

T0 Model: Granulation, Limits and Fundamental Asymmetry

Abstract

The T0 model describes a fundamental granulation of spacetime at the sub-Planck scale $\ell_0 = \xi \times \ell_P$ with $\xi \approx 1.333 \times 10^{-4}$. This work examines the consequences for scale hierarchies, time continuity, and the mathematical completeness of various gravitational theories. The time-mass duality $T(x, t) \cdot m(x, t) = 1$ requires both fields to be coupled and variable, while the fundamental ξ -asymmetry enables all developmental processes.

Contents

1 Granulation as Fundamental Principle of Reality

Minimum Length Scale ℓ_0

The T0 model introduces a fundamental length scale deeper than the Planck length:

$$\ell_0 = \xi \times \ell_P \approx \frac{4}{3} \times 10^{-4} \times 1.616 \times 10^{-35} \text{ m} \approx 2.155 \times 10^{-39} \text{ m} \quad (1)$$

Significance of ℓ_0 :

- Absolute physical lower limit for spatial structures
- Granulated spacetime structure - not continuous
- Sub-Planck physics with new fundamental laws
- Universal scale for all physical phenomena

The Extreme Scale Hierarchy

From ℓ_0 to cosmological scales extends a hierarchy of over 60 orders of magnitude:

$$\ell_0 \approx 10^{-39} \text{ m} \quad (\text{Sub-Planck minimum}) \quad (2)$$

$$\ell_P \approx 10^{-35} \text{ m} \quad (\text{Planck length}) \quad (3)$$

$$L_{\text{Casimir}} \approx 100 \text{ micrometers} \quad (\text{Casimir scale}) \quad (4)$$

$$L_{\text{Atom}} \approx 10^{-10} \text{ m} \quad (\text{Atomic scale}) \quad (5)$$

$$L_{\text{Macro}} \approx 1 \text{ m} \quad (\text{Human scale}) \quad (6)$$

$$L_{\text{Cosmo}} \approx 10^{26} \text{ m} \quad (\text{Cosmological scale}) \quad (7)$$

Casimir Scale as Evidence of Granulation

At the Casimir characteristic scale, first measurable effects appear:

$$L_\xi \approx \frac{1}{\sqrt{\xi \times \ell_P}} \approx 100 \text{ micrometers} \quad (8)$$

Experimental evidence:

- Deviations from $1/d^4$ law at distances $\approx 10 \text{ nm}$
- ξ -corrections in Casimir force measurements
- Limits of continuum physics become visible

2 Limit Systems and Scale Hierarchies

Three-Scale Hierarchy

The T0 model organizes all physical scales into three fundamental domains:

1. **ℓ_0 -domain:** Granulated physics, universal laws
2. **Planck domain:** Quantum gravity, transition dynamics
3. **Macro domain:** Classical physics with ξ -corrections

Relational Number System

Prime number ratios organize particles into natural generations:

- **3-limit:** u-, d-quarks (1st generation)
- **5-limit:** c-, s-quarks (2nd generation)
- **7-limit:** t-, b-quarks (3rd generation)

The next prime number (11) leads to ξ^{11} -corrections $\approx 10^{-44}$, which lie below the Planck scale.

CP Violation from Universal Asymmetry

The ξ -asymmetry explains:

- CP violation in weak interactions
- Matter-antimatter asymmetry in the universe
- Chiral symmetry breaking in nature

3 Fundamental Asymmetry as Motion Principle

The Universal ξ -Constant

$$\xi = \frac{4}{3} \times 10^{-4} \approx 1.333 \times 10^{-4} \quad (9)$$

Origin: Geometric 4/3-constant from optimal 3D space packing

Effect: Universal asymmetry enabling all development

Eternal Universe Without Big Bang

The T0 model describes an eternal, infinite, non-expanding universe:

- No beginning, no end - timeless existence
- Heisenberg's uncertainty principle forbids a classical Big Bang singularity with infinite density: $\Delta E \times \Delta t \geq \hbar/2$; instead, a tiny but finite core with minimal length scale L_0 (from ξ) remains.
- Structured development instead of chaotic explosion
- Continuous ξ -field dynamics instead of Big Bang

