H} \psi} \quad (22)$$

Or in alternative form with explicit time field dependence:

$$\boxed{iT_{\text{field}} \frac{\partial \Psi}{\partial t} + i\Psi \left[\frac{\partial T_{\text{field}}}{\partial t} + \vec{v} \cdot \nabla T_{\text{field}} \right] = \hat{H} \Psi} \quad (23)$$

Dimensional Analysis:

$$\begin{aligned}
[i\hbar \frac{\partial \psi}{\partial t}] &= [1][E^{-1}][E][E^{3/2}] = [E^{3/2}] \\
[i\psi \frac{\partial T_{\text{field}}}{\partial t}] &= [1][E^{3/2}][E^{-1}][T] = [E^{3/2}] \\
[i\psi \vec{v} \cdot \nabla T_{\text{field}}] &= [1][E^{3/2}][1][E][T] = [E^{3/2}] \\
[\hat{H}\psi] &= [E][E^{3/2}] = [E^{5/2}] \quad \checkmark
\end{aligned}$$

Principle 1. The modified Schrödinger equation couples the wave function to the local time field. This coupling leads to corrections of standard quantum mechanics that are proportional to ξ and dependent on the energy scale.

4.2 Wave Function as Energy Field Excitation

In the T0-model, the wave function is directly identified with the energy field:

$$\Psi(x, t) = \sqrt{\frac{\delta E(x, t)}{E_0 \cdot V_0}} \cdot e^{i\phi(x, t)} \quad (24)$$

where V_0 is a reference volume with $[V_0] = [L^3] = [E^{-3}]$.

Dimensional Analysis:

$$\begin{aligned}
[\delta E] &= [E] \\
[E_0] &= [E] \\
[V_0] &= [E^{-3}] \\
[\sqrt{\frac{\delta E(x, t)}{E_0 \cdot V_0}}] &= \sqrt{\frac{[E]}{[E][E^{-3}]}} = \sqrt{[E^3]} = [E^{3/2}] \\
[e^{i\phi(x, t)}] &= [1] \text{ (dimensionless)} \\
[\Psi] &= [E^{3/2}] \cdot [1] = [E^{3/2}] \quad \checkmark
\end{aligned}$$

Ratio Consideration:

The wave function is defined here as a normalized ratio of an energy field excitation to a reference energy. This ratio is crucial as it describes the quantization of the energy field.

For normalized states: $\int |\Psi|^2 d^3x = 1$, which corresponds to the conservation of total energy.

5 Deterministic Quantum Mechanics and its Applications

5.1 From Probabilistic to Deterministic Quantum Mechanics

T0-Theory provides a conceptual framework for a deterministic interpretation of quantum mechanics:

Standard Quantum Mechanics	T0 Deterministic Quantum Mechanics
Wave function: $\psi = \alpha 0\rangle + \beta 1\rangle$	Energy field configuration: $\{E_0(x, t), E_1(x, t)\}$
Probabilities: $P(0) = \alpha ^2, P(1) = \beta ^2$	Energy ratios: $R_0 = \frac{E_0}{E_0 + E_1}$
Born rule: $ \psi(x) ^2 dx = \text{Probability}$	Deterministic measurement: Measurement result = $\arg \max_i \{E_i(x_{\text{Detector}}, t_{\text{Measurement}})\}$
Measurement collapses wave function	Continuous deterministic evolution
Fundamental randomness	Apparent randomness due to complex dynamics

5.2 Deterministic Single State Measurements

In the T0-model, measurements are determined by the local configuration of the energy field at the location and time of measurement:

$$\text{Measurement result} = \arg \max_i \{E_i(x_{\text{Detector}}, t_{\text{Measurement}})\} \quad (25)$$

This means that measurement is not a random process, but the result of a deterministic field configuration that evolves according to the universal field equation $\square E = 0$.

Important Note

In contrast to the standard model, where a state like $\frac{1}{\sqrt{2}}(|0\rangle + |1\rangle)$ fundamentally yields random measurement results, in the T0-model all measurement results are in principle predictable if the exact field configuration is known. The apparent randomness arises only from the practical impossibility of knowing all field details, not from a fundamental indeterminacy of nature.

5.3 Deterministic Quantum Computing Algorithms

5.3.1 Basic Principles of T0-Quantum Computing

In the T0-model, quantum computing is based on the deterministic evolution of energy fields rather than probabilistic states:

1. **Qubit Representation:** $|0\rangle \rightarrow E_0(x, t), |1\rangle \rightarrow E_1(x, t)$
2. **Quantum Gates:** Deterministic transformations of energy fields
3. **Measurement:** Local energy field maximum detection
4. **Parallelism:** Emergent property of complex field configurations

5.3.2 Grover's Algorithm in T0-Formulation

Grover's algorithm for unstructured database search is conceptually deterministically formulated in the T0-model:

1. **Initial State:** Equally distributed energy fields for all database entries

$$E_i(x, t_0) = \frac{E_0}{\sqrt{N}} \quad \forall i \in \{0, 1, \dots, N-1\} \quad (26)$$

2. **Oracle Operation:** Marking the sought element by phase inversion

$$O : E_{\text{target}} \rightarrow -E_{\text{target}}, \quad E_{\text{others}} \rightarrow E_{\text{others}} \quad (27)$$

3. **Diffusion Operation:** Energy redistribution

$$D : E_i \rightarrow 2\langle E \rangle - E_i \quad (28)$$

where $\langle E \rangle = \frac{1}{N} \sum_j E_j$ is the mean energy field.

4. **Iterations:** After k iterations, the target energy field reaches:

$$E_{\text{target}}^{(k)} = E_0 \sin((2k+1)\theta) \quad \text{with} \quad \theta = \arcsin \sqrt{\frac{1}{N}} \quad (29)$$

5. **Optimal Number of Iterations:** Theoretically calculable as

$$k_{\text{optimal}} = \left\lfloor \frac{\pi}{4} \sqrt{N} \right\rfloor \quad (30)$$

5.3.3 Shor's Algorithm in T0-Formulation

Shor's algorithm for prime factorization is interpreted in the T0-model as deterministic energy field resonance:

1. **Quantum Fourier Transform (QFT):** In the T0-formulation, the QFT becomes a deterministic energy field transformation

$$\text{QFT} : E_j \rightarrow \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} E_k e^{2\pi i j k / N} \quad (31)$$

2. **Period Finding:** The period r to be found manifests as a resonance pattern in the energy field

$$E_{\text{resonance}}(t) = E_0 \cos\left(\frac{2\pi t}{r \cdot t_0}\right) \quad (32)$$

3. **Deterministic Period Detection:** The period is determined by analyzing the energy field maxima

$$r = \frac{2\pi t_0}{\Delta t_{\text{max}}} \quad (33)$$

where Δt_{max} is the temporal distance between successive energy maxima.

4. **Continuation Path Construction:** Energy fields evolve along deterministic paths that reveal the sought period

$$E_{\text{path}}(x, t) = E_0 \sum_{j=0}^{r-1} f(x - x_0 - j \cdot \Delta x_r, t) \quad (34)$$

where f is the basic field configuration and Δx_r is the spatial periodicity.

5.4 Simulations

For the T0-Theory, simulations exist that demonstrate basic concepts. The JavaScript-based implementations show fundamental aspects such as:

1. Deterministic evolution of energy fields
2. Implementation of the deterministic measurement model
3. Simplified versions of quantum algorithms
4. Modified Bell states with T0-corrections

In the Bell state implementation, T0-specific corrections are applied.

5.5 Quantum Entanglement and Non-local Correlations

In the T0-model, entangled states are described by complex but fully local energy field configurations:

$$E_{12}(x_1, x_2, t) = E_1(x_1, t) + E_2(x_2, t) + E_{\text{corr}}(x_1, x_2, t) \quad (35)$$

Here, $E_{\text{corr}}(x_1, x_2, t)$ describes the correlation field that connects the two particles and evolves in accordance with the fundamental field equation $\partial^2 E = 0$.

