Anomalous Magnetic Moments in FFGFT Theory

Geometric Derivation from Time-Mass Duality

Purely Geometric Formulas and Precise Ratio Predictions

Johann Pascher

February 2026

Abstract

T0 Theory (Fundamental Fractal Geometric Field Theory) explains anomalous magnetic moments of leptons from purely geometric principles. Leptons are winding structures in the 4D torsion lattice, whose spatial extension generates the anomalous moment. The formulas use exclusively the geometric fundamental constants φ (golden ratio), $\xi = 4/3 \times 10^{-4}$ (torsion constant), and $f = 7500 - 5\varphi$ (sub-Planck factor) without free fitting parameters. Absolute values deviate 2% from experiment (consistent with mass predictions), but ratios such as $\Delta a_\tau / \Delta a_\mu = f^{1/3} - 1 \approx 18.57$ are precisely predicted without parameters. This enables testable predictions for tau-g-2 at Belle II, analogous to the Koide formula for masses.

Note on Older Documents

Earlier versions of the g-2 analysis (018_T0_Anomale-g2-9_En.pdf) used semi-empirical factors. The present formulation uses **exclusively geometric factors** and is honest about the 2% deviation, which is consistent with the precision of all T0 predictions. Python scripts available at: github.com/jpascher/T0-Time-Mass-Duality

Keywords: Anomalous magnetic moment, g-2, T0 theory, time-mass duality, torsion lattice, ratio predictions, Koide formula

Contents

1 Introduction: Geometric vs. Semi-empirical Approaches

1.1 The Philosophy of T0 Theory

T0 Theory is based on the principle that **all** physical constants should follow from the geometric structure of a 4-dimensional torsion lattice. For anomalous magnetic moments this means:

- **NO** hidden fitting parameters
- **ONLY** geometric factors: φ, ξ, f
- Honesty about precision limits
- Consistency with other predictions

1.2 Consistency with Mass Predictions

T0 Theory predicts lepton masses with 1–2% deviation:

Lepton	T0 [MeV]	Exp [MeV]	Deviation
Electron	0.507	0.511	0.87%
Muon	103.5	105.7	2.09%
Tau	1815	1777	2.16%

Table 1: Lepton masses in T0

Expectation: g-2 should have similar precision (2%).

It would be **dishonest** to claim perfect agreement for g-2 when masses already deviate by 2%!

2 Physical Fundamentals

2.1 What is the Anomalous Magnetic Moment?

The magnetic moment of a charged spin-$1/2$ particle is:

$$\mu = g \cdot \frac{e}{2m} \cdot \frac{\hbar}{2} \tag{1}$$

where g is the gyromagnetic factor (g-factor).
Dirac prediction: For a point-like particle: $g = 2$
Quantum effects: Vacuum polarization, vertex corrections $\Rightarrow g \neq 2$
Anomaly: $a = (g-2)/2$
QED expectation: $a \approx \alpha/(2\pi) + \mathcal{O}(\alpha^2) \approx 0.00116$

2.2 T0 Interpretation: Windings in the Torsion Lattice

In T0 Theory, leptons are **winding structures** in the 4D torsion lattice:

- **Electron:** Simple winding (1st generation)
- **Muon:** Winding with fractal branching (2nd generation)
- **Tau:** More complex fractal structure (3rd generation)

The anomalous moment arises from:

1. The **rotation** of the winding (spin)
2. The **charge distribution** on the winding
3. The **projection** 4D $\rightarrow$ 3D

$\Rightarrow$ **No** point-like charge $\Rightarrow a \neq 0$

3 Geometric Formulas

3.1 Fundamental Parameters

T0 Theory uses exclusively three geometric fundamental constants:

$$\varphi = \frac{1+\sqrt{5}}{2} = 1.618\ldots \quad \text{(Golden Ratio)} \tag{2}$$

$$\xi = \frac{4}{3} \times 10^{-4} = 1.333 \times 10^{-4} \quad \text{(Torsion Constant)} \tag{3}$$

$$f_{\text{ideal}} = \frac{30000}{4} = 7500 \quad \text{(Ideal Lattice)} \tag{4}$$

$$\Delta = 5\varphi = 8.090 \quad \text{(Pentagonal Symmetry Breaking)} \tag{5}$$

$$f = f_{\text{ideal}} - \Delta = 7491.91 \quad \text{(Real Sub-Planck Factor)} \tag{6}$$

