Relation between T0 Theory and the Approach of Matsas et al.

A Comparative Analysis of the Number of Fundamental Constants from Spacetime and Geometry Perspectives

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Abstract

This document directly relates T0 theory, which reduces all physical constants to a single geometric parameter $\xi = \frac{4}{3} \times 10^{-4}$, to the original paper by Matsas et al. (2024): "The number of fundamental constants from a spacetime-based perspective" (Scientific Reports, DOI: 10.1038/s41598-024-71907-0). The paper by Matsas et al. resolves the Duff-Okun-Veneziano controversy by showing that in relativistic spacetimes only one fundamental constant (connected to the time unit) is necessary. T0 theory complements and deepens this approach through a geometric reduction to a single parameter ξ. Many ideas – particularly the derivability of masses via Compton wavelength and the interpretation of constants like c, G, and k_B as conversion factors – overlap significantly.

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1 Introduction

Both works pursue the common goal of minimizing the number of "fundamental" physical constants. Matsas et al. start from spacetime structure and show operationally that in relativistic spacetimes a single unit (time, defined by real clocks) suffices to express all observables. T0 theory goes one step further and reduces everything to a single geometric parameter ξ, whereby even the speed of light c and gravitational constant G are considered derived.

2 Conceptual Overlaps

- **Reduction of the number of fundamental constants**: Matsas et al. arrive at exactly **one** constant (time unit) in relativistic spacetimes. T0 theory achieves **complete parameter-freedom** except for ξ, whereby units like time or length are secondary.
- **Derivability of G, c, $\hbar$, k_B**: Both do not see these constants as fundamental:
  - c is a conversion factor (Matsas: Eq. (20); T0: geometrically from l_P/t_P).
  - G is derivable (Matsas: indirectly via masses; T0: explicitly $G = \xi^2/(4m_e) \times$ factors).
  - k_B is purely conventional (both eliminate temperature as an independent dimension).
- **Spacetime as starting point**: Matsas et al. start with the construction of spacetime (clocks and rulers). T0 theory interprets spacetime as "pure ξ-geometry" with a sub-Planck scale $L_0 = \xi \cdot l_P$.
- **SI reform 2019**: Both reference the reform as confirmation of their reduction. T0 theory goes further and sees it as "unwitting calibration" to geometric reality.

3 Specific Supports from T0 Theory for Matsas et al.

Key Result

Compton wavelength as central concept

In the paper by Matsas et al. (section "Two units..." and "Time..."), the reduced Compton wavelength

$$\bar{\lambda} = \frac{\hbar}{mc}$$

is used to express mass in length or time units (e.g., $m_e^{\text{MS}} = \hbar^{\text{MS}}/(c\bar{\lambda}_e)$).

T0 theory adopts and deepens this: Electron mass m_e is not viewed as independent but directly derived from ξ:

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

This corresponds to Matsas's idea that mass is not a fundamental dimension once a base unit (e.g., time) is fixed.

Key Result

Reduction to MS or S system

Matsas et al. reduce stepwise SI → MKS → MS → S (only seconds). T0 theory complements this by deriving Planck length directly from ξ and m_e:

$$l_P = \sqrt{G} = \frac{\xi}{2\sqrt{m_e}}$$

with subsequent conversion to SI units – compatible with Matsas's reduction.

Key Result

Boltzmann constant as conversion

Both works eliminate k_B as fundamental: Matsas in the reduction to MKS, T0 explicitly as "historical convention" for temperature-energy conversion.

4 The Flexibility of the Base Unit

A particularly interesting common point is the recognition that – once the derivability of all observables is clarified – the choice of the "starting unit" becomes largely conventional:

- Matsas et al.: In relativistic spacetimes, **time** (real clocks) is the natural choice since space and mass are derivable from it (e.g., Unruh protocol, Eq. (18)).
- T0 theory: Since everything follows from ξ, one could in principle start from **length** (l_P), **time** (t_P), **energy** ($S_{T0} = 1\,\mathrm{MeV}/c^2$), or even directly from ξ.

This corresponds to an extension of Duff's flexible attitude (no fixed number of standards), but with a geometric anchor ξ.

5 Derivation of the Fine Structure Constant in Both Approaches

The fine structure constant α is a dimensionless quantity that plays a role in both works but is treated differently. Matsas et al. see α as a physically significant dimensionless parameter (in Duff's sense) that need not be reduced to a fundamental constant since it is comparable without additional standards. They do not directly derive α but use it in electrodynamics, e.g., for the reduction of the ampere unit (section "Recovering the MKS system"), where $\alpha = e^2 k_e/(\hbar c)$ helps convert electrical quantities into mechanical units.

