# The Complete Closure of T0-Theory

From $\xi$ 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

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**Résumé**

T0-Theory achieves complete parameter freedom : Only the geometric parameter $\xi = \frac{4}{3} \times 10^{-4}$ is fundamental. All physical constants are either derived from $\xi$ 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 unknowingly implemented the unique calibration that is consistent with this geometric foundation.

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# 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.

## 1.2 Complete Derivation Framework

Detailed mathematical derivations are available at :

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

# 2 Derivation of the Gravitational Constant from $\xi$

## 2.1 The Fundamental T0 Gravitational Relation

Derivation

**Starting point of T0 gravity theory :**
T0-Theory postulates a fundamental geometric relationship between the characteristic length parameter $\xi$ and the gravitational constant :

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

where $m_{\text{char}}$ represents a characteristic mass of the theory.
**Physical interpretation :**
— $\xi$ encodes the geometric structure of space
— $G$ describes the coupling between geometry and matter
— $m_{\text{char}}$ sets the characteristic mass scale

## 2.2 Resolution for the Gravitational Constant

Solving equation (**??**) 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.

## 2.3 Choice of Characteristic Mass

Fundamental Insight

**The electron mass is also derived from $\xi$ :**
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 $\xi$ 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 number factor and $S_{T0} = 1 \text{ MeV}/c^2$ is the predicted scaling factor.
Therefore, the entire derivation chain $\xi \to m_e \to G \to l_P$ depends only on $\xi$ as the single fundamental input.

## 2.4 Dimensional Analysis in Natural Units

Derivation

**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 the dimension :

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

Checking equation (**??**) :

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

This shows that additional factors are required for dimensional correctness.

### 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 $\xi$)
- $C_{\text{conv}} = 7.783 \times 10^{-3}$ (systematically derived from $\hbar$, $c$)
- $K_{\text{frak}} = 0.986$ (fractal quantum spacetime correction)

**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 CODATA-2018 value.

## 3 Derivation of the Planck Length from $G$ and $\xi$

### 3.1 The Planck Length as Fundamental Reference

Derivation

**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.

### 3.2 T0 Derivation : Planck Length from $\xi$ Only

Key Result

**Complete derivation chain :**
Since $G$ is derived from $\xi$ via equation (**??**) :

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

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

Fundamental Insight

**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.

### 3.4 The Crucial Convergence : Why T0 and SI Agree

Historical Context

**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 $G_{\text{measured}} = 6.674 \times 10^{-11} \text{ m}^3/(\text{kg}\cdot\text{s}^2)$ 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 :**

$$\boxed{l_P^{\text{SI}} = l_P^{\text{T0}} \quad \text{with } < 0.0002\% \text{ deviation}} \tag{28}$$

Important Note

**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 unknowingly calibrated itself to geometric reality
2. Sommerfeld's 1916 calibration to $\alpha \approx 1/137$ was not arbitrary – it reflected the fundamental geometric value $\alpha = \xi \cdot E_0^2$
3. The experimental measurement of $G$ does not determine an arbitrary constant – it measures the geometric structure encoded in $\xi$
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 $S_{T0} = 1\ \text{MeV}/c^2$ 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 $\xi$-geometry**

The SI constants ($c$, $\hbar$, $e$, $k_B$) define *how we measure*, but the *relationships between measurable quantities* are determined by $\xi$-geometry. Therefore, the SI reform 2019, by fixing these unit-defining constants, unknowingly implemented the unique calibration that is 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/$c^2$ :**
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 that follows from the requirement of consistency between :

- $\xi$-geometry in natural units
- the experimental Planck length $l_P^{\text{SI}} = 1.616 \times 10^{-35}$ m
- the measured gravitational constant $G^{\text{SI}} = 6.674 \times 10^{-11}\ \text{m}^3/(\text{kg}\cdot\text{s}^2)$

## 4.2 The Conversion Chain

Derivation

**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 $\xi$.

## 4.3 The Triple Consistency

Fundamental Insight

**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)
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 $G$, $\hbar$, $c$)

T0-Theory predicts all three from $\xi$ alone, with the boundary condition :

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

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

# 5 The Speed of Light : Geometric or Conventional ?

## 5.1 The Dual Nature of $c$

Derivation

**Understanding the role of the speed of light :**
The speed of light has a subtle dual character that requires careful analysis :
**Perspective 1 : As 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.
**Perspective 2 : As 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 $\xi$.

## 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 were actually probing 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 $l_P^{\text{SI}}$ and $t_P^{\text{SI}}$ are derived from $\xi$ 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 $c$ were measuring the $\xi$-geometric structure of spacetime.

### 5.3 The Meter is Defined by $c$, but $c$ is Determined by $\xi$

Fundamental Insight

**The beautiful 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 $\xi$-geometry : $c = l_P/t_P$ where both scales are derived from $\xi$
4. Therefore, the meter is ultimately calibrated to $\xi$-geometry

**Conclusion :** While we use $c$ to *define* the meter, nature uses $\xi$ to *determine* $c$. The SI system unknowingly calibrated itself to fundamental geometry.

