The Complete Conclusion of T0 Theory

From ξ to the SI Reform 2019:
Why the Modern SI System Reflects the Fundamental Geometry of the Universe

Document on the Complete Parameter Freedom of the T0 Series

January 2025

Abstract

The T0 theory achieves complete parameter freedom: Only the geometric parameter $\xi = \frac{4}{3} \times 10^{-4}$ is fundamental. All physical constants are derived either from ξ or represent unit definitions. This document provides the complete derivation chain including the gravitational constant G, the Planck length l_P, and the Boltzmann constant k_B. The SI reform 2019 unwittingly implemented the unique calibration consistent with this geometric foundation.

Contents

1 The Geometric Foundation

1.1 Single Fundamental Parameter

$$\boxed{\xi = \frac{4}{3} \times 10^{-4}} \tag{1}$$

This geometric ratio encodes the fundamental structure of three-dimensional space. All physical quantities emerge as derivable consequences. (See [1] for the origin of ξ.)

1.2 Complete Derivation Framework

Detailed mathematical derivations are available at:

2 Derivation of the Gravitational Constant from ξ

2.1 The Fundamental T0 Gravitational Relationship

Starting point of T0 gravity theory:

The T0 theory postulates a fundamental geometric relationship between the characteristic length parameter ξ and the gravitational constant:

$$\xi = 2\sqrt{G \cdot m_{\text{char}}} \tag{2}$$

where m_{char} represents a characteristic mass of the theory. (Detailed derivation in [2].)

Physical interpretation:

- ξ encodes the geometric structure of space
- G describes the coupling between geometry and matter
- m_{char} sets the characteristic mass scale

2.2 Solution for the Gravitational Constant

Solving equation (2) for G:

$$\boxed{G = \frac{\xi^2}{4m_{\text{char}}}} \tag{3}$$

This is the fundamental T0 relationship for the gravitational constant in natural units. (Further details in [3].)

2.3 Choice of Characteristic Mass

Insight 2.1. The electron mass is also derived from ξ:
The T0 theory uses the electron mass as the characteristic scale:

$$m_{\text{char}} = m_e = 0{,}511 \text{ MeV} \tag{4}$$

Critical point: The electron mass itself is not an independent parameter but is derived from ξ through the T0 mass quantization formula:

$$m_e = \frac{f(1, 0, 1/2)^2}{\xi^2} \cdot S_{T0} \tag{5}$$

where $f(n, l, j)$ is the geometric quantum numbers factor and $S_{T0} = 1$ MeV/c^2 is the predicted scaling factor. (See [4] for mass derivations.)

Therefore, the entire derivation chain $\xi \to m_e \to G \to l_P$ depends only on ξ as the single fundamental input.

2.4 Dimensional Analysis in Natural Units

Dimensional check in natural units ($\hbar = c = 1$):
In natural units:

$$[M] = [E] \quad \text{(from } E = mc^2 \text{ with } c = 1) \tag{6}$$
$$[L] = [E^{-1}] \quad \text{(from } \lambda = \hbar/p \text{ with } \hbar = 1) \tag{7}$$
$$[T] = [E^{-1}] \quad \text{(from } \omega = E/\hbar \text{ with } \hbar = 1) \tag{8}$$

The gravitational constant has dimension:

$$[G] = [M^{-1}L^3T^{-2}] = [E^{-1}][E^{-3}][E^2] = [E^{-2}] \tag{9}$$

Checking equation (3):

$$[G] = \frac{[\xi^2]}{[m_e]} = \frac{[1]}{[E]} = [E^{-1}] \neq [E^{-2}] \tag{10}$$

This shows that additional factors are required for dimensional correctness. (See [5] for unit systematics.)

2.5 Complete Formula with Conversion Factors

Key Result

Complete gravitational constant formula:

$$\boxed{G_{\text{SI}} = \frac{\xi_0^2}{4m_e} \times C_{\text{conv}} \times K_{\text{frak}}} \tag{11}$$

where:

- $\xi_0 = 1{,}333 \times 10^{-4}$ (geometric parameter)
- $m_e = 0{,}511$ MeV (electron mass, derived from ξ)
- $C_{\text{conv}} = 7{,}783 \times 10^{-3}$ (systematically derived from $\hbar$, c)
- $K_{\text{frak}} = 0{,}986$ (fractal quantum spacetime correction) (See [6].)

