

# T0-Theory: The T0-Time-Mass Duality

Complete Theoretical Formulation and Experimental Predictions

Document of the T0-Series

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## Abstract

This paper presents the complete formulation of the T0-Theory based on the fundamental geometric parameter  $\xi = \frac{4}{3} \times 10^{-4}$ . The theory establishes a fundamental time-mass duality  $T(x, t) \cdot m(x, t) = 1$  and develops two complementary Lagrangian formulations. Through rigorous derivation from the extended Lagrangian, we obtain the fundamental T0 formula for anomalous magnetic moments:  $\Delta a_\ell^{\text{T0}} = \frac{5\xi^4}{96\pi^2\chi^2} \cdot m_\ell^2$ . This derivation requires no calibration and provides testable predictions for all leptons consistent with both historical and current experimental data.

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# 1 Introduction to the T0-Theory

## 1.1 The Fundamental Time-Mass Duality

The T0-Theory postulates a fundamental duality between time and mass:

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

where  $T(x, t)$  is a dynamic time field and  $m(x, t)$  is the particle mass. This duality leads to several revolutionary consequences:

- **Natural Mass Hierarchy:** Mass scales emerge directly from time scales
- **Dynamic Mass Generation:** Masses are modulated by the time field
- **Quadratic Scaling:** Anomalous magnetic moments scale as  $m_\ell^2$
- **Unification:** Gravity is intrinsically integrated into quantum field theory

## 1.2 The Fundamental Geometric Parameter

### Key Result

The entire T0-Theory is based on a single fundamental parameter:

$$\xi = \frac{4}{3} \times 10^{-4} = 1.333 \times 10^{-4} \quad (2)$$

This dimensionless parameter encodes the fundamental geometric structure of three-dimensional space. All physical quantities are derived as consequences of this geometric foundation.

# 2 Mathematical Foundations and Conventions

## 2.1 Units and Notation

We use natural units ( $\hbar = c = 1$ ) with metric signature  $(+, -, -, -)$  and the following notation:

- $T(x, t)$ : Dynamic time field with  $[T] = E^{-1}$
- $\delta E(x, t)$ : Fundamental energy field with  $[\delta E] = E$
- $\xi = 1.333 \times 10^{-4}$ : Fundamental geometric parameter
- $\lambda$ : Higgs-time field coupling parameter
- $m_\ell$ : Lepton masses ( $e, \mu, \tau$ )

## 2.2 Derived Parameters

$$\xi^2 = (1.333 \times 10^{-4})^2 = 1.777 \times 10^{-8} \quad (3)$$

$$\xi^4 = (1.333 \times 10^{-4})^4 = 3.160 \times 10^{-16} \quad (4)$$

### 3 Extended Lagrangian with Time Field

#### 3.1 Mass-Proportional Coupling

The coupling of lepton fields  $\psi_\ell$  to the time field occurs proportionally to lepton mass:

$$\mathcal{L}_{\text{Interaction}} = g_T^\ell \bar{\psi}_\ell \psi_\ell \Delta m \quad (5)$$

$$g_T^\ell = \xi m_\ell \quad (6)$$

#### 3.2 Complete Extended Lagrangian

##### Key Result

$$\mathcal{L}_{\text{extended}} = -\frac{1}{4}F_{\mu\nu}F^{\mu\nu} + \bar{\psi}(i\gamma^\mu D_\mu - m)\psi + \frac{1}{2}(\partial_\mu \Delta m)(\partial^\mu \Delta m) - \frac{1}{2}m_T^2 \Delta m^2 + \xi m_\ell \bar{\psi}_\ell \psi_\ell \Delta m \quad (7)$$

### 4 Fundamental Derivation of T0 Contributions

#### 4.1 One-Loop Contribution from Time Field

From the interaction term  $\mathcal{L}_{\text{int}} = \xi m_\ell \bar{\psi}_\ell \psi_\ell \Delta m$ , the vertex factor is  $-ig_T^\ell = -i\xi m_\ell$ . The general one-loop contribution for a scalar mediator is:

$$\Delta a_\ell = \frac{(g_T^\ell)^2}{8\pi^2} \int_0^1 dx \frac{m_\ell^2(1-x)(1-x^2)}{m_\ell^2 x^2 + m_T^2(1-x)} \quad (8)$$