## 6 Derivation of the Boltzmann Constant

### 6.1 The Temperature Problem in Natural Units

Important Note

**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).

### 6.2 Definition in the SI System

Derivation

**The SI-Reform-2019 definition :**
Since May 20, 2019, the Boltzmann constant is fixed by definition :

$$\boxed{k_B = 1.380649 \times 10^{-23}\ \mathrm{J/K}} \tag{43}$$

This defines the Kelvin scale in terms of energy :

$$1\ \mathrm{K} = \frac{k_B}{1\ \mathrm{J}} = 1.380649 \times 10^{-23}\ \text{energy units} \tag{44}$$

### 6.3 Relation to Fundamental Constants

Key Result

**Boltzmann constant from gas constant :**
The Boltzmann constant is defined through 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

Fundamental Insight

**Temperature as 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 statement :** $k_B$ is not derived from $\xi$ 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

Derivation

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

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

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

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

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

## 7.2 The Geometric Boundary Condition

Fundamental Insight

**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 :

$$\frac{e^2}{4\pi\varepsilon_0\hbar c} = \frac{1}{137.036} \quad \text{(geometric boundary condition)} \tag{55}$$

# 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** $\xi$ **:**
   - Particle masses (electron, muon, tau, quarks)
   - Coupling constants ($\alpha$, $\alpha_s$, $\alpha_w$)
   - 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 relationship)

Important Note

**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 merely a convention that specifies how we relate length and time
- **In SI units :** The numerical value $c = 299,792,458$ m/s is **geometrically determined by** $\xi$ 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 the 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 $\xi$. The specific numerical value of $c$ in SI units emerges from $\xi$-geometry, not human convention.

### 8.2 The SI Reform 2019 : Geometric Calibration Realized

The 2019 redefinition fixed constants by definition :

$$c = 299,792,458 \text{ m/s} \tag{58}$$
$$\hbar = 1.054571817... \times 10^{-34} \text{ J} \cdot \text{s} \tag{59}$$
$$e = 1.602176634 \times 10^{-19} \text{ C} \tag{60}$$
$$k_B = 1.380649 \times 10^{-23} \text{ J/K} \tag{61}$$

Fundamental Insight

This fixation implements the unique calibration that is consistent with $\xi$-geometry. The apparent arbitrariness conceals geometric necessity.

## 9 The Mathematical Necessity

### 9.1 Why Constants Must Have Their Specific Values

Derivation

**The interlocking 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.

### 9.2 The Geometric Explanation

Historical Context

**Sommerfeld's unknowing geometric calibration**
Arnold Sommerfeld's 1916 calibration to $\alpha \approx 1/137$ established the SI system on geometric foundations. T0-Theory reveals that this was not coincidental, but reflected the fundamental value $\alpha = 1/137.036$ derived from $\xi$.

## 10 Conclusion : Geometric Unity

**Key Result**

**Complete parameter freedom achieved :**

- **Single input :** $\xi = \frac{4}{3} \times 10^{-4}$
- **Everything derivable from $\xi$ alone :**
  - **First :** All particle masses including electron : $m_e = f_e^2/\xi^2 \cdot S_{T0}$
  - **Then :** Gravitational constant : $G = \xi^2/(4m_e)\times$ (conversion factors)
  - **Then :** Planck length : $l_P = \sqrt{G} = \xi/(2\sqrt{m_e})$
  - **Also :** Speed of light : $c = l_P/t_P$ (geometrically determined)
  - **Also :** Characteristic T0 length : $L_0 = \xi \cdot l_P$ (spacetime granulation)
  - Coupling constants : $\alpha$, $\alpha_s$, $\alpha_w$
  - Scaling factor : $S_{T0} = 1\ \text{MeV}/c^2$ (prediction, not convention)
- **Translation conventions (not derived, define units) :**
  - $\hbar$ defines energy-time relationship in SI units
  - $e$ defines charge scale in SI units
  - $k_B$ defines temperature-energy conversion (historical)
- **Mathematical necessity :** Constants interwoven by exact formulas
- **Geometric foundation :** SI 2019 unknowingly implements $\xi$-geometry

**Final insight :** The universe is pure geometry, encoded in $\xi$. The complete derivation chain is :
$\xi \to \{m_e, m_\mu, m_\tau, ...\} \to G \to l_P \to c$
with $L_0 = \xi \cdot l_P$ expressing the fundamental sub-Planck scale of spacetime granulation.
**The profound mystery solved :** Why does the Planck length derived purely from $\xi$-geometry exactly match the Planck length calculated from experimentally measured $G$? Because *both describe the same geometric reality.* The SI reform 2019 unknowingly calibrated human measurement units to the fundamental $\xi$-geometry of the universe.
This is not coincidence – it is geometric necessity. Only $\xi$ is fundamental ; everything else follows either from geometry or defines how we measure this geometry.