3.2 Electron: Base Winding

Formula:

$$a_e = \frac{S_3/f}{k_{\text{geom}}} \tag{7}$$

where:

- $S_3 = 2\pi^2 = 19.739$: 3D surface of the 4D winding
- $f = 7491.91$: Sub-Planck scaling
- k_{geom}: Geometric projection factor

Geometric Projection Factor:

$$k_{\text{geom}} = \frac{2}{\sqrt{\varphi}} \times \sqrt{2} \tag{8}$$

Explanation of Factors:

- $2/\sqrt{\varphi} = 1.572$: Pentagonal projection (from ξ-structure)
- $\sqrt{2} = 1.414$: Diagonal projection 4D $\to$ 3D
- $k_{\text{geom}} = 2.224$: Completely geometric!

Numerical Calculation:

$$k_{\text{geom}} = \frac{2}{\sqrt{1.618}} \times \sqrt{2} = 2.224 \tag{9}$$

$$a_e = \frac{19.739/7491.91}{2.224} \tag{10}$$

$$a_e = 1.185 \times 10^{-3} \tag{11}$$

Comparison:

- T0: $a_e = 1.185 \times 10^{-3}$
- Experiment: $a_e = 1.160 \times 10^{-3}$
- Deviation: **2.18%**

3.3 Muon: Fractal Additional Winding

Formula:

$$a_\mu = a_e + \Delta a_{\text{fractal}} \tag{12}$$

with

$$\Delta a_{\text{fractal}} = \frac{4\pi}{f^{p_\mu}} \tag{13}$$

where:

- $p_\mu = 5/3$: Fractal Hausdorff dimension
- 4π: Complete torsion revolution

Meaning of $p_\mu = 5/3$:
This is the well-known Hausdorff dimension of:

- Brownian motion in 2D
- Self-avoiding random walk
- Koch curve (fractal)

⇒ Physically plausible for "partially branched winding"!
Numerical Calculation:

$$\Delta a_{\text{fractal}} = \frac{4\pi}{7491.91^{5/3}} = 4.381 \times 10^{-6} \tag{14}$$

$$a_\mu = 1.185 \times 10^{-3} + 4.381 \times 10^{-6} \tag{15}$$

$$a_\mu = 1.189 \times 10^{-3} \tag{16}$$

Comparison:

- T0: $a_\mu = 1.189 \times 10^{-3}$
- Experiment: $a_\mu = 1.166 \times 10^{-3}$
- Deviation: **2.00%**

3.4 Tau: More Complex Fractal Structure

Formula:

$$a_\tau = a_e + \frac{4\pi}{f^{p_\tau}} \tag{17}$$

where:

- $p_\tau = 4/3$: Stronger fractal branching

Meaning of $p_\tau = 4/3$:
This is the box-counting dimension of many fractals (e.g., Koch curve, Mandelbrot set).

Numerical Calculation:

$$\Delta a_{\text{fractal}} = \frac{4\pi}{7491.91^{4/3}} = 8.572 \times 10^{-5} \tag{18}$$
$$a_\tau = 1.185 \times 10^{-3} + 8.572 \times 10^{-5} \tag{19}$$
$$a_\tau = 1.271 \times 10^{-3} \tag{20}$$

Status: This is a **prediction** – tau-g-2 has not been measured yet!

4 Summary of Absolute Values

Lepton	T0	Experiment	Dev.	Status
Electron	1.185×10^{-3}	1.160×10^{-3}	2.18%	✓
Muon	1.189×10^{-3}	1.166×10^{-3}	2.00%	✓
Tau	1.271×10^{-3}	(not measured)	–	Prediction

Table 2: g-2 Absolute Values: T0 vs. Experiment

Assessment:
- ✓ All factors geometrically explained
- ✓ No hidden fitting parameters
- ✓ 2% deviation consistent with masses
- ✓ Honest about limitations

5 Two Classes of Predictions: Absolute Values vs. Ratios

5.1 Why 2% Deviation for Absolute Values?

T0 Theory uses exclusively geometric factors without fitting parameters. The 2% deviation in absolute g-2 values is:
- **Consistent** with all T0 predictions (masses: 0.87–2.16%)
- **Expected** for a purely geometric description
- **Comparable** to α^2 effects in QED (1–2%)
- **NOT a weakness**, but a property of the theory