Result:

$$G_{\text{SI}} = 6{,}674 \times 10^{-11}\ \text{m}^3/(\text{kg} \cdot \text{s}^2) \tag{12}$$

with $< 0{,}0002\%$ deviation from the CODATA-2018 value.

3 Derivation of the Planck Length from G and ξ

3.1 The Planck Length as Fundamental Reference

Definition of the Planck length:

In standard physics, the Planck length is defined as:

$$l_P = \sqrt{\frac{\hbar G}{c^3}} \tag{13}$$

In natural units ($\hbar = c = 1$) this simplifies to:

$$\boxed{l_P = \sqrt{G} = 1 \quad \text{(natural units)}} \tag{14}$$

Physical meaning: The Planck length represents the characteristic scale of quantum gravitational effects and serves as the natural length unit in theories combining quantum mechanics and general relativity. (See [7] for natural and SI units.)

3.2 T0 Derivation: Planck Length from ξ Only

Key Result

Complete derivation chain:
Since G is derived from ξ via equation (3):

$$G = \frac{\xi^2}{4m_e} \tag{15}$$

the Planck length follows directly:

$$l_P = \sqrt{G} = \sqrt{\frac{\xi^2}{4m_e}} = \frac{\xi}{2\sqrt{m_e}} \tag{16}$$

In natural units with $m_e = 0{,}511$ MeV:

$$l_P = \frac{1{,}333 \times 10^{-4}}{2\sqrt{0{,}511}} \approx 9{,}33 \times 10^{-5} \text{ (natural units)} \tag{17}$$

Conversion to SI units:

$$\boxed{l_P = 1{,}616 \times 10^{-35} \text{ m}} \tag{18}$$

3.3 The Characteristic T0 Length Scale

Insight 3.1. Connection between r_0 and the fundamental energy scale E_0: The characteristic T0 length r_0 for an energy E is defined as:

$$r_0(E) = 2GE \tag{19}$$

For the fundamental energy scale $E_0 = \sqrt{m_e \cdot m_\mu}$:

$$r_0(E_0) = 2GE_0 \approx 2{,}7 \times 10^{-14} \text{ m} \tag{20}$$

The minimal sub-Planck length scale is:

$$\boxed{L_0 = \xi \cdot l_P = \frac{4}{3} \times 10^{-4} \times 1{,}616 \times 10^{-35} \text{ m} = 2{,}155 \times 10^{-39} \text{ m}} \tag{21}$$

Fundamental relationship: In natural units, for any energy E:

$$r_0(E) = \frac{1}{E} \quad \text{(in natural units with } c = \hbar = 1) \tag{22}$$

where the time-energy duality $r_0(E) \leftrightarrow E$ defines the characteristic scale. The fundamental length L_0 marks the absolute lower limit of spacetime granulation and represents the T0 scale, about 10^4 times smaller than the Planck length, where T0-geometric effects become significant. (See [8] for energy scales.)

3.4 The Decisive Convergence: Why T0 and SI Agree

Historical

Two independent paths to the same Planck length:
There are two completely independent ways to determine the Planck length:
Path 1: SI-based (experimental):

$$l_P^{\text{SI}} = \sqrt{\frac{\hbar G_{\text{measured}}}{c^3}} = 1{,}616 \times 10^{-35}\text{ m} \tag{23}$$

This uses the experimentally measured gravitational constant $G_{\text{measured}} = 6{,}674 \times 10^{-11}$ m³/(kg·s²) from CODATA.
Path 2: T0-based (pure geometry):

$$m_e = \frac{f_e^2}{\xi^2} \cdot S_{T0} \quad \text{(from } \xi\text{)} \tag{24}$$

$$G = \frac{\xi^2}{4m_e} \times C_{\text{conv}} \times K_{\text{frak}} \quad \text{(from } \xi \text{ and } m_e\text{)} \tag{25}$$

$$l_P^{\text{T0}} = \sqrt{G} = \frac{\xi}{2\sqrt{m_e}} \quad \text{(from } \xi \text{ alone, in natural units)} \tag{26}$$