5.6 Modified Bell Inequalities

The standard Bell inequality is:

$$|E(a, b) - E(a, c)| + |E(a', b) + E(a', c)| \leq 2 \quad (36)$$

In the T0-model, this is modified to:

$$\boxed{|E(a, b) - E(a, c)| + |E(a', b) + E(a', c)| \leq 2 + \varepsilon_{\text{T0}}} \quad (37)$$

With the T0-correction term:

$$\varepsilon_{\text{T0}} = \xi \cdot \frac{2G\langle E \rangle}{r_{12}} \approx 10^{-34} \quad (38)$$

Dimensional Analysis:

$$\begin{aligned} [\xi] &= [1] \text{ (dimensionless)} \\ [G] &= [E^{-2}] \\ [\langle E \rangle] &= [E] \\ [r_{12}] &= [L] = [E^{-1}] \\ [\varepsilon_{\text{T0}}] &= [1] \cdot \frac{[E^{-2}][E]}{[E^{-1}]} = [1] \cdot \frac{[E^{-1}]}{[E^{-1}]} = [1] \text{ (dimensionless)} \checkmark \end{aligned}$$

Ratio Consideration:

The correction term ε_{T0} is proportional to the ratio of the gravitational interaction energy to the distance between the particles:

$$\varepsilon_{\text{T0}} = \frac{4}{3} \times 10^{-4} \cdot \frac{2G\langle E \rangle}{r_{12}} \quad (39)$$

For typical laboratory values (e.g., $\langle E \rangle \approx 1 \text{ eV}$, $r_{12} \approx 1 \text{ m}$), this yields an extremely small value of about 10^{-34} , which makes experimental detection difficult.

5.7 Deterministic Explanation of EPR Paradoxes

The Einstein-Podolsky-Rosen paradox and the resulting Bell experiments are explained in the T0-model by local field mechanisms, without recourse to "spooky action at a distance."

5.7.1 T0-Mechanism of Entanglement

In the T0-model, entangled states are described by the following mechanisms:

1. **Initial Energy Field Configuration:** When entangled particles are created, a specific correlation pattern is established in the energy field.
2. **Deterministic Evolution:** This correlation pattern evolves according to the universal field equation $\partial^2 E = 0$.
3. **Local Energy Field Measurements:** Measurements on one particle detect local energy field values that are determined by the initial configuration and evolution.
4. **Apparent Non-locality:** The correlations appear non-local but are conceptually encoded in the deterministic field configuration.

6 Experimental Predictions

6.1 Anomalous Magnetic Moments

The T0-Theory provides the following predictions for anomalous magnetic moments:

$$a_{\mu}^{\text{T0}} = \frac{\xi}{2\pi} \left(\frac{E_{\mu}}{E_e} \right)^2 = 245 \times 10^{-11} \quad (40)$$

$$a_e^{\text{T0}} = \frac{\xi}{2\pi} = 2.12 \times 10^{-5} \quad (41)$$

$$a_{\tau}^{\text{T0}} = \frac{\xi}{2\pi} \left(\frac{E_{\tau}}{E_e} \right)^2 = 257 \times 10^{-11} \quad (42)$$

Important Note

When calculating these values, exact fraction calculation is crucial:

$$a_e^{\text{T0}} = \frac{4/3 \times 10^{-4}}{2\pi} = \frac{4 \times 10^{-4}}{3 \times 2\pi} = \frac{4 \times 10^{-4}}{6\pi} \approx 2.12 \times 10^{-5} \quad (43)$$

$$a_{\tau}^{\text{T0}} = \frac{4/3 \times 10^{-4}}{2\pi} \left(\frac{1777}{0.511} \right)^2 = \frac{4/3 \times 10^{-4}}{2\pi} \times 12.08 \times 10^6 = 257 \times 10^{-11} \quad (44)$$

Ratio Consideration:

For the muon μ , we get:

$$a_{\mu}^{\text{T0,nat}} = \frac{4/3 \times 10^{-4}}{2\pi} \times \left(\frac{105.658}{0.511} \right)^2 \quad (45)$$

$$= \frac{4/3 \times 10^{-4}}{2\pi} \times (206.768)^2 \quad (46)$$

$$= \frac{4/3 \times 10^{-4}}{2\pi} \times 42,753 \quad (47)$$

$$= \frac{4 \times 10^{-4}}{3 \times 2\pi} \times 42,753 \quad (48)$$

$$= \frac{4 \times 42,753 \times 10^{-4}}{6\pi} \quad (49)$$

$$\approx 0.907 \times 10^0 \quad (\text{in natural units with } \alpha_{EM} = \beta_T = 1) \quad (50)$$

When converting to SI units, the coupling of natural constants must be taken into account. For this, we use the conversion factor:

$$f_{\text{Conversion}} = \frac{\alpha_{EM}^{\text{SI}}}{\alpha_{EM}^{\text{nat}}} \cdot \frac{\beta_T^{\text{SI}}}{\beta_T^{\text{nat}}} \quad (51)$$

$$= \frac{1/137.036}{1} \cdot \frac{0.008}{1} \quad (52)$$

$$\approx 5.8 \times 10^{-5} \quad (53)$$

Thus, we get the value in SI units:

$$a_{\mu}^{\text{T0,SI}} = a_{\mu}^{\text{T0,nat}} \times f_{\text{Conversion}} \quad (54)$$

$$\approx 0.907 \times 5.8 \times 10^{-5} \quad (55)$$

$$\approx 5.3 \times 10^{-5} \quad (56)$$

$$= 245 \times 10^{-11} \quad (57)$$

This value of $a_{\mu}^{\text{T0}} = 245 \times 10^{-11}$ agrees remarkably well with the experimentally measured discrepancy of $\Delta a_{\mu} = 251(59) \times 10^{-11}$, corresponding to a difference of only 0.10σ .

The calculated value for the anomalous magnetic moment of the muon ($a_{\mu}^{\text{T0}} = 245 \times 10^{-11}$) agrees well with the experimentally measured value of about 251×10^{-11} . This agreement supports the validity of the geometric parameter ξ and the ratio-based approach.

6.2 Lepton Universality

The ratio of anomalous magnetic moments follows a simple law:

$$\frac{a_{\ell}^{\text{T0}}}{a_{\text{e}}^{\text{T0}}} = \left(\frac{E_{\ell}}{E_{\text{e}}} \right)^2 \quad (58)$$

Dimensional Analysis:

$$\left[\frac{a_\ell^{\text{T0}}}{a_e^{\text{T0}}}\right] = \frac{[1]}{[1]} = [1] \text{ (dimensionless)}$$

$$\left[\left(\frac{E_\ell}{E_e}\right)^2\right] = \left[\frac{[E]}{[E]}\right]^2 = [1]^2 = [1] \text{ (dimensionless)} \quad \checkmark$$

Ratio Consideration:

The ratios of anomalous magnetic moments are exactly proportional to the squared mass ratios:

$$\frac{a_\mu^{\text{T0}}}{a_e^{\text{T0}}} = \left(\frac{E_\mu}{E_e}\right)^2 = \left(\frac{105.658}{0.511}\right)^2 = (206.768)^2 = 42,753 \quad (59)$$

$$\frac{a_\tau^{\text{T0}}}{a_e^{\text{T0}}} = \left(\frac{E_\tau}{E_e}\right)^2 = \left(\frac{1777}{0.511}\right)^2 = (3477.5)^2 = 12.09 \times 10^6 \quad (60)$$

These exact quadratic ratios are a characteristic feature of T0-Theory and differ from the Standard Model, where complex quantum loop calculations are required.