Causes of the 2% Deviation:

1. **Higher-order quantum effects:** T0 captures the leading geometric structure, but not all loop corrections
2. **Discrete lattice structure:** The torsion lattice is discrete, not continuous
3. **Pentagonal symmetry breaking:** $\Delta = 5\varphi$ leads to 0.1% corrections

5.2 Ratios are Mathematically Exact

In contrast to absolute values, **ratios of differences** are structurally exact:

$$\frac{\Delta a(\tau - \mu)}{\Delta a(\mu - e)} = \frac{4\pi/f^{4/3} - 4\pi/f^{5/3}}{4\pi/f^{5/3}} = f^{1/3} - 1 \tag{21}$$

Why is this exact?

- The common factor 4π cancels
- The projection factor k_{geom} cancels
- Only the fractal exponents ($5/3$ and $4/3$) determine the ratio
- The result depends **only** on f: $f^{1/3} - 1 = 18.567$

Important

Fundamental Distinction **Absolute values:**

- Depend on k_{geom}, f, and SI conversion
- 2% deviation from higher-order quantum effects
- Consistent with all T0 predictions

Ratios:

- Depend **only** on f
- k_{geom} and SI factors cancel
- Mathematically exact from fractal exponents
- Difference $< 10^{-13}$ (numerical precision)

$\Rightarrow$ The ratio prediction is **not an approximation**, but an **exact geometric relation**!

5.3 Analogy to the Koide Formula

This behavior is analogous to the Koide formula for lepton masses:

- **Individual masses:** 1–2% deviation
- **Koide ratio:** $\pm 0.0004\%$ precision!

The ratio is more **fundamental** than absolute values because systematic factors cancel.

For g-2 in T0:

- **Absolute values:** 2% deviation
- **Ratio** $\Delta a(\tau - \mu)/\Delta a(\mu - e)$**:** Exactly $= f^{1/3} - 1$
  This is **not a weakness**, but shows the **geometric structure** of the theory!

6 Precise Ratio Predictions

6.1 Analogy to the Koide Formula

The Koide formula for lepton masses:

$$\frac{m_e + m_\mu + m_\tau}{(\sqrt{m_e} + \sqrt{m_\mu} + \sqrt{m_\tau})^2} = \frac{2}{3} \pm 0.0004\% \tag{22}$$

shows: **Ratios** are more precise than absolute values!
Question: Does this also hold for g-2?

6.2 The Ratio of Differences

Define the differences:

$$\Delta a(\mu - e) = a_\mu - a_e = \frac{4\pi}{f^{5/3}} \tag{23}$$

$$\Delta a(\tau - \mu) = a_\tau - a_\mu = \frac{4\pi}{f^{4/3}} - \frac{4\pi}{f^{5/3}} \tag{24}$$

Ratio:

$$\frac{\Delta a(\tau - \mu)}{\Delta a(\mu - e)} = \frac{4\pi/f^{4/3} - 4\pi/f^{5/3}}{4\pi/f^{5/3}} \tag{25}$$

$$= \frac{f^{5/3}}{f^{4/3}} - 1 \tag{26}$$

$$= f^{5/3-4/3} - 1 \tag{27}$$

$$= f^{1/3} - 1 \tag{28}$$

Important

Core Prediction

$$\boxed{\frac{\Delta a(\tau - \mu)}{\Delta a(\mu - e)} = f^{1/3} - 1 = 18.567} \tag{29}$$

This relation is:

- **Parameter-free** (only f!)
- **Independent** of k_{geom}
- **Exact** (difference $< 10^{-13}$)
- **Testable** at Belle II

6.3 Numerical Verification

With $f = 7491.91$:

$$f^{1/3} = 7491.91^{1/3} = 19.567 \tag{30}$$
$$f^{1/3} - 1 = 18.567 \tag{31}$$

From T0 values:

$$\Delta a(\mu - e) = 4.381 \times 10^{-6} \tag{32}$$
$$\Delta a(\tau - \mu) = 8.134 \times 10^{-5} \tag{33}$$
$$\text{Ratio} = \frac{8.134 \times 10^{-5}}{4.381 \times 10^{-6}} = 18.567 \tag{34}$$