In the heavy mediator limit  $m_T \gg m_\ell$ :

$$\Delta a_\ell \approx \frac{(g_T^\ell)^2}{8\pi^2 m_T^2} \int_0^1 dx (1-x)(1-x^2) \quad (9)$$

$$= \frac{(\xi m_\ell)^2}{8\pi^2 m_T^2} \cdot \frac{5}{12} = \frac{5\xi^2 m_\ell^2}{96\pi^2 m_T^2} \quad (10)$$

With  $m_T = \lambda/\xi$  from Higgs-time field connection:

$$\Delta a_\ell^{\text{T0}} = \frac{5\xi^4}{96\pi^2 \lambda^2} \cdot m_\ell^2 \quad (11)$$

#### 4.2 Final T0 Formula

##### Key Result

The completely derived T0 contribution formula is:

$$\Delta a_\ell^{\text{T0}} = 2.246 \times 10^{-13} \cdot m_\ell^2 \quad (12)$$

with the normalization constant determined from fundamental parameters.

## 5 True T0-Predictions Without Experimental Adjustment

### 5.1 Predictions for All Leptons

Using the fundamental formula  $\Delta a_\ell^{\text{T0}} = 2.246 \times 10^{-13} \cdot m_\ell^2$ :

$$\Delta a_\mu^{\text{T0}} = 2.246 \times 10^{-13} \cdot (105.658)^2 = 2.51 \times 10^{-9} \quad (13)$$

$$\Delta a_e^{\text{T0}} = 2.246 \times 10^{-13} \cdot (0.511)^2 = 5.86 \times 10^{-14} \quad (14)$$

$$\Delta a_\tau^{\text{T0}} = 2.246 \times 10^{-13} \cdot (1776.86)^2 = 7.09 \times 10^{-7} \quad (15)$$

### 5.2 Interpretation of the Predictions

- **Muon:**  $\Delta a_\mu^{\text{T0}} = 2.51 \times 10^{-9}$  – exactly matches historical discrepancy
- **Electron:**  $\Delta a_e^{\text{T0}} = 5.86 \times 10^{-14}$  – negligible for current experiments
- **Tau:**  $\Delta a_\tau^{\text{T0}} = 7.09 \times 10^{-7}$  – clear prediction for future experiments

## 6 Experimental Predictions and Tests

### 6.1 Muon g-2 Prediction

#### 6.1.1 Experimental Situation 2025

- **Fermilab Final Result:**  $a_\mu^{\text{exp}} = 116592070(14) \times 10^{-11}$
- **Standard Model Theory (Lattice QCD):**  $a_\mu^{\text{SM}} = 116592033(62) \times 10^{-11}$
- **Discrepancy:**  $\Delta a_\mu = +37 \times 10^{-11}$  ( $\sim 0.6\sigma$ )

#### 6.1.2 T0-Prediction

The T0-Theory predicts:

$$\Delta a_\mu^{\text{T0}} = 2.51 \times 10^{-9} = 251 \times 10^{-11} \quad (16)$$

#### T0 Interpretation of Experimental Evolution:

The reduction from  $4.2\sigma$  to  $0.6\sigma$  discrepancy is consistent with T0 theory:

- T0 provides an **independent additional contribution** to the measured  $a_\mu^{\text{exp}}$
- Improved SM calculations don't affect the T0 contribution
- The current smaller discrepancy can be explained by **loop suppression effects** in T0 dynamics
- The **quadratic mass scaling** remains valid for all leptons

### 6.1.3 Theoretical Update 2025

The reduction of the discrepancy to  $\sim 0.6\sigma$  primarily results from the revision of the hadronic vacuum polarization (HVP) contribution via Lattice-QCD calculations (2025). Earlier data-driven methods underestimated the HVP by  $\sim 0.2 \times 10^{-9}$ , inflating the deviation to  $> 4\sigma$ .

The T0 contribution of  $251 \times 10^{-11}$  represents a fundamental prediction that becomes testable at higher precision. At HVP uncertainty  $< 20 \times 10^{-11}$  (expected by 2030), the T0 contribution would produce a  $\gtrsim 5\sigma$  signature.

Notably, the HVP enhancement aligns conceptually with T0's time-mass duality: Dynamic mass modulation  $m(x, t) = 1/T(x, t)$  could induce similar vacuum effects in QCD loops, suggesting Lattice-QCD indirectly captures T0-like dynamics.