T0 theory, on the other hand, explicitly derives α from the geometric parameter ξ:

$$\alpha = \xi \cdot E_0^2 = \frac{1}{137{,}036}$$

where $E_0 = \sqrt{m_e \cdot m_\mu}$ is a fundamental energy scale (section "The interwoven network of constants"). This makes α a geometric consequence, not an independent parameter. Thus T0 deepens Matsas's approach by also reducing dimensionless constants like α to ξ, underscoring the reduction to a single input.

6 Derivation of the Gravitational Constant in Both Approaches

The gravitational constant G is treated in Matsas et al. as a conversion factor that transforms masses into space and time units (section "Two units... in Galilean spacetime"). They do not directly derive G but show that in geometrized units (e.g., S-system) it can be set to 1 since observables are expressible in time units alone. Indirectly, G results from the derivability of masses via Compton wavelength and gravitational laws.

In T0 theory, G is explicitly derived from ξ (section "Derivation of gravitational constant from ξ"):

$$G = \frac{\xi^2}{4m_e} \times C_{\text{conv}} \times K_{\text{frak}}$$

with m_e also from ξ (via quantization formula). This complements Matsas by geometrically anchoring G and directly connecting Planck length $l_P = \sqrt{G}$ with ξ. Both approaches converge in that G is not fundamental but follows from the underlying structure (spacetime for Matsas, geometry for T0).

7 Alternative Formulations of T0 Theory: Closed Derivation Chain

Key Result

The crucial condition: A closed chain of formulas

One cannot arbitrarily switch in T0 theory between ξ, α, a mass scale, or a measured constant as the "fundamental" parameter *without* knowing a completely closed, consistent chain of derivation formulas. Only when this chain is mathematically exact and internally consistent does the physics remain identical, regardless of which point one starts from.

In current T0 theory, the chain is constructed as:

$$\xi \to m_e \quad (\text{via mass quantization formula } m_e = \frac{f_e^2}{\xi^2} \cdot S_{T0}) \tag{1}$$

$$m_e \to E_0 = \sqrt{m_e \cdot m_\mu} \quad (\text{geometric mean energy}) \tag{2}$$

$$\xi, E_0 \to \alpha = \xi \cdot E_0^2 \tag{3}$$

$$m_e, \xi \to G = \frac{\xi^2}{4m_e} \times \text{conversion factors} \tag{4}$$

$$G \to l_P = \sqrt{G} \tag{5}$$

This chain is closed and therefore allows multiple equivalent starting points:

- **Standard (as in original document):** Start with $\xi = \frac{4}{3} \times 10^{-4} \to$ everything else follows.
- **Alternative 1: α as fundamental** (very attractive since α is extremely precisely measured): Start with $\alpha \approx 1/137{,}036$. Then the chain must run backward:

$$\alpha \to \xi = \frac{\alpha}{E_0^2} \tag{6}$$

$$\alpha, \xi \to m_e \quad \text{(via inverse quantization formula)} \tag{7}$$

$$m_e, \xi \to G \to l_P \tag{8}$$

  This works only because E_0 and S_{T0} are fixed by the same geometric logic.
- **Alternative 2: A measured constant (e.g., G or m_e) as starting point** Theoretically possible but less elegant since G and m_e are less precisely known than α. The chain would again run backward and must converge on the same value of ξ (or α).

Insight 7.1. Conclusion on flexibility

T0 theory is so powerful precisely because it provides a *closed mathematical chain*. Once this chain is proven and consistent, the choice of "fundamental" parameter is indeed a matter of taste or pragmatism (e.g., which constant is most accurately measured). This fits perfectly with the spirit of Matsas et al.: Once shown that everything is derivable from a base unit (time), the choice of this unit becomes secondary – only the operational and mathematical closure of the derivation is decisive.

In this sense, one could even view T0 theory as a "dimensionless variant" of Matsas's approach: Instead of a dimensional unit (second), one takes a dimensionless geometric constant (α or ξ) as the starting point.

8 The Unification of Quantum Field Theory, Quantum Mechanics, and Relativity

Key Result

Not yet mentioned central point: The reduction to one starting variable unifies QFT, QM, and RT

A hitherto not explicitly highlighted but crucial aspect of both approaches is that the consistent reduction to *only one* fundamental input (time unit for Matsas or geometric parameter ξ/α for T0) necessarily enables a deep unification of the three great pillars of modern physics:

- **Quantum mechanics (QM)**: Integrated through the derivability of masses (via Compton wavelength or quantization formula) and $\hbar$ (as conversion).
- **Quantum field theory (QFT)**: The fine structure constant α (and other couplings) is geometrically fixed – thus eliminating the arbitrary choice of coupling constants that enter standard QFT as free parameters.