Time Exists Only After Field-Asymmetry Excitation

Hierarchy of time emergence:

1. **Timeless universe:** Perfect symmetry, no time
2. **ξ -asymmetry arises:** Symmetry breaking activates time field
3. **Time-energy duality:** $T(x, t) \cdot E(x, t) = 1$ becomes active
4. **Manifested time:** Local time emerges through field dynamics
5. **Directed time:** Thermodynamic arrow of time stabilizes
Time is not fundamental but emergent from field asymmetry.

4 Hierarchical Structure: Universe > Field > Space

The Fundamental Order Hierarchy

Universe (highest order level):

- Superordinate structure with eternal, infinite properties
- Global organizational principles determine everything below
- ξ -asymmetry as universal guiding structure

- Thermodynamic overall balance of all processes
Field (middle organizational level):
- Universal ξ -field as mediator between universe and space
- Local dynamics within global constraints
- Time-energy duality as field principle
- Structure-forming processes through asymmetry
Space (manifestation level):
- 3D geometry as stage for field manifestations
- Granulation at ℓ_0 -scale
- Local interactions between field excitations

Causal Downward Coupling

$$\text{UNIVERSE} \rightarrow \text{FIELD} \rightarrow \text{SPACE} \rightarrow \text{PARTICLES} \quad (10)$$

The universe is not just the sum of its spatial parts. Superordinate properties emerge only at the highest level. The ξ -constant is universal, not a space property.

5 Continuous Time Beyond Certain Scales

The Crucial Scale Hierarchy of Time

In the T0 model, different time domains exist with fundamentally different properties. The further we move from ℓ_0 , the more continuous and constant time becomes.

Granulated Zone (below ℓ_0)

$$\ell_0 = \xi \times \ell_P \approx 2.155 \times 10^{-39} \text{ m} \quad (11)$$

- Time is discretely granulated, not continuous
- Chaotic quantum fluctuations dominate
- Physics loses classical meaning
- All fundamental forces equally strong

Transition Zone (around ℓ_0)

- Time-mass duality $T \cdot m = 1$ becomes fully active

- Intensive interaction of all fields
- Transition from granulated to continuous

Continuous Zone (above ℓ_0)

Central Insight

$$\text{Distance to } \ell_0 \uparrow \Rightarrow \text{Time continuity} \uparrow \Rightarrow \text{Constant direction} \uparrow \quad (12)$$

- Beyond a certain point, time becomes continuous
- Constant directed flow direction emerges
- The greater the distance to ℓ_0 , the more stable the time direction
- Emergent classical physics with ξ -corrections

Quantitative Scaling of Time Continuity

Time continuity as function of distance to ℓ_0 :

$$\text{Time continuity} \propto \log\left(\frac{L}{\ell_0}\right) \quad \text{for } L \gg \ell_0 \quad (13)$$

Practical scales:

$$L = 10^{-35} \text{ m (Planck)} : \text{ Still granulated} \quad (14)$$

$$L = 10^{-15} \text{ m (Nuclear)} : \text{ Transition to continuity} \quad (15)$$

$$L = 10^{-10} \text{ m (Atomic)} : \text{ Practically continuous} \quad (16)$$

$$L = 10^{-3} \text{ m (mm)} : \text{ Completely continuous, constant direction} \quad (17)$$

$$L = 1 \text{ m (Meter)} : \text{ Perfectly linear, directed time} \quad (18)$$

Thermodynamic Arrow of Time

Scale-dependent entropy:

- **Granulated level (ℓ_0)**: Maximum entropy, perfect symmetry
- **Transition level**: Entropy gradients emerge
- **Continuous level**: Second law becomes active
- **Macroscopic level**: Irreversible time direction

6 Practical vs. Fundamental Physics

Time is Practically Experienced as Constant

De facto for us: Time flows constantly in our experience domain

- **Local scales (m to km):** Time is practically perfectly linear and constant
- **Measurable variations:** Only under extreme conditions (GPS satellites, particle accelerators)
- **Everyday physics:** Time constancy is a good approximation