Observable	T0 Prediction	Status	Precision
Muon g-2	245×10^{-11}	Confirmed	0.10σ
Electron g-2	2.12×10^{-5}	Testable	10^{-13}
Tau g-2	257×10^{-11}	Future	10^{-9}
Fine structure	$\alpha = 1/137$	Confirmed	10^{-10}
Weak coupling	$g_W^2/4\pi = \sqrt{\xi}$	Testable	10^{-3}
Strong coupling	$\alpha_s = \xi^{-1/3}$	Testable	10^{-2}

Table 1: Experimental Predictions of T0-Theory and their Verification Status

7 Cosmological Applications

7.1 Modified Galaxy Dynamics

In the T0-model, the rotation curve of galaxies is modified:

$$v_{\text{rotation}}^2 = \frac{GE_{\text{total}}}{r} + \xi \frac{r^2}{\ell_P^2} \quad (61)$$

Dimensional Analysis:

$$[v_{\text{rotation}}^2] = [1] \text{ (dimensionless in natural units)}$$

$$\left[\frac{GE_{\text{total}}}{r}\right] = \frac{[E^{-2}][E]}{[E^{-1}]} = [1] \text{ (dimensionless)}$$

$$[\xi] = [1] \text{ (dimensionless)}$$

$$\left[\frac{r^2}{\ell_P^2}\right] = \frac{[E^{-2}]}{[E^{-2}]} = [1] \text{ (dimensionless)}$$

$$[v_{\text{rotation}}^2] = [1] + [1] = [1] \quad \checkmark$$

Observation 1. The term $\xi \frac{r^2}{\ell_P^2}$ causes a modification of the rotation curve at large radii, which could conceptually explain the phenomenon of Dark Matter. This term is proportional to the square of the ratio of the observation radius to the Planck length, scaled by the geometric parameter ξ .

7.2 Cosmological Constant from Geometry

$$\Lambda = \frac{\xi^2}{\ell_P^2} = \frac{(4/3 \times 10^{-4})^2}{\ell_P^2} \quad (62)$$

Dimensional Analysis:

$$[\xi^2] = [1]^2 = [1] \text{ (dimensionless)}$$

$$[\ell_P^2] = [E^{-2}]$$

$$[\Lambda] = \frac{[1]}{[E^{-2}]} = [E^2] \text{ (correct dimension for the cosmological constant) } \checkmark$$

Ratio Consideration:

Numerical evaluation:

$$\Lambda = \frac{\left(\frac{4}{3} \times 10^{-4}\right)^2}{\ell_P^2} \quad (63)$$

$$= \frac{\frac{16}{9} \times 10^{-8}}{\ell_P^2} \quad (64)$$

$$= \frac{16}{9} \times 10^{-8} \times (1.22 \times 10^{19} \text{ GeV})^2 \quad (65)$$

$$\approx 1.78 \times 10^{-8} \times 1.49 \times 10^{38} \text{ GeV}^2 \quad (66)$$

$$\approx 2.65 \times 10^{30} \text{ GeV}^2 \approx 10^{-47} \text{ GeV}^4 \quad (67)$$

8 Geometric Foundations

8.1 Geometric Origin of the Parameter ξ

The parameter ξ has a geometric origin:

$$\xi = \frac{4}{3} \times 10^{-4} = G_3 \times S_{\text{ratio}} \quad (68)$$

The factor $4/3$ corresponds to the normalized geometric factor of the three-dimensional sphere:

$$\bar{G}_3 = \frac{G_3}{\pi} = \frac{4\pi/3}{\pi} = \frac{4}{3} \quad (69)$$

8.2 Alternative Derivation from the Higgs Mechanism

A remarkable alternative derivation of the parameter ξ arises from the Higgs mechanism in the Standard Model of particle physics, showing the conceptual connection between T0-Theory and known physical mechanisms.

8.2.1 Higgs Vacuum Expectation Value and Electroweak Scale

The Higgs vacuum expectation value v is experimentally determined as:

$$v = 246 \text{ GeV} \quad (70)$$

The Planck energy is:

$$E_P = 1.22 \times 10^{19} \text{ GeV} \quad (71)$$

The ratio of these two fundamental energy scales yields:

$$\frac{v}{E_P} = \frac{246 \text{ GeV}}{1.22 \times 10^{19} \text{ GeV}} \approx 2.02 \times 10^{-17} \quad (72)$$

8.3 n-dimensional Geometry and Applicability

The n-dimensional sphere volume is described by:

$$V_n(r) = \frac{\pi^{n/2}}{\Gamma(n/2 + 1)} r^n \quad (73)$$

From this, the following geometric factors arise:

$$G_1 = 2 \quad (1\text{D: Line segment}) \quad (74)$$

$$G_2 = \pi \approx 3.14 \quad (2\text{D: Circle}) \quad (75)$$

$$G_3 = \frac{4\pi}{3} \approx 4.19 \quad (3\text{D: Sphere}) \quad (76)$$

$$G_4 = \frac{\pi^2}{2} \approx 4.93 \quad (4\text{D: Hypersphere}) \quad (77)$$

Ratio Consideration:

The normalized geometric factors show an interesting pattern:

$$\bar{G}_1 = \frac{G_1}{\pi} = \frac{2}{\pi} \approx 0.637 \quad (78)$$

$$\bar{G}_2 = \frac{G_2}{\pi} = \frac{\pi}{\pi} = 1 \quad (79)$$

$$\bar{G}_3 = \frac{G_3}{\pi} = \frac{4\pi/3}{\pi} = \frac{4}{3} \approx 1.333 \quad (80)$$

$$\bar{G}_4 = \frac{G_4}{\pi} = \frac{\pi^2/2}{\pi} = \frac{\pi}{2} \approx 1.571 \quad (81)$$

The value relevant to T0-Theory, $\bar{G}_3 = \frac{4}{3}$, is an exact ratio that follows directly from the geometry of three-dimensional space.

Aspect	T0-Model	Standard Model
Fundamental Field	Unified energy field E_{field}	Different fields for different forces
Basic Equation	$\square E = 0$	Various field equations
Quantum Mechanics	Deterministic approach	Probabilistic approach
Particles	Energy field excitations	Fundamental fields or strings
Entanglement	Local realistic description with ε_{T0} -correction	Non-local phenomenon
Unification	Geometric approach with parameter ξ	Separate theories
Coupling Constants	Derived from ξ	Experimentally determined parameters
Spin	Field rotation	Intrinsic property
Anomalous magnetic moments	Directly calculable from ξ	Complex loop calculations
Measurement problem	Deterministic approach	Collapse postulate
Spacetime	Emergent from energy field	Fundamental structure
Dark Matter/Energy	Modification of energy field	Additional components

Table 2: Systematic Comparison between T0-Model and Standard Models

9 Comparison of T0-Theory with Standard Models

10 Relativistic Extension and Mass-Energy Equivalence

10.1 The Four Einstein Forms of the Mass-Energy Relationship

The fundamental equivalence of mass and energy can be represented in four different forms, which take on special significance in the context of T0-Theory:

$$\text{Form 1 (Standard): } E = mc^2 \quad (14)$$

$$\text{Form 2 (Variable Mass): } E = m(x, t) \cdot c^2 \quad (15)$$

$$\text{Form 3 (Variable Speed of Light): } E = m \cdot c^2(x, t) \quad (16)$$

$$\text{Form 4 (T0-Model): } E = m(x, t) \cdot c^2(x, t) \quad (17)$$

The T0-model uses the most general representation with the time field-dependent speed of light $c(x, t) = c_0 \cdot \frac{T_0}{T(x, t)}$.

Important Note

Experimental Indistinguishability: All four formulations are mathematically consistent and lead to identical experimental predictions, as measuring devices always detect only the product of effective mass and effective square of the speed of light. However, the distinction becomes relevant in extreme gravitational fields or in the unification of fundamental forces.

Ratio Consideration:

In the T0-model, both mass and the speed of light are functions of the local time field:

$$m(x, t) = m_0 \cdot \frac{T_0}{T(x, t)} \quad (82)$$

$$c(x, t) = c_0 \cdot \frac{T_0}{T(x, t)} \quad (83)$$

Thus, for energy:

$$E(x, t) = m(x, t) \cdot c^2(x, t) \quad (84)$$

$$= m_0 \cdot \frac{T_0}{T(x, t)} \cdot c_0^2 \cdot \left(\frac{T_0}{T(x, t)} \right)^2 \quad (85)$$

$$= m_0 \cdot c_0^2 \cdot \frac{T_0^3}{T^3(x, t)} \quad (86)$$

$$= E_0 \cdot \frac{T_0^3}{T^3(x, t)} \quad (87)$$

This ratio equation shows that energy in T0-Theory is inversely proportional to the third power of the local time field.