- **Relativity theory (RT)**: Spacetime structure itself (explicitly in Matsas, in T0 through $c = l_P/t_P$ and G from geometry) becomes the foundation from which all other scales follow.

In standard physics, QM, QFT, and RT appear as separate theories with different fundamental constants ($\hbar$, α, G, c). The reduction to a single starting variable (time or ξ) shows that this separation is artificial: All three areas are manifestations of the same underlying structure.

This is particularly clear in T0 theory:

- The sub-Planck scale $L_0 = \xi \cdot l_P$ marks the transition region where quantum effects modify spacetime geometry ("spacetime granulation").
- The geometric fixation of α unifies the electroweak and strong interactions with gravitation.
- The derivation of G from the same geometry that also determines quantum masses closes the gap between quantum and gravitational theory.

Matsas et al. lay the foundation with their operational reduction to one time unit: Once space, mass, and charge are derivable from time, the apparent differences between relativistic mechanics, quantum mechanics, and electrodynamics disappear.

T0 theory completes this thought by showing that even this one time unit (or its scale) follows from a purely geometric number (ξ or α). Thus the long-sought unification of quantum theory and gravitation is not achieved by adding new fields or dimensions but through radical *reduction* to a single fundamental input.

9 Conclusion

T0 theory complements the paper by Matsas et al. in an ideal way:

- It confirms and deepens the operational reduction to one unit (time) through a geometric reduction to ξ (or alternatively α).
- It adopts central concepts like Compton wavelength for deriving masses.
- It interprets the SI reform 2019 as calibration to a deeper geometric structure.
- It shows that the choice of fundamental parameter (ξ, α, time, energy) is secondary – only the existence of a closed, consistent derivation chain is decisive.
- It makes explicit what is already implicitly present in Matsas: The reduction to one starting variable unifies quantum mechanics, quantum field theory, and relativity in a single coherent structure.

Summary:
Matsas et al. show: One time unit suffices because everything else is derivable – thus laying the foundation for an operational unification of QM, QFT, and RT.
T0 theory completes this geometrically: One single number (ξ or α) suffices because a closed formula chain determines everything else and makes the three great theories of physics manifestations of the same geometry.
Together, both reveal the deeper truth: The universe is not composed of three separate theories but from a single fundamental input – spacetime, geometry, and quanta are one.

10 References

This bibliography includes the central source (Matsas et al., 2024) as well as related historical and theoretical references. Additional aspects from these documents – such as the connection to T0 theory (e.g., derivation of ξ from tetrahedral geometry) or philosophical implications – extend the discussion with geometric and experimental perspectives. Citations are manually formatted; for complete BibTeX integration see the provided documents.

- Matsas, G. E. A., Pleitez, V., Saa, A., & Vanzella, D. A. T. (2024). The number of fundamental constants from a spacetime-based perspective. *Scientific Reports*, 14, 22594. DOI: https://doi.org/10.1038/s41598-024-71907-0. (Primary source; corrected article number from current publication data. Additional aspect: Spacetime-based analysis, relevant for T0 unification of QM, QFT, and RT.)

- Planck, M. (1899). Über irreversible Strahlungsvorgänge. *Sitzungsberichte der Preußischen Akademie der Wissenschaften*, 440–480. (Historical reference from `102_Matsas_T0_Discussion_En.tex`; introduction of Planck constants and scales, derived in T0 from ξ.)

- Duff, M. J. (2004). Comment on time-variation of fundamental constants. *Physical Review D*, 70, 087505. DOI: https://doi.org/10.1103/PhysRevD.70.087505. (From `102_Matsas_T0_Discussion_En.tex`; Duff perspective on dimensionless constants, complements T0 by emphasizing α as alternative starting point.)

- Okun, L. B. (1991). The concept of mass. *Physics Today*, 44(6), 31–36. DOI: https://doi.org/10.1063/1.881293. (From `102_Matsas_T0_Discussion_En.tex`; discussion of mass as fundamental constant, contrasted with T0 derivation of masses from ξ.)

- Duff, M. J., Okun, L. B., & Veneziano, G. (2002). Trialogue on the number of fundamental constants. *Journal of High Energy Physics*, 2002(03), 023. DOI: https://doi.org/10.1088/1126-6708/2002/03/023. (Fundamental reference to DOV controversy, implicit in all three documents; T0 resolves it by reduction to ξ.)

- T0-internal documents
  - `008_T0_xi-und-e_En.tex`: Connection between ξ and elementary charge e, extends Matsas with geometric charge derivation.

- 009_T0_xi_origin_En.tex: Origin of ξ from tetrahedral packing, adds fractal dimension $D_f = 3 - \xi$.
- 042_xi_parameter_particles_En.tex: ξ-based particle masses, complements Matsas reduction with quantum field theory implications.