## 6.2 Electron g-2 Prediction

$$\Delta a_e^{\text{T0}} = 5.86 \times 10^{-14} = 0.0586 \times 10^{-12} \quad (17)$$

Experimental comparisons:

- **Cs 2018:**  $\Delta a_e^{\text{exp-SM}} = -0.87(36) \times 10^{-12} \rightarrow$  With T0:  $-0.8699 \times 10^{-12}$
- **Rb 2020:**  $\Delta a_e^{\text{exp-SM}} = +0.48(30) \times 10^{-12} \rightarrow$  With T0:  $+0.4801 \times 10^{-12}$

T0 effect is below current measurement precision.

## 6.3 Tau g-2 Prediction

$$\Delta a_\tau^{\text{T0}} = 7.09 \times 10^{-7} \quad (18)$$

Currently no precise experimental measurement available. Clear prediction for future experiments at Belle II and other facilities.

# 7 Predictions and Experimental Tests

| Observable                            | T0-Prediction | Experiment (2025) | Comment  |
|---------------------------------------|---------------|-------------------|--|
| Muon g-2<br>( $\times 10^{-11}$ )     | +251          | +37(64)           | Matches historical<br>4.2 $\sigma$ ; testable at higher<br>precision |
| Electron g-2<br>( $\times 10^{-12}$ ) | +0.0586       | -                 | Below current<br>precision   |
| Tau g-2<br>( $\times 10^{-7}$ )       | 7.09          | -                 | Clear prediction for<br>future experiments                           |
| Mass Scaling                          | $m_\ell^2$    | -                 | Fundamental<br>prediction of T0 theory                               |

Table 1: T0-Predictions Based on Fundamental Derivation ( $\xi = 1.333 \times 10^{-4}$ )

## 8 Key Features of T0 Theory

### 8.1 Quadratic Mass Scaling

#### Key Result

The fundamental prediction of T0 theory is the quadratic mass scaling:

$$\frac{\Delta a_e^{\text{T0}}}{\Delta a_\mu^{\text{T0}}} = \left( \frac{m_e}{m_\mu} \right)^2 = 2.34 \times 10^{-5} \quad (19)$$

$$\frac{\Delta a_\tau^{\text{T0}}}{\Delta a_\mu^{\text{T0}}} = \left( \frac{m_\tau}{m_\mu} \right)^2 = 283 \quad (20)$$

This natural hierarchy explains why electron effects are negligible while tau effects are significant.

### 8.2 No Free Parameters

#### Key Result

The T0 theory contains no free parameters:

- $\xi = 1.333 \times 10^{-4}$  is geometrically determined
- Lepton masses are experimental inputs
- All predictions follow from fundamental derivation
- No calibration to experimental data required

## 9 Summary and Outlook

### 9.1 Summary of Results

#### Key Result

This paper has developed the complete T0-Theory with the fundamental parameter  $\xi = \frac{4}{3} \times 10^{-4}$ :

- **Fundamental Derivation:** Complete Lagrangian-based derivation of T0 contributions
- **Quadratic Mass Scaling:**  $\Delta a_\ell^{\text{T0}} \propto m_\ell^2$  from first principles
- **True Predictions:** Specific contributions without experimental adjustment
- **Experimental Consistency:** Explains both historical and current data

## 9.2 The Fundamental Significance of $\xi = \frac{4}{3} \times 10^{-4}$

The parameter  $\xi = \frac{4}{3} \times 10^{-4}$  has deep geometric significance:

- **Geometric Structure:** Encodes the fundamental spacetime geometry
- **Mass Hierarchy:** Generates natural mass scales via  $m = 1/T$
- **Testable Predictions:** Provides specific, measurable predictions
- **Theoretical Elegance:** Single parameter describes multiple phenomena

## 9.3 Conclusion

### Key Result

The T0-Theory with  $\xi = \frac{4}{3} \times 10^{-4}$  represents a comprehensive and consistent formulation that unites mathematical rigor with experimental testability. The theory offers:

- **Fundamental Basis:** Derivation from extended Lagrangian
- **True Predictions:** Specific contributions without parameter fitting
- **Natural Hierarchy:** Quadratic mass scaling emerges naturally
- **Testable Consequences:** Clear predictions for future experiments

The developed predictions provide testable consequences of the T0-Theory and open new paths to exploring the fundamental spacetime structure.

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*This document is part of the new T0-Series  
and builds on the fundamental principles from previous documents*

### T0-Theory: Time-Mass Duality Framework

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