Speed of Light as Clear Upper Limit

Observed reality:

- $c = 299,792,458 \text{ m/s}$ is measurable upper limit for information transfer
- **Causality:** No signals faster than c observed
- **Relativistic effects:** Clearly measurable at $v \rightarrow c$
- **Particle accelerators:** Confirm c -limit daily

Resolution of the Apparent Contradiction

Macroscopic level (our world):

$$L = 1 \text{ m to } 10^6 \text{ m (km range)} \quad (19)$$

- Time flows constantly: $dt/dt_0 \approx 1 + 10^{-16}$ (immeasurable)
- c is practically constant: $\Delta c/c \approx 10^{-16}$ (immeasurable)
- Einstein physics works perfectly

Fundamental level (T0 model):

$$\ell_0 = 10^{-39} \text{ m to } \ell_P = 10^{-35} \text{ m} \quad (20)$$

- Time-mass duality: $T \cdot m = 1$ is fundamental
- c is ratio: $c = L/T$ (must be variable)
- Mathematical consistency requires coupled variation

These variations are 10^6 times smaller than our best measurement precision!

7 Gravitation: Mass Variation vs. Space Curvature

Two Equivalent Interpretations

Einstein interpretation:

- $m = \text{constant}$ (fixed mass)
- $g_{\mu\nu} = \text{variable}$ (curved spacetime)
- Mass causes space curvature

TO interpretation:

- $m(x, t) = \text{variable}$ (dynamic mass)
- $g_{\mu\nu} = \text{fixed}$ (flat Euclidean space)
- Mass varies locally through ξ -field

Important Insight: We Don't Know!

Attention - Fundamental Point

We DO NOT KNOW whether mass causes space curvature or whether mass itself varies!

This is an assumption, not a proven fact!

Both interpretations are equally valid:

Einstein assumption:

$$\text{Mass/energy} \rightarrow \text{Space curvature} \rightarrow \text{Gravitation} \quad (21)$$

$$G_{\mu\nu} = 8\pi T_{\mu\nu} \quad (22)$$

TO alternative:

$$\xi\text{-field} \rightarrow \text{Mass variation} \rightarrow \text{Gravitational effects} \quad (23)$$

$$m(x, t) = m_0 \cdot (1 + \xi \cdot \Phi(x, t)) \quad (24)$$

Experimental Indistinguishability

All measurements are frequency-based:

- **Clocks:** Hyperfine transition frequencies
- **Scales:** Spring oscillations/resonance frequencies
- **Spectrometers:** Light frequencies and transitions
- **Interferometers:** Phases = frequency integrals

Identical frequency shifts:

$$\text{Einstein : } \nu' = \nu_0 \sqrt{1 + 2\Phi/c^2} \approx \nu_0(1 + \Phi/c^2) \quad (25)$$

$$\text{TO : } \nu' = \nu_0 \cdot \frac{m(x, t)}{T(x, t)} \approx \nu_0(1 + \Phi/c^2) \quad (26)$$

Only frequency ratios are measurable - absolute frequencies are fundamentally inaccessible!

8 Mathematical Completeness: Both Fields Coupled Variable

The Correct Mathematical Formulation

Mathematically correct in TO model:

$$T(x, t) = \text{variable} \quad (\text{Time as dynamic field}) \quad (27)$$

$$m(x, t) = \text{variable} \quad (\text{Mass as dynamic field}) \quad (28)$$

Coupled through fundamental duality:

$$T(x, t) \cdot m(x, t) = 1 \quad (29)$$

Both fields vary TOGETHER:

$$T(x, t) = T_0 \cdot (1 + \xi \cdot \Phi(x, t)) \quad (30)$$

$$m(x, t) = m_0 \cdot (1 - \xi \cdot \Phi(x, t)) \quad (31)$$

Verification of Mathematical Consistency

Duality check:

$$T(x, t) \cdot m(x, t) = T_0 m_0 \cdot (1 + \xi \Phi)(1 - \xi \Phi) \quad (32)$$

$$= T_0 m_0 \cdot (1 - \xi^2 \Phi^2) \quad (33)$$

$$\approx T_0 m_0 = 1 \quad (\text{for } \xi \Phi \ll 1) \quad (34)$$

Mathematical consistency confirmed!

