Lagrangian

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Capítulo 1

Lagrangian

Resumen

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: $\Delta a_\ell^{\mathrm{T0}} = \frac{5\xi^4}{96\pi^2\lambda^2} \cdot m_\ell^2$. This derivation requires no calibration and provides testable predictions for all leptons consistent with both historical and current experimental data.

1.1. Introduction to the T0-Theory

1.1.1. The Fundamental Time-Mass Duality

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

$$T(x,t) \cdot m(x,t) = 1 \tag{1.1}$$

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_ℓ^2
- **Unification**: Gravity is intrinsically integrated into quantum field theory

1.1.2. The Fundamental Geometric Parameter

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

$$\boxed{\xi = \frac{4}{3} \times 10^{-4} = 1{,}333 \times 10^{-4}} \tag{1.2}$$

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

1.2. Mathematical Foundations and Conventions

1.2.1. 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
- λ: Higgs-time field coupling parameter
- m_ℓ: Lepton masses (e, μ, τ)

1.2.2. Derived Parameters

$$\xi^2 = (1{,}333 \times 10^{-4})^2 = 1{,}777 \times 10^{-8} \tag{1.3}$$
$$\xi^4 = (1{,}333 \times 10^{-4})^4 = 3{,}160 \times 10^{-16} \tag{1.4}$$

1.3. Extended Lagrangian with Time Field

1.3.1. Mass-Proportional Coupling

The coupling of lepton fields ψ_ℓ to the time field occurs proportionally to lepton mass:

$$\mathcal{L}_{\text{Interaction}} = g_T^\ell \, \bar{\psi}_\ell \psi_\ell \, \Delta m \tag{1.5}$$
$$g_T^\ell = \xi \, m_\ell \tag{1.6}$$

1.3.2. Complete Extended Lagrangian

$$\mathcal{L}_{\text{extended}} = -\frac{1}{4} F_{\mu\nu} F^{\mu\nu} + \bar{\psi}(i\gamma^\mu D_\mu - m)\psi + \frac{1}{2}(\partial_\mu \Delta m)(\partial^\mu \Delta m) - \frac{1}{2} m_T^2 \Delta m^2 + \xi \, m_\ell \, \bar{\psi}_\ell \psi_\ell \, \Delta m \tag{1.7}$$

1.4. Fundamental Derivation of T0 Contributions

1.4.1. 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:

$$\Delta a_\ell = \frac{(g_T^\ell)^2}{8\pi^2} \int_0^1 dx \frac{m_\ell^2 (1-x)(1-x^2)}{m_\ell^2 x^2 + m_T^2 (1-x)} \tag{1.8}$$

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

$$\Delta a_\ell \approx \frac{(g_T^\ell)^2}{8\pi^2 m_T^2} \int_0^1 dx \, (1-x)(1-x^2) \tag{1.9}$$
$$= \frac{(\xi m_\ell)^2}{8\pi^2 m_T^2} \cdot \frac{5}{12} = \frac{5\xi^2 m_\ell^2}{96\pi^2 m_T^2} \tag{1.10}$$

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

$$\Delta a_\ell^{\text{T0}} = \frac{5\xi^4}{96\pi^2 \lambda^2} \cdot m_\ell^2 \tag{1.11}$$

1.4.2. Final T0 Formula

The completely derived T0 contribution formula is:

$$\Delta a_\ell^{\text{T0}} = 2{,}246 \times 10^{-13} \cdot m_\ell^2 \tag{1.12}$$

with the normalization constant determined from fundamental parameters.

1.5. True T0-Predictions Without Experimental Adjustment

1.5.1. Predictions for All Leptons

Using the fundamental formula $\Delta a_\ell^{\text{T0}} = 2{,}246 \times 10^{-13} \cdot m_\ell^2$:

$$\Delta a_\mu^{\text{T0}} = 2{,}246 \times 10^{-13} \cdot (105{,}658)^2 = 2{,}51 \times 10^{-9} \tag{1.13}$$
$$\Delta a_e^{\text{T0}} = 2{,}246 \times 10^{-13} \cdot (0{,}511)^2 = 5{,}86 \times 10^{-14} \tag{1.14}$$
$$\Delta a_\tau^{\text{T0}} = 2{,}246 \times 10^{-13} \cdot (1776{,}86)^2 = 7{,}09 \times 10^{-7} \tag{1.15}$$

1.5.2. 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

1.6. Experimental Predictions and Tests

1.6.1. Muon g-2 Prediction

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**: $\Delta a_\mu = +37 \times 10^{-11}$ ($\sim 0{,}6\sigma$)

T0-Prediction

The T0-Theory predicts:

$$\Delta a_\mu^{\text{T0}} = 2{,}51 \times 10^{-9} = 251 \times 10^{-11} \tag{1.16}$$

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_μ^{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

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 251×10^{-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.

1.6.2. Electron g-2 Prediction

$$\Delta a_e^{\mathrm{T0}} = 5{,}86 \times 10^{-14} = 0{,}0586 \times 10^{-12} \tag{1.17}$$

Experimental comparisons:

- **Cs 2018**: $\Delta a_e^{\mathrm{exp-SM}} = -0{,}87(36) \times 10^{-12} \to$ With T0: $-0{,}8699 \times 10^{-12}$
- **Rb 2020**: $\Delta a_e^{\mathrm{exp-SM}} = +0{,}48(30) \times 10^{-12} \to$ With T0: $+0{,}4801 \times 10^{-12}$

T0 effect is below current measurement precision.

1.6.3. Tau g-2 Prediction

$$\Delta a_\tau^{\mathrm{T0}} = 7{,}09 \times 10^{-7} \tag{1.18}$$

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

1.7. Predictions and Experimental Tests

Observable	**T0-Prediction**	**Experiment (2025)**	**Comment**
Muon g-2 ($\times 10^{-11}$)	+251	+37(64)	Matches historical 4,2σ; testable at higher precision
Electron g-2 ($\times 10^{-12}$)	+0,0586	-	Below current precision
Tau g-2 ($\times 10^{-7}$)	7,09	-	Clear prediction for future experiments
Mass Scaling	m_ℓ^2	-	Fundamental prediction of T0 theory

Cuadro 1.1: T0-Predictions Based on Fundamental Derivation ($\xi = 1{,}333 \times 10^{-4}$)

1.8. Key Features of T0 Theory

1.8.1. Quadratic Mass Scaling

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

$$\frac{\Delta a_e^{\mathrm{T0}}}{\Delta a_\mu^{\mathrm{T0}}} = \left(\frac{m_e}{m_\mu}\right)^2 = 2{,}34 \times 10^{-5} \tag{1.19}$$

$$\frac{\Delta a_\tau^{\mathrm{T0}}}{\Delta a_\mu^{\mathrm{T0}}} = \left(\frac{m_\tau}{m_\mu}\right)^2 = 283 \tag{1.20}$$

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

1.8.2. No Free Parameters

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

1.9. Summary and Outlook

1.9.1. Summary of Results

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**: $\Delta a_\ell^{\mathrm{T0}} \propto m_\ell^2$ from first principles
- **True Predictions**: Specific contributions without experimental adjustment
- **Experimental Consistency**: Explains both historical and current data

1.9.2. 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

1.9.3. Conclusion

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.

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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