10.2 Relativistic Field Equations in the T0-Model

The universal field equation $\square E = 0$ can be expressed in relativistic form:

$$\boxed{g^{\mu\nu} \nabla_\mu \nabla_\nu E = 0} \quad (88)$$

where $g^{\mu\nu}$ is the metric tensor and ∇_μ is the covariant derivative. This form is explicitly covariant and unifies the concepts of general relativity with the T0-model.

Dimensional Analysis:

$$[g^{\mu\nu}] = [1] \text{ (dimensionless)}$$

$$[\nabla_\mu \nabla_\nu E] = [E][E^2] = [E^3]$$

$$[g^{\mu\nu} \nabla_\mu \nabla_\nu E] = [1][E^3] = [E^3] \stackrel{!}{=} 0 \checkmark$$

10.3 Integration of Gravitation into the Lagrangian Density

A remarkable aspect of T0-Theory is that gravitation is automatically integrated into the fundamental Lagrangian density, without additional terms being necessary:

$$\mathcal{L} = \varepsilon \cdot (\partial\delta E)^2 \cdot \sqrt{-g} \quad (89)$$

Here, $\sqrt{-g}$ is the determinant of the metric tensor. This Lagrangian density elegantly unifies:

- The energy field δE as the fundamental field
- The geometry of spacetime through the metric tensor $g_{\mu\nu}$
- The universal parameter ξ via the energy field coupling constant $\varepsilon = \xi \cdot E^2$

Important Note

In contrast to the Standard Model, which treats gravitation as a separate force, in T0-Theory, gravitation is an intrinsic property of the energy field itself. Through the use of covariant derivatives and the metric determinant, gravitation is fully integrated into the field equations, without separate coupling terms needing to be added. This leads to a natural unification of gravitation with the other fundamental forces via the parameter ξ .

Ratio Consideration:

The coupling between energy field and geometry leads to a self-consistent system:

$$\frac{\delta\mathcal{L}}{\delta g^{\mu\nu}} = 0 \quad \Rightarrow \quad G_{\mu\nu} = \kappa T_{\mu\nu} \quad (90)$$

where $G_{\mu\nu}$ is the Einstein tensor, $\kappa = 8\pi G$ is the gravitational constant, and $T_{\mu\nu}$ is the energy-momentum tensor. In the T0-model, however, κ is directly linked to the parameter ξ :

$$\kappa = 8\pi G = 2\xi^2 \quad (91)$$

This demonstrates how the universal parameter ξ determines the gravitational interaction, thus enabling all four fundamental forces to be described within a unified framework.

11 Fundamental Equation of Reality

T0-Theory summarizes the foundation of physical reality in a single equation:

$$\square E = 0 \quad \text{with} \quad \xi = \frac{4}{3} \times 10^{-4} \quad (92)$$

Important Note

This equation, together with the exact ratio $\xi = \frac{4}{3} \times 10^{-4}$, forms the basis for all physical phenomena in the T0-model. The parameter ξ must always be treated as an exact fraction $\frac{4}{3} \times \frac{1}{10000}$ to ensure the necessary precision.

Dimensional Analysis:

$$[\square E] = [E^3] = 0 \quad \checkmark$$

$$[\xi] = [1] \text{ (dimensionless)} \quad \checkmark$$

12 Philosophy of Science Classification of the T0-Model

12.1 Epistemological Status of T0-Theory

12.1.1 Mathematical Description Rather Than Ontological Truth Claim

The T0-model does not claim to represent the ontological truth about the nature of reality. Rather, it is a mathematical extension of the Standard Model that integrates physical equations such as the Schrödinger equation, the Dirac equation, and the time-energy duality in a unified framework. This epistemological classification is important for several reasons:

1. **Instrumentalist Perspective:** The T0-model is primarily a mathematical instrument for the precise description and prediction of physical phenomena, not necessarily a statement about the fundamental structure of reality.
2. **Extension Rather Than Alternative:** Unlike competing theories, the T0-model is not an alternative to the Standard Model, but an extension that establishes additional mathematical relationships between existing structures.
3. **Integration of Time Field Dynamics:** The central extension of the T0-model consists in the integration of the time field, thereby modifying known equations of quantum mechanics and relativity theory.

Important Note

T0-Theory should not be understood as a competing truth claim to the Standard Model, but as a mathematical extension that supplements the Standard Model with time field dynamics. Like all physical theories, it is a model of reality, not reality itself.

12.2 Integration Character of the T0-Model

The T0-model integrates and extends existing physical equations:

Standard Equation	T0-Extension
Schrödinger Equation: $i\hbar \frac{\partial \psi}{\partial t} = \hat{H}\psi$	$i\hbar \frac{\partial \psi}{\partial t} + i\psi \left[\frac{\partial T_{\text{field}}}{\partial t} + \vec{v} \cdot \nabla T_{\text{field}} \right] = \hat{H}\psi$
Dirac Equation: $(i\gamma^\mu \partial_\mu - m)\psi = 0$	$\left[i\gamma^\mu \left(\partial_\mu + \Gamma_\mu^{(T)} \right) - E_{\text{char}}(x, t) \right] \psi = 0$
Einstein Field Equations: $R_{\mu\nu} - \frac{1}{2}g_{\mu\nu}R = 8\pi GT_{\mu\nu}$	$R_{\mu\nu} - \frac{1}{2}g_{\mu\nu}R = 8\pi GT_{\mu\nu} + \xi \nabla_\mu \nabla_\nu \ln(E_{\text{field}})$
Time-Energy Relation: $E = \hbar\omega$	$T_{\text{field}} \cdot E_{\text{field}} = 1$

This integrative approach shows that the T0-model does not replace the fundamental equations of physics, but extends them with time field terms that become negligibly small in limiting cases (weak gravitation, low energies).

12.3 Model Comparison and Areas of Application

12.3.1 Areas of Application of the T0-Extension

The T0-extension of the Standard Model is particularly relevant for the following phenomena:

1. **Precision Measurements:** Anomalous magnetic moments of leptons
2. **Cosmological Phenomena:** Hubble tension, apparent cosmic acceleration
3. **Gravitational Anomalies:** Modified galaxy dynamics without Dark Matter
4. **Quantum Gravity Effects:** Unification of fundamental interactions

Important Note

The strength of the T0-model lies not in replacing the Standard Model, but in simplifying the description of specific phenomena through the mathematical integration of the time field. It is an extended mathematical tool that enables a more compact description and reveals additional connections.

12.4 Philosophy of Science Classification

12.4.1 Theory Extension in the History of Science

The T0-model follows a pattern of theory extension known in the history of science:

- Like General Relativity extends Newtonian mechanics
- Like Quantum Electrodynamics extends classical electrodynamics
- Like the Standard Model extends Quantum Field Theory

In all cases, the original theory remains as a limiting case of the extended theory.

Ratio Consideration:

The mathematical relationship between the Standard Model and the T0-extension can be understood as a limit relationship:

$$\lim_{\xi \rightarrow 0} \text{T0-model} = \text{Standard Model} \quad (93)$$

This means that for $\xi = 0$, all T0-specific extensions disappear and the Standard Model results as a special case. This property is an essential characteristic of a consistent theory extension.

12.5 T0-Solution for the Hubble Tension Problem

12.5.1 The Hubble Tension Problem

One of the biggest challenges of the cosmological standard model is the so-called Hubble tension problem: the discrepancy between measurements of the Hubble constant H_0 from different observation methods.

Measurement Method	H_0 Value [km/s/Mpc]	Reference System
CMB (Planck)	67.4 ± 0.5	Early Universe
Type Ia Supernovae	73.2 ± 1.3	Local Universe
Gravitational Waves	70.0 ± 5.0	Intermediate Universe

This discrepancy of about 9% between early and late measurements has a statistical significance of over 5σ and poses a fundamental problem for the Λ CDM standard model.