Why Both Fields Must Be Variable

Lagrange formalism requires:

$$\delta S = \int \delta \mathcal{L} d^4x = 0 \quad (35)$$

Complete variation:

$$\delta \mathcal{L} = \frac{\partial \mathcal{L}}{\partial T} \delta T + \frac{\partial \mathcal{L}}{\partial m} \delta m + \frac{\partial \mathcal{L}}{\partial \partial_\mu T} \delta \partial_\mu T + \frac{\partial \mathcal{L}}{\partial \partial_\mu m} \delta \partial_\mu m \quad (36)$$

For mathematical completeness:

- $\delta T \neq 0$ (Time must be variable)
- $\delta m \neq 0$ (Mass must be variable)
- Both coupled through $T \cdot m = 1$

Einstein's Arbitrary Constant Setting

Einstein arbitrarily sets:

$$m_0 = \text{constant} \Rightarrow \delta m = 0 \quad (37)$$

Mathematical problem:

- Incomplete variation of the Lagrangian
- Violates variation principle of field theory
- Arbitrary symmetry breaking without justification

Parameter Elegance

$$\text{Einstein : } m_0, c, G, \hbar, \Lambda, \alpha_{\text{EM}}, \dots \quad (\gg 10 \text{ free parameters}) \quad (38)$$

$$\text{T0 : } \xi \quad (1 \text{ universal parameter}) \quad (39)$$

9 Pragmatic Preference: Variable Mass with Constant Time

The Pragmatic Alternative for Our Experience Space

As pragmatists, one can certainly prefer:

$$\text{Time : } t = \text{constant} \quad (\text{practical experience}) \quad (40)$$

$$\text{Mass : } m(x, t) = \text{variable} \quad (\text{dynamic adjustment}) \quad (41)$$

Why this is pragmatically sensible:

- Time constancy corresponds to our direct experience
- Mass variation is conceptually easier to imagine
- Practical calculations often become simpler
- Intuitive understandability for applications

Practical Advantages of Constant Time

In our experienceable space (m to km):

- Time flows linearly and constantly - our direct experience
- Clocks tick uniformly - practical time measurement
- Causal sequences are clearly defined
- Technical applications (GPS, navigation) function

Language convention:

- Time passes constantly
- Mass adapts to the fields
- Matter becomes heavier/lighter depending on location

Variable Mass as Intuitive Concept

Pragmatic interpretation:

$$m(x) = m_0 \cdot (1 + \xi \cdot \text{Gravitational field}(x)) \quad (42)$$

Intuitive conception:

- Mass increases in strong gravitational fields
- Mass decreases in weaker fields
- Matter feels the local ξ -field
- Dynamic adaptation to environment

Scientific Legitimacy of Preference

Important Insight

Pragmatic preferences are scientifically justified when both approaches are experimentally equivalent!

Justification:

- Scientifically equivalent to Einstein approach
- Often practically advantageous for applications
- Didactically easier to teach
- Technically more efficient to implement

The choice between constant time + variable mass vs. Einstein is a matter of taste - both are scientifically equally justified!

10 The Eternal Philosophical Boundary

What the T0 Model Explains

- HOW the ξ -asymmetry works
- WHAT the consequences are
- WHICH laws follow from it
- WHEN time and development emerge

What the T0 Model CANNOT Explain

The fundamental questions remain:

- WHY does the ξ -asymmetry exist?
- WHERE does the original energy come from?
- WHO/WHAT gave the first impulse?
- WHY does anything exist at all instead of nothing?

Scientific Humility

The eternal boundary: Every explanation needs unexplained axioms. The ultimate reason always remains mysterious. The that of existence is given, the why remains open.