Agreement: Perfect! ✓✓✓

6.4 Testable Prediction for Tau

With experimental values for e and μ:

$$a_e^{\text{exp}} = 1.160 \times 10^{-3} \tag{35}$$
$$a_\mu^{\text{exp}} = 1.166 \times 10^{-3} \tag{36}$$
$$\Delta a(\mu - e)^{\text{exp}} = 6.269 \times 10^{-6} \tag{37}$$

Prediction:

$$\Delta a(\tau - \mu) = \Delta a(\mu - e)^{\text{exp}} \times (f^{1/3} - 1) \tag{38}$$
$$= 6.269 \times 10^{-6} \times 18.567 \tag{39}$$
$$= 1.164 \times 10^{-4} \tag{40}$$
$$a_\tau^{\text{predicted}} = 1.166 \times 10^{-3} + 1.164 \times 10^{-4} \tag{41}$$
$$= 1.282 \times 10^{-3} \tag{42}$$

7 Why 2% Deviation?

7.1 Higher-Order Quantum Effects

QED calculates g-2 as a perturbation series:

$$a = \frac{\alpha}{2\pi} + \mathcal{O}(\alpha^2) + \mathcal{O}(\alpha^3) + \ldots \tag{43}$$

T0 captures the **geometric fundamental structure**, but not all higher-order quantum corrections.

⇒ 2% corresponds roughly to α^2 effects!

7.2 Discrete Lattice Structure

The torsion lattice is **discrete**, not continuous.

This leads to small corrections compared to continuous QFT.

7.3 Pentagonal Symmetry Breaking

$$f = f_{\text{ideal}} - 5\varphi \tag{44}$$

This symmetry breaking (0.1%) explains:

- Matter-antimatter asymmetry
- Generation structure
- Small corrections to idealized values

8 Experimental Tests

8.1 Belle II (2027–2028)

Belle II expects sensitivity of $\sim 10^{-7}$ for a_τ.

Test 1: Absolute value

- T0 prediction: $a_\tau = 1.271 \times 10^{-3}$
- From ratio: $a_\tau = 1.282 \times 10^{-3}$
- Difference: 1%

Test 2: Ratio

- T0 prediction: $\Delta a(\tau - \mu)/\Delta a(\mu - e) = 18.567$
- This is the **more precise** prediction!
- Independent of absolute calibration

Possible outcomes:

1. **Confirmation:** Ratio ≈ 18.6
   $\Rightarrow$ Strong evidence for fractal structure hypothesis
2. **Deviation:** Ratio $\neq 18.6$
   $\Rightarrow$ Different fractal dimensions or additional physics
3. **Null result:** $a_\tau < 10^{-8}$
   $\Rightarrow$ T0 contributions suppressed or theory needs revision

8.2 Fermilab/J-PARC

Further precision improvements for a_μ:

- Reduction of experimental uncertainties
- Clearer determination of the SM discrepancy
- Refinement of the $\Delta a(\mu - e)$ measurement

9 Comparison with Other Approaches

Approach	Precision	Parameters	Explainable
QED (SM)	Perfect	Many	Yes
T0 (semi-empirical)	0.1%	1 fitted	Partially
T0 (geometric)	2%	0	**Completely**

Table 3: Comparison of different approaches

T0 Philosophy: We choose **explanatory power** over precision!

10 Reconstruction of the Correction Factor from Experimental Data

10.1 The Central Observation

The ratio $\Delta a(\tau - \mu)/\Delta a(\mu - e) = f^{1/3} - 1$ is **mathematically exact** because the correction factor k_{geom} cancels out completely.

Since experimental measurements of a_e and a_μ are more precise (10^{-10}) than our geometric derivation of k_{geom} (2%), we can **determine this factor backwards from the experiments**.

10.2 Reconstruction of k_{geom}

From the experimental electron value:

$$k_{\text{geom}}^{\text{(reconstructed)}} = \frac{S_3/f}{a_e^{\text{(exp)}}} = \frac{2\pi^2/7491.91}{1.160 \times 10^{-3}} = 2.272 \tag{45}$$

Comparison:

- Geometrically derived: $k_{\text{geom}} = (2/\sqrt{\varphi}) \times \sqrt{2} = 2.224$
- Reconstructed from experiment: $k_{\text{geom}}^{\text{(rec)}} = 2.272$
- Difference: 2.2% (exactly within the expected uncertainty range!)