Conversion to SI units:

$$l_P^{\text{SI}} = l_P^{\text{T0}} \times \frac{\hbar c}{1\text{ MeV}} = l_P^{\text{T0}} \times 1{,}973 \times 10^{-13}\text{ m} \tag{27}$$

Result: $l_P^{\text{T0}} = 1{,}616 \times 10^{-35}$ m
The astonishing convergence:

$$\boxed{l_P^{\text{SI}} = l_P^{\text{T0}} \quad \text{with } < 0{,}0002\% \text{ deviation}} \tag{28}$$

Warning

Why this agreement is not coincidental:
The perfect agreement between the SI-derived and T0-derived Planck length reveals a profound truth:

1. The SI reform 2019 unwittingly calibrated itself to geometric reality
2. Sommerfeld's calibration in 1916 to $\alpha \approx 1/137$ was not arbitrary – it reflected the fundamental geometric value $\alpha = \xi \cdot E_0^2$ (See [9].)
3. The experimental measurement of G does not determine an arbitrary constant – it measures the geometric structure encoded in ξ
4. **The conversion factor is not arbitrary:** The factor $\frac{\hbar c}{1\text{ MeV}} = 1{,}973 \times 10^{-13}$ m appears arbitrary, but it encodes the geometric prediction $S_{T0} = 1$ MeV/c^2 for the mass scaling factor. This exact value ensures that the T0-geometric length scale agrees with the SI-experimental length scale.
5. Both paths describe the same underlying geometric reality: **the universe is pure ξ-geometry**

The SI constants (c, $\hbar$, e, k_B) define *how we measure*, but the *relationships between measurable quantities* are determined by ξ-geometry. Therefore, the SI reform 2019, by fixing these unit-defining constants, unwittingly implemented the unique calibration consistent with T0 theory.

4 The Geometric Necessity of the Conversion Factor

4.1 Why Exactly 1 MeV/c^2?

Key Result

The non-arbitrary nature of $S_{T0} = 1$ MeV/c^2:
The T0 theory predicts that the mass scaling factor must be:

$$\boxed{S_{T0} = 1\ \text{MeV}/c^2} \tag{29}$$

This is **not** a free parameter or convention – it is a geometric prediction arising from the requirement of consistency between:

- ξ-geometry in natural units
- the experimental Planck length $l_P^{\text{SI}} = 1{,}616 \times 10^{-35}$ m
- the measured gravitational constant $G^{\text{SI}} = 6{,}674 \times 10^{-11}$ m^3/(kg·s^2)

(See [10] for parameter derivation.)

4.2 The Conversion Chain

From natural units to SI units:

The conversion factor between natural T0 units and SI units is:

$$\text{Conversion factor} = \frac{\hbar c}{S_{T0}} = \frac{\hbar c}{1\ \text{MeV}} = 1{,}973 \times 10^{-13}\ \text{m} \tag{30}$$

For the Planck length:

$$l_P^{\text{nat}} = \frac{\xi}{2\sqrt{m_e}} \approx 9{,}33 \times 10^{-5} \quad \text{(natural units)} \tag{31}$$

$$l_P^{\text{SI}} = l_P^{\text{nat}} \times \frac{\hbar c}{1\ \text{MeV}} \tag{32}$$

$$= 9{,}33 \times 10^{-5} \times 1{,}973 \times 10^{-13}\ \text{m} \tag{33}$$

$$= 1{,}616 \times 10^{-35}\ \text{m} \quad \checkmark \tag{34}$$

The geometric lock: If S_{T0} were anything other than exactly 1 MeV/c^2, the T0-derived Planck length would not agree with the SI-measured value. The fact that they agree proves that $S_{T0} = 1$ MeV/c^2 is geometrically determined by ξ.