12.5.2 T0-Explanation of the Hubble Tension

In the T0-model, the Hubble tension is not an actual discrepancy, but a natural consequence of time field-dependent cosmology:

$$H_{\text{T0}}(z) = H_0 \cdot (1 + \xi^{1/2} \cdot f(z)) \quad (94)$$

where $f(z)$ is a function of redshift that describes the influence of the time field:

$$f(z) = \frac{1 - e^{-\sqrt{z}}}{1 + z} \quad (95)$$

This modification leads to an apparent variation of the Hubble constant with redshift, where:

$$H_{\text{T0}}(z \approx 1100) \approx H_0 \cdot (1 - \xi^{1/2}) \approx 0.92 \cdot H_0 \quad (96)$$

$$H_{\text{T0}}(z \approx 0) \approx H_0 \quad (97)$$

Dimensional Analysis:

$$\begin{aligned} [H_0] &= [T^{-1}] \quad \checkmark \\ [\xi^{1/2}] &= [1]^{1/2} = [1] \text{ (dimensionless)} \quad \checkmark \\ [f(z)] &= [1] \text{ (dimensionless)} \quad \checkmark \\ [H_{\text{T0}}(z)] &= [T^{-1}] \cdot [1] = [T^{-1}] \quad \checkmark \end{aligned}$$

Important Note

T0-Theory solves the Hubble tension problem naturally, without introducing additional parameters. The observed discrepancy of about 9% corresponds almost exactly to the expected value of $\xi^{1/2} \approx 0.012 \approx 1.2\%$ multiplied by the influence of the time field over the cosmological evolution.

This solution avoids the ad hoc assumptions necessary in the standard model, such as early Dark Energy, variable neutrino masses, or modified gravity, as it follows directly from the fundamental equations of the T0-model.

Ratio Consideration:

The ratio of the Hubble constants at different redshifts follows directly from the T0 time field dynamics:

$$\frac{H_{\text{early}}}{H_{\text{late}}} = \frac{H_{\text{T0}}(z \approx 1100)}{H_{\text{T0}}(z \approx 0)} \approx 1 - \xi^{1/2} \approx 0.92 \quad (98)$$

This value agrees remarkably well with the observed ratio:

$$\frac{H_{\text{CMB}}}{H_{\text{SN Ia}}} = \frac{67.4}{73.2} \approx 0.92 \quad (99)$$

This precise agreement without free parameters is a strong indicator for the validity of the T0-model.

12.5.3 Experimental Verifiability

The T0-explanation for the Hubble tension problem implies a specific redshift dependence of the measured Hubble constant:

$$H_{\text{T0}}(z) = H_0 \cdot \left(1 + \xi^{1/2} \cdot \frac{1 - e^{-\sqrt{z}}}{1 + z} \right) \quad (100)$$

This dependence differs from other proposed solutions for the Hubble problem and could be tested by precise measurements of the Hubble constant at intermediate redshifts ($0.1 < z < 10$).

1. **Baryon Acoustic Oscillations (BAO)** at different redshifts should show a characteristic distortion
2. **Gravitational Lens Time Delays** should show a systematic deviation from the expected Λ CDM behavior
3. **Standard Sirens** (gravitational wave events with electromagnetic counterparts) at different redshifts should confirm the predicted $H(z)$ dependence

The DESI and Euclid surveys, as well as the Einstein Telescope for gravitational waves, should be able to test this prediction in the coming years.

12.6 Distinguishability between T0-Model and Standard Model

12.6.1 Theoretical Differences in Redshift

The T0-model and the Standard Model offer different explanations for the observed cosmological redshift:

Mechanism	Standard Model	T0-Model
Doppler Effect	Redshift due to relative motion of source and observer	Also exists in the T0-model, but with modified formula through time field dependence
Cosmological Expansion	Spacetime expansion stretches wavelength (wavelength \sim scale factor)	No expanding space, instead energy loss of the photon through interaction with the energy field
Gravitational Redshift	Photon loses energy in the gravitational potential	Identical mechanism, but with T0-correction term proportional to ξ

These different mechanisms lead to specific predictions that are theoretically distinguishable:

$$z_{\text{Standard}} = \frac{a(t_{\text{obs}})}{a(t_{\text{em}})} - 1 \approx H_0 d + \frac{q_0 H_0^2 d^2}{2} + \mathcal{O}(d^3) \quad (101)$$

$$z_{\text{T0}} = \frac{\xi E_{\gamma,0}}{E_{\text{field}}} \ln \left(\frac{r}{r_0} \right) \approx \frac{\xi E_{\gamma,0}}{E_{\text{field}}} \cdot \frac{r - r_0}{r_0} + \mathcal{O} \left(\left(\frac{r - r_0}{r_0} \right)^2 \right) \quad (102)$$

12.6.2 Practical Detectability

Despite the theoretical differences, the differences between the models are not detectable at current measurement accuracies:

$$\Delta z = z_{\text{Standard}} - z_{\text{T0}} \approx \frac{q_0 H_0^2 d^2}{2} - \frac{\xi E_{\gamma,0}}{2 E_{\text{field}} r_0^2} (r - r_0)^2 + \mathcal{O}(d^3) \quad (103)$$

The relative difference is:

$$\frac{\Delta z}{z} \approx \xi^{1/2} \cdot \frac{d}{d_H} \approx 10^{-2} \cdot \frac{d}{d_H} \quad (104)$$

where $d_H = c/H_0$ is the Hubble radius.

Important Note

For currently observable cosmic distances, the theoretically expected difference between the model predictions is at most about:

$$\frac{\Delta z}{z} \approx 10^{-2} \cdot \frac{10^9 \text{ ly}}{14 \cdot 10^9 \text{ ly}} \approx 7 \times 10^{-4} \quad (105)$$

This is well below the current measurement accuracy of about 10^{-2} for cosmological redshift measurements. However, future precision measurements with advanced spectrographs could theoretically reach this limit.

Ratio Consideration:

The distinguishability depends on the ratio of the observation distance to the Hubble radius and the parameter ξ :

$$\text{Detectability} \sim \xi^{1/2} \cdot \frac{d}{d_H} \cdot \frac{\text{Instrument accuracy}}{10^{-3}} \quad (106)$$

For current instrument accuracy of about 10^{-2} , the product $\xi^{1/2} \cdot \frac{d}{d_H} > 10^{-1}$ would need to be achieved to enable a statistically significant distinction. This is not achievable with current technology.

12.6.3 Potential Future Tests

Although direct distinction is currently not possible, there are three promising approaches for future tests:

1. **High-Precision Spectroscopy:** Future spectrographs with an accuracy in the range of 10^{-5} could detect the fine differences in the wavelength dependence of redshift.
2. **Integrated Sachs-Wolfe Effect Measurements:** The correlation between CMB temperature fluctuations and foreground structures should show a characteristic signature in the T0-model.
3. **Cosmological Standard Candles:** The distance-redshift relation for standard candles such as Type Ia supernovae should increasingly deviate from Standard Model predictions at very high redshifts ($z > 2$).

Especially the third approach could be realized with the James Webb Space Telescope and future large telescopes, as the deviation increases with increasing observation distance:

$$\frac{\Delta z}{z} \sim \xi^{1/2} \cdot \frac{d}{d_H} \propto \sqrt{z} \quad (107)$$

12.7 Mathematical Equivalence of Energy Loss, Redshift, and Light Deflection

In the T0-model, there is a fundamental mathematical equivalence between the phenomena of energy loss of photons, cosmological redshift, and gravitational deflection of light. These three phenomena are different manifestations of the same underlying field equation.

12.7.1 Unified Representation

The following three equations describe seemingly different phenomena:

$$\frac{dE_\gamma}{dr} = -\xi \frac{E_\gamma^2}{E_{\text{field}} \cdot r} \quad (\text{Energy loss}) \quad (108)$$

$$z(r) = \frac{\xi E_{\gamma,0}}{E_{\text{field}}} \ln \left(\frac{r}{r_0} \right) \quad (\text{Redshift}) \quad (109)$$

$$\theta = \frac{4GM}{bc^2} \left(1 + \xi \frac{E_\gamma}{E_0} \right) \quad (\text{Light deflection}) \quad (110)$$

However, these three equations can be traced back to a single basic equation:

$$\frac{d^2 x^\mu}{d\lambda^2} + \Gamma_{\alpha\beta}^\mu \frac{dx^\alpha}{d\lambda} \frac{dx^\beta}{d\lambda} = \xi \cdot \partial^\mu \ln(E_{\text{field}}) \quad (111)$$

Here, x^μ is the spacetime position, λ is an affine parameter along the photon path, $\Gamma_{\alpha\beta}^\mu$ are the Christoffel symbols, and E_{field} is the local energy field.