The elegant shift: The T0 model shifts the mystery to a deeper, more elegant level - but it cannot resolve the fundamental riddle of existence.

And that is good. Because a universe without mystery would be a boring universe.

11 Experimental Predictions and Tests

Casimir Effect Modifications

- Deviations from $1/d^4$ law at $d \approx 10 \text{ nm}$
- ξ -corrections in precision measurements
- Frequency-dependent Casimir forces

Atom Interferometry

- ξ -resonances in quantum interferometers
- Mass variations in gravitational fields
- Time-mass duality in precision experiments

Gravitational Wave Detection

- ξ -corrections in LIGO/Virgo data
- Modifications of wave dispersion
- Sub-Planck structures in gravitational waves

12 Mathematical Proof: The Formula $T \cdot m = 1$ Excludes Singularities

Important Clarification: T as Oscillation Period

ATTENTION: In this analysis, T does not mean the experienced, continuously flowing time, but the **oscillation period** or **characteristic time constant** of a system. This is a fundamental difference:

- T = oscillation period (discrete, characteristic time unit)
- Not: T = continuous time coordinate (our everyday experience)

The Fundamental Exclusion Property

The equation $T \cdot m = 1$ is not just a mathematical relationship – it is an **exclusion theorem**. Through its algebraic structure, it makes certain states mathematically impossible.

Proof 1: Exclusion of Infinite Mass

Assumption: There exists an infinite mass $m = \infty$

Mathematical consequence:

$$T \cdot m = 1 \quad (43)$$

$$T \cdot \infty = 1 \quad (44)$$

$$T = \frac{1}{\infty} = 0 \quad (45)$$

Contradiction: $T = 0$ is not in the domain of the equation $T \cdot m = 1$, since:

- The product $0 \cdot \infty$ is mathematically undefined
- The original equation $T \cdot m = 1$ would be violated ($0 \cdot \infty \neq 1$)

Conclusion: $m = \infty$ is excluded by the formula.

Proof 2: Exclusion of Infinite Time

Assumption: There exists an infinite time $T = \infty$

Mathematical consequence:

$$T \cdot m = 1 \quad (46)$$

$$\infty \cdot m = 1 \quad (47)$$

$$m = \frac{1}{\infty} = 0 \quad (48)$$

Contradiction: $m = 0$ is not in the domain, since:

- The product $\infty \cdot 0$ is mathematically undefined
- The equation $T \cdot m = 1$ would be violated ($\infty \cdot 0 \neq 1$)

Conclusion: $T = \infty$ is excluded by the formula.

Proof 3: Exclusion of Zero Values

Assumption: There exists $T = 0$ or $m = 0$

Case 1: $T = 0$

$$T \cdot m = 1 \Rightarrow 0 \cdot m = 1 \quad (49)$$

This is impossible for any finite value of m , since $0 \cdot m = 0 \neq 1$.

Case 2: $m = 0$

$$T \cdot m = 1 \Rightarrow T \cdot 0 = 1 \quad (50)$$

This is impossible for any finite value of T , since $T \cdot 0 = 0 \neq 1$.

Conclusion: Both $T = 0$ and $m = 0$ are excluded by the formula.

Proof 4: Exclusion of Mathematical Singularities

Definition of a singularity: A point where a function becomes undefined or infinite.

Analysis of the function $T = \frac{1}{m}$:

Potential singularities could occur at:

- $m = 0$ (division by zero)
- $T \rightarrow \infty$ (infinite function values)

Exclusion by the constraint $T \cdot m = 1$:

1. **At** $m = 0$: The equation $T \cdot m = 1$ cannot be satisfied
2. **At** $T \rightarrow \infty$: Would require $m \rightarrow 0$, which is already excluded

Mathematical proof of singularity freedom:

For every point (T, m) with $T \cdot m = 1$:

$$T = \frac{1}{m} \text{ with } m \in (0, +\infty) \quad (51)$$

$$m = \frac{1}{T} \text{ with } T \in (0, +\infty) \quad (52)$$

Both functions are on their entire domain:

- **Continuous**
- **Differentiable**
- **Finite Well-defined**

The Algebraic Protection Function

The equation $T \cdot m = 1$ acts like an **algebraic protection** against singularities:

Automatic Correction

If m becomes very small $\Rightarrow T$ automatically becomes very large (53)

If T becomes very small $\Rightarrow m$ automatically becomes very large (54)

But: $T \cdot m$ always remains exactly 1 (55)

Mathematical Stability

$\lim_{m \rightarrow 0^+} T = +\infty$, but $T \cdot m = 1$ remains satisfied (56)

$\lim_{T \rightarrow 0^+} m = +\infty$, but $T \cdot m = 1$ remains satisfied (57)

The constraint **forces** the variables into a finite, well-defined region.

Proof 5: Positive Definiteness

Theorem: All solutions of $T \cdot m = 1$ are positive.

Proof:

$$T \cdot m = 1 > 0 \quad (58)$$

Since the product is positive, both factors must have the same sign.

Exclusion of negative values:

- If $T < 0$ and $m < 0$, then $T \cdot m > 0$, but physically meaningless
- If $T > 0$ and $m < 0$, then $T \cdot m < 0 \neq 1$
- If $T < 0$ and $m > 0$, then $T \cdot m < 0 \neq 1$

Conclusion: Only $T > 0$ and $m > 0$ satisfy the equation.

The Fundamental Insight About Time and Continuity

Important physical clarification:

The formula $T \cdot m = 1$ describes **discrete, characteristic properties** of systems, not the continuous time flow of our experience. This means:

What $T \cdot m = 1$ does NOT state:

- „Time stands still“ ($T = 0$)
- „Processes take infinitely long“ ($T = \infty$)
- „The time flow is interrupted“
- „Our experienced time disappears“

What $T \cdot m = 1$ actually describes:

- **Oscillation periods** have mathematical limits
- **Characteristic time constants** cannot become arbitrary
- **Discrete time units** stand in fixed relation to mass
- **Periodic processes** follow the constraint $T \cdot m = 1$

The continuous time flow remains unaffected

The continuous time coordinate t (our „arrow time“) is **not affected** by this relationship. $T \cdot m = 1$ regulates only the **intrinsic time scales** of physical systems, not the superordinate time flow in which these systems exist.

Important insight about our time perception:

Our continuous time perception could practically be only a **tiny excerpt** of a much larger period – an oscillation period so immense that it far exceeds anything humans could ever experience or conceive.

Conceivable orders of magnitude:

- **Human life:** $\sim 10^2$ years
- **Human history:** $\sim 10^4$ years
- **Earth age:** $\sim 10^9$ years
- **Universe age:** $\sim 10^{10}$ years **Possible cosmic period:** 10^{50} , 10^{100} or even larger time scales

In such a scenario, our entire observable universe would experience only an **infinitesimal small fraction** of a fundamental oscillation period. For us, time appears linear and continuous because we perceive only a vanishingly small section of a huge cosmic „oscillation“.

Analogy: Just as a bacterium on a clock hand would perceive the movement as „straight ahead“, although it moves on a circular path, we might experience „linear time“, although we are in a gigantic periodic structure.

This perspective shows that $T \cdot m = 1$ and our time perception can operate on completely different scales without contradicting each other.

Cosmological Implications

This viewpoint opens new possibilities:

What we observe as cosmic development and change could be only a **small section** in a much larger cyclic pattern that follows the fundamental relationship $T \cdot m = 1$.

Possible cosmic structure:

- **Local time perception:** Linear, continuous (our experience domain)
- **Middle time scales:** Observable cosmic developments
- **Fundamental time scale:** Gigantic period according to $T \cdot m = 1$

Implications:

- Nature could be organized in **layered-periodic** fashion
- Different time scales follow different regularities
- $T \cdot m = 1$ could be the **master constraint** for the largest scale
- Our observable cosmic development would be a fragment of a cyclic system

This interpretation shows how mathematical constraints ($T \cdot m = 1$) and physical observations (linear time perception) can coexist in a **hierarchical time model**.