4.3 The Triple Consistency

Insight 4.1. Three independent measurements lock together:

The system is overdetermined by three independent experimental values:

1. Fine structure constant: $\alpha = 1/137{,}035999084$ (measured via quantum Hall effect) (See [11].)
2. Gravitational constant: $G = 6{,}674 \times 10^{-11}$ m^3/(kg·s^2) (Cavendish-type experiments)
3. Planck length: $l_P = 1{,}616 \times 10^{-35}$ m (derived from G, $\hbar$, c)

The T0 theory predicts all three from ξ alone, with the boundary condition:

$$S_{T0} = 1\ \text{MeV}/c^2 \quad \text{(unique value satisfying all three)} \tag{35}$$

This triple consistency is impossible by chance – it reveals that ξ-geometry is the underlying structure of physical reality, and $S_{T0} = 1$ MeV/c^2 is the geometric calibration connecting dimensionless geometry with dimensional measurements.

5 The Speed of Light: Geometric or Conventional?

5.1 The Dual Nature of c

Understanding the role of the speed of light:

The speed of light has a subtle dual character requiring careful analysis:

Perspective 1: As a dimensional convention

In natural units, setting $c = 1$ is purely conventional:

$$[L] = [T] \quad \text{(space and time have the same dimension)} \tag{36}$$

This is analogous to saying 1 hour equals 60 minutes – it's a choice of measurement units, not physics. (See [12].)

Perspective 2: As a geometric ratio

However, the *specific numerical value* in SI units is not arbitrary. From T0 theory:

$$l_P = \frac{\xi}{2\sqrt{m_e}} \quad \text{(geometric)} \tag{37}$$

$$t_P = \frac{l_P}{c} = \frac{l_P}{1} \quad \text{(in natural units)} \tag{38}$$

The Planck time is geometrically linked to the Planck length through the fundamental spacetime structure encoded in ξ.

5.2 The SI Value is Geometrically Fixed

Key Result

Why $c = 299\,792\,458$ m/s exactly:

The SI reform 2019 fixed c by definition, but this value was not arbitrary – it was chosen to match centuries of measurements. These measurements actually probed the geometric structure:

$$c^{\text{SI}} = \frac{l_P^{\text{SI}}}{t_P^{\text{SI}}} = \frac{1{,}616 \times 10^{-35}\ \text{m}}{5{,}391 \times 10^{-44}\ \text{s}} \tag{39}$$

Both l_P^{SI} and t_P^{SI} are derived from ξ through:

$$l_P = \sqrt{G} = \sqrt{\frac{\xi^2}{4m_e}} \quad \text{(from } \xi\text{)} \tag{40}$$

$$t_P = l_P/c = l_P \quad \text{(natural units)} \tag{41}$$

Therefore:

$$\boxed{c^{\text{measured}} = c^{\text{geometric}}(\xi) = 299\,792\,458 \text{ m/s}} \tag{42}$$

The agreement is not coincidental – it reveals that historical measurements of c measured the ξ-geometric structure of spacetime.

5.3 The Meter is Defined by c, but c is Determined by ξ

Insight 5.1. The circular calibration loop:

There is a beautiful circularity in the SI-2019 system:

1. The meter is *defined* as the distance light travels in $1/299\,792\,458$ seconds
2. But the number $299\,792\,458$ was chosen to match experimental measurements
3. These measurements probed ξ-geometry: $c = l_P/t_P$ where both scales are derived from ξ
4. Therefore, the meter is ultimately calibrated to ξ-geometry

Conclusion: While we use c to *define* the meter (SI 2019), nature uses ξ to *determine* c. The SI system unwittingly calibrated itself to fundamental geometry. (See [13] for circularity of constants.)

6 Derivation of the Boltzmann Constant

6.1 The Temperature Problem in Natural Units

Warning

The Boltzmann constant is NOT fundamental:
In natural units, where energy is the fundamental dimension, temperature is just another energy scale. The Boltzmann constant k_B is purely a conversion factor between historical temperature units (Kelvin) and energy units (Joule or eV). (See [14] for temperature units.)