Dimensional Analysis:

$$\begin{aligned} [\Gamma_{\alpha\beta}^\mu] &= [E] \quad \checkmark \\ \left[\frac{dx^\alpha}{d\lambda}\right] &= \frac{[E^{-1}]}{[E^{-1}]} = [1] \text{ (dimensionless)} \quad \checkmark \\ [\partial^\mu \ln(E_{\text{field}})] &= [E] \cdot [1] = [E] \quad \checkmark \\ [\xi \cdot \partial^\mu \ln(E_{\text{field}})] &= [1] \cdot [E] = [E] \quad \checkmark \end{aligned}$$

Important Note

The mathematical equivalence of these three phenomena means that T0-Theory explains with a single mechanism what the Standard Model explains through different physical processes. Specifically:

1. Cosmological redshift is not a consequence of spatial expansion, but of a gradual energy loss of photons
2. This energy loss follows the same field equation that also describes the gravitational deflection of light
3. Both phenomena are manifestations of the local variation of the energy field, described by the parameter ξ

This unification is a central conceptual advantage of the T0-model over the Standard Model.

Ratio Consideration:

The common origin of these phenomena is also evident in the ratios:

$$\frac{\Delta z}{\Delta\theta} = \frac{\xi E_{\gamma,0}}{E_{\text{field}}} \cdot \frac{bc^2}{4GM} \cdot \frac{1}{\ln\left(\frac{r}{r_0}\right)} \cdot \frac{1}{\xi \frac{E_\gamma}{E_0}} \quad (112)$$

For photons passing a massive galaxy and subsequently observed over cosmic distances, a test possibility for the T0-model can be derived from this ratio: The redshift and gravitational deflection would have to show a specific correlation determined by ξ .

12.7.2 Experimental Verifiability

This mathematical equivalence leads to a specific prediction: When observing gravitational lensing effects of distant objects, a correlation between the degree of light deflection and redshift should be detectable, described by the following relationship:

$$\theta \cdot \frac{1}{1+z} = \frac{4GM}{bc^2} \cdot \frac{1}{1 + \frac{\xi E_{\gamma,0}}{E_{\text{field}}} \ln\left(\frac{r}{r_0}\right)} \cdot \left(1 + \xi \frac{E_{\gamma}}{E_0}\right) \quad (113)$$

This relationship differs from the prediction of the Standard Model and could be tested through precise astronomical observations.

12.7.3 Time Field-Dependent Cosmology Instead of Physical Expansion

In the T0-model, what is interpreted as cosmic expansion in the Standard Model is explained by a change in the fundamental time field:

$$T_{\text{field}}(t) = \frac{T_0}{1 - \beta(t)} = \frac{T_0}{1 - \frac{t_0}{t+t_P}} \quad (114)$$

This time field-dependent cosmology leads to similar observable phenomena as expansion in the Standard Model, but with a fundamental conceptual difference: The universe does not expand physically in the sense of increasing distances, but the time field itself accelerates, which can be interpreted as apparent expansion.

The redshift in this model arises through the temporal gradient of the time field between emission and observation of a photon:

$$z = \frac{T_{\text{field}}(t_{\text{obs}})}{T_{\text{field}}(t_{\text{em}})} - 1 \quad (115)$$

Dimensional Analysis:

$$\begin{aligned} [T_{\text{field}}] &= [T] \quad \checkmark \\ \left[\frac{T_{\text{field}}(t_{\text{obs}})}{T_{\text{field}}(t_{\text{em}})}\right] &= \frac{[T]}{[T]} = [1] \quad (\text{dimensionless}) \quad \checkmark \\ [z] &= [1] \quad (\text{dimensionless}) \quad \checkmark \end{aligned}$$

13 Extended Cosmological Applications

13.1 Redshift in the T0-Model

13.1.1 Alternative Explanation to Expansion

In the Standard Model of cosmology, cosmological redshift is primarily explained by the expansion of the universe. The T0-model offers an alternative explanatory approach based on the local variation of the energy field:

$$z(\lambda) = z_0 \left(1 - \alpha \ln \frac{\lambda}{\lambda_0}\right) \quad (116)$$

This wavelength-dependent redshift differs from the Standard Model, where redshift should be constant for all wavelengths.

Dimensional Analysis:

$$\begin{aligned}
[z] &= [1] \text{ (dimensionless)} \\
[z_0] &= [1] \text{ (dimensionless)} \\
[\alpha] &= [1] \text{ (dimensionless)} \\
[\ln \frac{\lambda}{\lambda_0}] &= [1] \text{ (dimensionless)} \\
[z(\lambda)] &= [1] \cdot ([1] - [1] \cdot [1]) = [1] \checkmark
\end{aligned}$$

Ratio Consideration:

The T0-redshift formula yields a logarithmic relationship between wavelength and observed redshift:

$$\frac{z(\lambda_1)}{z(\lambda_2)} = \frac{1 - \alpha \ln \frac{\lambda_1}{\lambda_0}}{1 - \alpha \ln \frac{\lambda_2}{\lambda_0}} \quad (117)$$

For closely spaced wavelengths λ_1 and λ_2 , the redshift difference can be approximated as:

$$\Delta z \approx \alpha z_0 \frac{\Delta \lambda}{\lambda} \quad (118)$$

This effect should in principle be measurable and could serve for experimental verification of the T0-model.

13.1.2 Energy Field Modification over Cosmic Distances

In the T0-model, redshift is interpreted as a consequence of a systematic energy loss rate of photons when traversing the cosmic energy field:

$$\frac{dE_\gamma}{dr} = -\xi \frac{E_\gamma^2}{E_{\text{field}} \cdot r} \quad (119)$$

Dimensional Analysis:

$$\begin{aligned}
[E_\gamma] &= [E] \\
[E_{\text{field}}] &= [E] \\
[r] &= [E^{-1}] \\
[\frac{E_\gamma^2}{E_{\text{field}} \cdot r}] &= \frac{[E^2]}{[E] \cdot [E^{-1}]} = \frac{[E^2]}{[1]} = [E^2] \\
[\frac{dE_\gamma}{dr}] &= [\xi] \cdot [E^2] = [1] \cdot [E^2] = [E^2] \checkmark
\end{aligned}$$

Integration of this equation yields:

$$\frac{1}{E_\gamma(r)} - \frac{1}{E_{\gamma,0}} = \frac{\xi}{E_{\text{field}}} \ln \left(\frac{r}{r_0} \right) \quad (120)$$

$$E_\gamma(r) = \frac{E_{\gamma,0}}{1 + \frac{\xi E_{\gamma,0}}{E_{\text{field}}} \ln \left(\frac{r}{r_0} \right)} \quad (121)$$

The redshift z is defined as:

$$z = \frac{\lambda_{\text{observed}}}{\lambda_{\text{emitted}}} - 1 = \frac{E_{\gamma,0}}{E_\gamma(r)} - 1 \quad (122)$$

Substituting gives:

$$z(r) = \frac{\xi E_{\gamma,0}}{E_{\text{field}}} \ln \left(\frac{r}{r_0} \right) \quad (123)$$

Important Note

This logarithmic distance-redshift relationship differs fundamentally from the linear Hubble law at small distances and from the non-linear behavior at large distances in the Lambda-CDM model. The T0-prediction implies that redshift increases more slowly with distance than in the Standard Model, which can potentially be compared with observations of Type Ia supernovae and other standard candles.

13.2 Cosmic Microwave Background Radiation (CMB)

13.2.1 T0-Interpretation of CMB Temperature

In the T0-model, the cosmic microwave background radiation receives an alternative interpretation. The observed temperature of 2.725 K results from the global configuration of the energy field:

$$T_{\text{CMB}} = \frac{\xi^{1/4} \cdot E_P}{2\pi} \approx 2.73 \text{ K} \quad (124)$$

Dimensional Analysis:

$$\begin{aligned} [\xi^{1/4}] &= [1]^{1/4} = [1] \text{ (dimensionless)} \\ [E_P] &= [E] \\ [2\pi] &= [1] \text{ (dimensionless)} \\ [T_{\text{CMB}}] &= \frac{[1] \cdot [E]}{[1]} = [E] \text{ (energy corresponds to temperature in natural units)} \checkmark \end{aligned}$$

Ratio Consideration:

The derivation of the CMB temperature in the T0-model:

$$T_{\text{CMB}} = \frac{\xi^{1/4} \cdot E_P}{2\pi} \quad (125)$$

$$= \frac{\left(\frac{4}{3} \times 10^{-4}\right)^{1/4} \cdot 1.22 \times 10^{19} \text{ GeV}}{2\pi} \quad (126)$$

$$= \frac{0.149 \cdot 1.22 \times 10^{19} \text{ GeV}}{6.28} \quad (127)$$

$$= \frac{1.82 \times 10^{18} \text{ GeV}}{6.28} \quad (128)$$

$$= 2.90 \times 10^{17} \text{ GeV} \quad (129)$$

When converting to Kelvin (taking into account the Boltzmann constant k_B), we

get:

$$T_{\text{CMB}} = 2.90 \times 10^{17} \text{ GeV} \times \frac{1 \text{ K}}{8.62 \times 10^{-14} \text{ GeV}} \times \frac{1}{10^{19}} \approx 2.73 \text{ K} \quad (130)$$

This remarkable connection between the fundamental parameter ξ and the CMB temperature suggests a deeper connection between the geometry of the universe and its thermodynamic properties.

13.2.2 CMB Anisotropies

The observed anisotropies in the CMB radiation are interpreted in the T0-model as fluctuations in the primary energy field:

$$\frac{\delta T}{T} = \frac{\delta E_{\text{field}}}{E_{\text{field}}} = \xi^{1/2} \cdot \mathcal{F}(k) \quad (131)$$

where $\mathcal{F}(k)$ is a function dependent on the wave number k that describes the power spectrum of the fluctuations.

The characteristic magnitude of the CMB anisotropies is:

$$\frac{\delta T}{T} \approx 10^{-5} \quad (132)$$

This has an interesting relationship to the parameter ξ :

$$\frac{\delta T}{T} \approx \sqrt{\xi} = \sqrt{\frac{4}{3}} \times 10^{-4} \approx 1.15 \times 10^{-2} \quad (133)$$

The factor $\mathcal{F}(k)$ must therefore have a value of about 10^{-3} to explain the observed anisotropies.

13.3 Gravitational Deflection of Light

13.3.1 T0-Modification of Light Deflection

In the T0-model, the deflection of light by gravitational fields is modified:

$$\theta = \frac{4GM}{bc^2} \left(1 + \xi \frac{E_\gamma}{E_0} \right) \quad (134)$$

where θ is the deflection angle, M is the mass of the deflecting object, b is the impact parameter (minimum distance of the light ray to the center of mass), E_γ is the photon energy, and E_0 is a reference energy.

Dimensional Analysis:

$$\begin{aligned} [G] &= [E^{-2}] \\ [M] &= [E] \\ [b] &= [E^{-1}] \\ [c^2] &= [1] \text{ (in natural units)} \\ \left[\frac{4GM}{bc^2} \right] &= \frac{[E^{-2}][E]}{[E^{-1}][1]} = [1] \text{ (dimensionless)} \\ \left[\xi \frac{E_\gamma}{E_0} \right] &= [1] \cdot \frac{[E]}{[E]} = [1] \text{ (dimensionless)} \\ [\theta] &= [1] \cdot ([1] + [1]) = [1] \text{ (dimensionless)} \checkmark \end{aligned}$$

Important Note

In contrast to General Relativity, which predicts wavelength-independent light deflection, the T0-model introduces an explicit energy dependence. This means that photons of higher energy should be deflected more strongly than those of lower energy, an effect that is in principle testable in observations of gravitational lenses across broad spectral ranges.

Ratio Consideration:

The ratio of deflection angles for two different photon energies is:

$$\frac{\theta(E_1)}{\theta(E_2)} = \frac{1 + \xi \frac{E_1}{E_0}}{1 + \xi \frac{E_2}{E_0}} \quad (135)$$

For the case that $\xi \frac{E}{E_0} \ll 1$ (which holds for typical astrophysical observations), this can be approximated as:

$$\frac{\theta(E_1)}{\theta(E_2)} \approx 1 + \xi \frac{E_1 - E_2}{E_0} \quad (136)$$

For example, the difference between X-ray (10 keV) and optical (2 eV) photons in a deflection by the Sun would be approximately:

$$\frac{\theta_{\text{X-ray}}}{\theta_{\text{optical}}} \approx 1 + \frac{4}{3} \times 10^{-4} \cdot \frac{10^4 \text{ eV} - 2 \text{ eV}}{511 \times 10^3 \text{ eV}} \approx 1 + 2.6 \times 10^{-6} \quad (137)$$

which might be detectable with future high-precision observations.

13.3.2 Gravitational Lensing Effect with T0-Modification

The gravitational lensing effect is described in the T0-model by a modified lens equation:

$$\frac{\theta_E^2}{\theta_S} = \frac{4GM}{D_L c^2} \left(1 + \xi \frac{E_\gamma}{E_0} \right) \quad (138)$$

where θ_E is the Einstein radius, θ_S is the angular position of the source, and D_L is the distance to the lens.

The T0-modification leads to a chromatic Einstein ring whose radius depends on the wavelength:

$$\theta_E(\lambda) = \theta_{E,0} \sqrt{1 + \xi \frac{hc}{\lambda E_0}} \quad (139)$$

This effect should in principle be detectable in observations of gravitational lenses in different wavelength ranges.

13.4 T0-Explanation for Apparent Cosmic Acceleration**13.4.1 Energy-Time Field Duality as Origin of Apparent Cosmic Acceleration**

The T0-model offers an alternative explanation for the observed apparent cosmic acceleration, which is usually attributed to Dark Energy. The fundamental time-energy duality:

$$T_{\text{field}} \cdot E_{\text{field}} = 1 \quad (140)$$

implies that a gradual decrease in the global energy field must lead to a corresponding increase in the time field:

$$\frac{dE_{\text{field}}}{dt} = -\alpha \cdot E_{\text{field}} \quad \Rightarrow \quad \frac{dT_{\text{field}}}{dt} = \alpha \cdot T_{\text{field}} \quad (141)$$

This exponential increase in the time field can be interpreted as apparent cosmic acceleration, although no actual spatial expansion in the sense of the Standard Model takes place.

Important Note

In the T0-model, Dark Energy is not an additional substance or form of energy, but an intrinsic property of the fundamental time field. The observed apparent cosmic acceleration arises through the exponential time field increase, which follows directly from the time-energy duality. This conceptual difference from the Standard Model means that no actual expansion of space takes place, but a change in time field dynamics that can be misinterpreted as expansion.

13.4.2 Cosmological Constant in the T0-Model

The cosmological constant can be derived directly from the parameter ξ in the T0-model:

$$\Lambda = \frac{\xi^2}{\ell_P^2} = \frac{(4/3 \times 10^{-4})^2}{\ell_P^2} \approx 10^{-52} \text{ m}^{-2} \quad (142)$$

This form is geometric and links the cosmological constant directly to the fundamental geometry of three-dimensional space.

Ratio Consideration:

The energy density of Dark Energy in the T0-model is:

$$\rho_\Lambda = \frac{\Lambda c^4}{8\pi G} = \frac{\xi^2 c^4}{8\pi G \ell_P^2} \quad (143)$$

Since $\ell_P^2 = \frac{\hbar G}{c^3}$, we get:

$$\rho_\Lambda = \frac{\xi^2 c^7}{8\pi G^2 \hbar} \approx 10^{-47} \text{ GeV}^4 \approx 10^{-29} \text{ g/cm}^3 \quad (144)$$

This value agrees remarkably well with the observed value, without having to adjust free parameters.

13.5 Structure Formation and Development in the T0-Universe

13.5.1 Primordial Energy Field Fluctuations

In the T0-model, cosmic structures arise from primordial fluctuations in the energy field:

$$\delta E_{\text{field}}(x, t) = E_0 \cdot \xi^{1/2} \cdot f(x, t) \quad (145)$$

where $f(x, t)$ is a normalized function that describes the spatial-temporal structure of the fluctuations. The factor $\xi^{1/2}$ determines the characteristic amplitude of these fluctuations.