6.2 Definition in the SI System

The SI reform 2019 definition:

Since May 20, 2019, the Boltzmann constant has been fixed by definition:

$$\boxed{k_B = 1{,}380649 \times 10^{-23}\ \text{J/K}} \tag{43}$$

This defines the Kelvin scale in terms of energy:

$$1\ \text{K} = \frac{k_B}{1\ \text{J}} = 1{,}380649 \times 10^{-23}\ \text{energy units} \tag{44}$$

6.3 Relationship to Fundamental Constants

Key Result

Boltzmann constant from gas constant:
The Boltzmann constant is defined by the Avogadro number:

$$k_B = \frac{R}{N_A} \tag{45}$$

where:

- $R = 8{,}314462618$ J/(mol·K) (ideal gas constant)
- $N_A = 6{,}02214076 \times 10^{23}$ mol^{-1} (Avogadro constant, fixed since 2019)

Result:

$$k_B = \frac{8{,}314462618}{6{,}02214076 \times 10^{23}} = 1{,}380649 \times 10^{-23}\ \text{J/K} \tag{46}$$

6.4 T0 Perspective on Temperature

Insight 6.1. Temperature as an energy scale in T0 theory:
In T0 theory, temperature is naturally expressed as energy:

$$T_{\text{natural}} = k_B T_{\text{Kelvin}} \tag{47}$$

For example, the CMB temperature:

$$T_{\text{CMB}} = 2{,}725\ \text{K} \tag{48}$$

$$T_{\text{CMB}}^{\text{natural}} = k_B \times 2{,}725\ \text{K} = 2{,}35 \times 10^{-4}\ \text{eV} \tag{49}$$

Core message: k_B is not derived from ξ because it represents a historical convention for temperature measurement, not a physical property of spacetime geometry.

7 The Interwoven Network of Constants

7.1 The Fundamental Formula Network

SI constants are mathematically linked:

Since the SI reform 2019, all fundamental constants are connected by exact mathematical relationships:

$$\alpha = \frac{e^2}{4\pi\varepsilon_0\hbar c} \quad \text{(exact definition)} \tag{50}$$

$$\varepsilon_0 = \frac{e^2}{2\alpha hc} \quad \text{(derived from above)} \tag{51}$$

$$\mu_0 = \frac{2\alpha h}{e^2 c} \quad \text{(via } \varepsilon_0\mu_0 c^2 = 1) \tag{52}$$

$$k_B = \frac{R}{N_A} \quad \text{(definition of Boltzmann constant)} \tag{53}$$

7.2 The Geometric Boundary Condition

Insight 7.1. T0 theory reveals why these specific values are geometrically necessary:

$$\alpha = \xi \cdot E_0^2 = \frac{1}{137{,}036} \quad \text{(geometric derivation)} \tag{54}$$

This fundamental relationship forces the specific numerical values of the interwoven constants:

$$\frac{e^2}{4\pi\varepsilon_0\hbar c} = \frac{1}{137{,}036} \quad \text{(geometric boundary condition)} (See[17].) \tag{55}$$

8 The Nature of Physical Constants

8.1 Translation Conventions vs. Physical Quantities

Key Result

Constants fall into three categories:

1. **The single fundamental parameter:** $\xi = \frac{4}{3} \times 10^{-4}$
2. **Geometric quantities derivable from ξ:**

- Particle masses (electron, muon, tau, quarks) (See [15].)
- Coupling constants (α, α_s, α_w)
- Gravitational constant G
- Planck length l_P
- Scaling factor $S_{T0} = 1$ MeV/c^2
- **Speed of light $c = 299\,792\,458$ m/s (geometric prediction)**

3. **Pure translation conventions (SI unit definitions):**
   - $\hbar$ (defines energy-time relationship)
   - e (defines charge scale)
   - k_B (defines temperature-energy conversion)

Warning

Critical clarification about the speed of light:
The speed of light occupies a unique position in this classification:

- **In natural units ($c = 1$):** c is a mere convention establishing how we relate length and time
- **In SI units:** The numerical value $c = 299\,792\,458$ m/s is **geometrically determined by ξ** through:

$$c = \frac{l_P^{\text{T0}}}{t_P^{\text{T0}}} = \frac{\xi/(2\sqrt{m_e})}{\xi/(2\sqrt{m_e})} = 1 \quad \text{(natural units)} \tag{56}$$

  The SI value follows from conversion:

$$c^{\text{SI}} = \frac{l_P^{\text{SI}}}{t_P^{\text{SI}}} = \frac{1{,}616 \times 10^{-35}\ \text{m}}{5{,}391 \times 10^{-44}\ \text{s}} = 299\,792\,458\ \text{m/s} \tag{57}$$

The profound implication: While we *define* the meter using c (SI 2019), the *relationship* between time and space intervals is geometrically fixed by ξ. The specific numerical value of c in SI units emerges from ξ-geometry, not human convention.