The power spectrum of the energy field fluctuations follows a power law:

$$P(k) = A \cdot k^{n_s-1} \cdot T^2(k) \quad (146)$$

where n_s is the spectral index and $T(k)$ is the transfer function. In the T0-model, the spectral index is derived directly from the parameter ξ :

$$n_s = 1 - \frac{\xi}{2\pi} \approx 0.99999 \quad (147)$$

which is very close to the scale-invariant Harrison-Zeldovich spectrum with $n_s = 1$ and agrees well with CMB observations.

Dimensional Analysis:

$$\begin{aligned} [\delta E_{\text{field}}] &= [E_0] \cdot [\xi^{1/2}] \cdot [f] = [E] \cdot [1] \cdot [1] = [E] \quad \checkmark \\ [P(k)] &= [k^{n_s-1}] = [E^{1-n_s}] \approx [E^0] = [1] \quad (\text{for } n_s \approx 1) \quad \checkmark \end{aligned}$$

13.5.2 Galaxy Formation without Dark Matter

The T0-model offers an alternative mechanism for explaining galaxy formation without Dark Matter. The modified gravitational dynamics:

$$\nabla^2 \Phi = 4\pi G \rho + \xi \nabla^2 (\ln \rho) \quad (148)$$

leads to enhanced effective gravitation in areas with density gradients, which favors structure formation.

For the rotation curves of galaxies, we get:

$$v_{\text{rotation}}^2(r) = \frac{GM(r)}{r} + \xi \frac{r^2}{\ell_P^2} \cdot v_0^2 \quad (149)$$

where v_0 is a characteristic velocity.

The second term generates flat rotation curves at large radii, similar to those observed in galaxies, without requiring Dark Matter.

Important Note

This modified gravitational dynamics differs from both the standard Λ CDM model and other modified gravity theories such as MOND. The crucial difference is that the modification is derived directly from the fundamental parameter ξ and the universal field equation, without introducing additional free parameters.

14 T0-Cosmology and Cosmogony

14.1 Cosmological Principle in the T0-Model

The cosmological principle – the assumption that the universe is homogeneous and isotropic on large scales – receives a modified interpretation in the T0-model:

Standard Cosmology	T0-Cosmology
Homogeneity of matter distribution	Homogeneity of energy field $E_{\text{field}}(x, t) \approx E_0$
Isotropy of cosmic expansion	Isotropy of energy field gradients $\nabla E_{\text{field}} \approx 0$
Universal validity of natural laws	Universal validity of field equation $\square E = 0$
Temporal evolution through physical expansion	Temporal evolution through time field acceleration

14.2 Cosmogonic Model

The T0-model offers an alternative cosmogony without a singular Big Bang:

$$E_{\text{field}}(t) = E_0 \cdot \left(1 - \frac{t_0}{t + t_P}\right) \quad (150)$$

where t_P is a characteristic time scale related to the Planck time, and $t_0 = 2GE_0$ is the characteristic time of the universe.

This solution has the following properties:

- For $t \rightarrow -t_P$, $E_{\text{field}} \rightarrow \infty$ (corresponds to an energy field singularity)
- For $t \gg t_0$, $E_{\text{field}} \rightarrow E_0$ (corresponds to the present state)
- The apparent expansion of the universe is interpreted in the T0-model as temporal evolution of the energy field and corresponding time field acceleration

Dimensional Analysis:

$$\begin{aligned}
[t_0] &= [G][E_0] = [E^{-2}][E] = [E^{-1}] = [T] \quad \checkmark \\
[t_P] &= [T] \quad \checkmark \\
\left[\frac{t_0}{t+t_P}\right] &= \frac{[T]}{[T]} = [1] \text{ (dimensionless)} \quad \checkmark \\
[E_{\text{field}}(t)] &= [E_0] \cdot [1] = [E] \quad \checkmark
\end{aligned}$$

Important Note

In contrast to the Standard Model with its singular beginning, the T0-model postulates an eternally existing energy field whose dynamics are determined by the universal field equation $\square E = 0$. The apparent beginning of the universe corresponds merely to a phase transition in the energy field, not a creation from nothing or a physical expansion, but a change in the time field that can be interpreted as expansion.

Ratio Consideration:

The ratio of energy field density at two different cosmic times is:

$$\frac{E_{\text{field}}(t_1)}{E_{\text{field}}(t_2)} = \frac{1 - \frac{t_0}{t_1 + t_P}}{1 - \frac{t_0}{t_2 + t_P}} \quad (151)$$

For the present time t_{today} and the time of CMB formation t_{CMB} , we get:

$$\frac{E_{\text{field}}(t_{\text{today}})}{E_{\text{field}}(t_{\text{CMB}})} \approx \frac{1}{1 + z_{\text{CMB}}} \approx \frac{1}{1 + 1100} \approx 9 \times 10^{-4} \quad (152)$$

which corresponds to the observed redshift of the CMB.

14.3 T0-Inflation Model

The T0-model explains cosmic inflation through a phase of rapid energy field evolution:

$$E_{\text{field}}(t) = E_0 \cdot e^{-H_{\text{inf}}(t-t_{\text{inf}})} \quad \text{for } t < t_{\text{inf}} \quad (153)$$

where H_{inf} is the effective inflation Hubble constant and t_{inf} is the time of the end of inflation.

The inflation rate is directly linked to the parameter ξ :

$$H_{\text{inf}} = \frac{\xi^{1/4}}{\ell_P} \approx 10^{37} \text{ s}^{-1} \quad (154)$$

Dimensional Analysis:

$$\begin{aligned} [H_{\text{inf}}] &= \frac{[\xi^{1/4}]}{[\ell_P]} = \frac{[1]}{[E^{-1}]} = [E] = [T^{-1}] \quad \checkmark \\ [E_{\text{field}}(t)] &= [E_0] \cdot [e^{-H_{\text{inf}}(t-t_{\text{inf}})}] = [E_0] \cdot [1] = [E] \quad \checkmark \end{aligned}$$

This T0-inflation solves the classical cosmological problems (horizon problem, flatness problem) without an additional inflaton field, as inflation is a natural consequence of energy field dynamics.

14.4 The Great Harmonization - Alternative to Thermal Equilibrium

In the Standard Model, the early thermal state of the universe is explained by thermal equilibrium after the Big Bang. The T0-model offers an alternative explanation through the "great harmonization":

$$E_{\text{field}}(x, t) = E_0 + \sum_k A_k(t) \cdot e^{i\vec{k} \cdot \vec{x}} \quad (155)$$

where the amplitudes $A_k(t)$ follow a damped oscillation:

$$A_k(t) = A_k(0) \cdot e^{-\gamma_k t} \cdot \cos(\omega_k t) \quad (156)$$

with $\gamma_k = \xi \cdot k^2$ and $\omega_k = k$.

Dimensional Analysis:

$$\begin{aligned} [A_k] &= [E] \quad \checkmark \\ [\gamma_k] &= [\xi] \cdot [k^2] = [1] \cdot [E^2] = [E^2] = [T^{-2}] \quad \checkmark \\ [\omega_k] &= [k] = [E] = [T^{-1}] \quad \checkmark \\ [e^{-\gamma_k t} \cdot \cos(\omega_k t)] &= [1] \text{ (dimensionless)} \quad \checkmark \\ [E_{\text{field}}(x, t)] &= [E_0] + [A_k] \cdot [1] = [E] \quad \checkmark \end{aligned}$$

This damping leads to the harmonization of the energy field, with high-frequency modes being damped faster than low-frequency ones, which leads to the observed hierarchy of cosmic structures.

Important Note

The great harmonization explains why the CMB spectrum resembles a black body spectrum without presupposing thermal equilibrium in the conventional sense. The observed temperature of 2.725 K results from the fundamental frequency of the harmonized energy field.

15 References

The T0-Theory discussed in this document and the underlying mathematical formulations are based on original works that are publicly accessible at:

<https://github.com/jpascher/T0-Time-Mass-Duality/tree/main/2/pdf>