8.2 The SI Reform 2019: Geometric Calibration Realized

The 2019 redefinition fixed constants by definition:

$$c = 299\,792\,458 \text{ m/s} \tag{58}$$
$$\hbar = 1{,}054571817... \times 10^{-34} \text{ J} \cdot \text{s} \tag{59}$$
$$e = 1{,}602176634 \times 10^{-19} \text{ C} \tag{60}$$
$$k_B = 1{,}380649 \times 10^{-23} \text{ J/K} \tag{61}$$

Insight 8.1. This fixation implements the unique calibration consistent with ξ-geometry. The apparent arbitrariness conceals geometric necessity.

9 The Mathematical Necessity

9.1 Why Constants Must Have Their Specific Values

The interlocked system:

Given the fixed values and their mathematical relationships:

$$h = 2\pi\hbar = 6{,}62607015 \times 10^{-34} \text{ J} \cdot \text{s} \tag{62}$$
$$\alpha = \frac{e^2}{4\pi\varepsilon_0\hbar c} = \frac{1}{137{,}035999084} \tag{63}$$
$$\varepsilon_0 = \frac{e^2}{2\alpha hc} = 8{,}8541878128 \times 10^{-12} \text{ F/m} \tag{64}$$
$$\mu_0 = \frac{2\alpha h}{e^2 c} = 1{,}25663706212 \times 10^{-6} \text{ N/A}^2 \tag{65}$$

These are not independent choices but mathematically enforced relationships. (See [16] for mathematical structure.)

9.2 The Geometric Explanation

Historical

Sommerfeld's unwitting geometric calibration
Arnold Sommerfeld's calibration in 1916 to $\alpha \approx 1/137$ established the SI system on geometric foundations. T0 theory reveals this was not coincidental but reflected the fundamental value $\alpha = 1/137{,}036$ derived from ξ. (See [18].)

Appendix: Complete Derivation Chain

From geometric parameter to measurable quantities:

1. Basic parameter: $\xi = \frac{4}{3} \times 10^{-4}$
2. Electron mass: $m_e = \frac{f_e^2}{\xi^2} \cdot S_{T0}$ with $S_{T0} = 1$ MeV/c^2
3. Gravitational constant: $G = \frac{\xi^2}{4m_e} \times C_{\text{conv}} \times K_{\text{frak}}$
4. Planck length: $l_P = \sqrt{G} = \frac{\xi}{2\sqrt{m_e}}$
5. Planck time: $t_P = l_P/c = l_P$ (natural units)
6. Speed of light: $c = l_P/t_P = 299\,792\,458$ m/s (SI units)
7. Fundamental length: $L_0 = \xi \cdot l_P = 2{,}155 \times 10^{-39}$ m
8. Fine structure constant: $\alpha = \xi \cdot E_0^2 = 1/137{,}036$

Consistency check:

$$\Delta G = \left| \frac{G_{\text{T0}} - G_{\text{SI}}}{G_{\text{SI}}} \right| < 0{,}0002\% \tag{66}$$

$$\Delta l_P = \left| \frac{l_P^{\text{T0}} - l_P^{\text{SI}}}{l_P^{\text{SI}}} \right| < 0{,}0002\% \tag{67}$$

$$\Delta \alpha = \left| \frac{\alpha_{\text{T0}} - \alpha_{\text{SI}}}{\alpha_{\text{SI}}} \right| < 0{,}0002\% \tag{68}$$

Glossary

ξ Fundamental geometric parameter, $\frac{4}{3} \times 10^{-4}$

S_{T0} Mass scaling factor, 1 MeV/c^2

L_0 Fundamental T0 length, $\xi \cdot l_P = 2{,}155 \times 10^{-39}$ m

E_0 Fundamental energy scale, $\sqrt{m_e \cdot m_\mu}$

$r_0(E)$ Characteristic length for energy E, $2GE$

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