10.3 Using the Reconstructed Correction Factor

If we use the reconstructed value $k_{\text{geom}}^{\text{(rec)}} = 2.272$:

Lepton	With $k = 2.224$	With $k = 2.272$	Experiment	Dev.
Electron	1.185×10^{-3}	1.160×10^{-3}	1.160×10^{-3}	**0%** ✓
Muon	1.189×10^{-3}	1.164×10^{-3}	1.166×10^{-3}	**0.2%** ✓
Tau	1.271×10^{-3}	1.246×10^{-3}	(not measured)	Prediction

Table 4: Absolute values with geometric vs. reconstructed k_{geom}

Important

Crucial Point With the reconstructed correction factor $k_{\text{geom}}^{\text{(rec)}} = 2.272$, the deviations disappear:

- Electron: 0% deviation (by definition, since reconstructed from a_e)
- Muon: 0.2% deviation (reduced from 2% to 0.2%!)
- Tau: New prediction $a_\tau = 1.246 \times 10^{-3}$

This shows: The 2% deviation originates **exclusively** from the uncertainty in k_{geom}, not from the fundamental T0 structure!

10.4 Alternative: Directly from the Ratio Relation

Even more precise is the calculation directly from the exact ratio:

$$\Delta a(\mu - e)^{\text{(exp)}} = a_\mu^{\text{(exp)}} - a_e^{\text{(exp)}} = 6.269 \times 10^{-6} \tag{46}$$
$$\Delta a(\tau - \mu) = \Delta a(\mu - e)^{\text{(exp)}} \times (f^{1/3} - 1) \tag{47}$$
$$= 6.269 \times 10^{-6} \times 18.567 = 1.164 \times 10^{-4} \tag{48}$$
$$a_\tau^{\text{(Ratio)}} = a_\mu^{\text{(exp)}} + \Delta a(\tau - \mu) \tag{49}$$
$$= 1.166 \times 10^{-3} + 1.164 \times 10^{-4} \tag{50}$$
$$= \boxed{1.282 \times 10^{-3}} \tag{51}$$

Note: This prediction is **independent** of k_{geom} and uses only the exact geometric ratio structure!

10.5 Two Complementary Tau Predictions

Method	a_τ Prediction	Depends on
Purely geometric	1.271×10^{-3}	$k_{\text{geom}} = 2.224$ (geometric)
With rec. k_{geom}	1.246×10^{-3}	$k_{\text{geom}} = 2.272$ (from a_e)
From ratio	1.282×10^{-3}	Only f (exact)
Range	1.25–1.28×10^{-3}	$\pm 1.5\%$

Table 5: Three T0 predictions for a_τ

10.6 What This Means for Belle II

If Belle II measures:

1. $a_\tau \approx 1.28 \times 10^{-3}$**:**
   - ✓ Confirms the exact ratio relation $f^{1/3} - 1$
   - ✓ Shows that experimental a_μ and ratio structure are correct
   - → **Strongest confirmation of T0 geometry**
2. $a_\tau \approx 1.25 \times 10^{-3}$**:**
   - ✓ Confirms reconstructed $k_{\text{geom}} = 2.272$
   - ✓ Shows that a_e, a_μ are both slightly shifted
   - → Consistent with T0, but different ratio interpretation
3. $a_\tau \approx 1.27 \times 10^{-3}$**:**
   - ✓ Confirms purely geometric $k_{\text{geom}} = 2.224$

- ? Ratio deviates → fractal exponent $p_\tau \neq 4/3$?

4. a_τ **outside** 1.25–1.28:
   - × T0 structure requires revision

Core Statement

The 2% deviation of the purely geometric T0 predictions originates **exclusively** from the uncertainty in deriving k_{geom}.
If we reconstruct k_{geom} from experimental data, the deviations disappear:

- Electron: 0% (by definition)
- Muon: 0.2% (instead of 2%)

This shows: The **fundamental T0 structure is correct**, only the derivation of the projection factor $k_{\text{geom}} = (2/\sqrt{\varphi}) \times \sqrt{2}$ has a 2% uncertainty.
The most precise T0 prediction for tau uses the exact ratio relation:

$$\boxed{a_\tau = 1.282 \times 10^{-3}} \tag{52}$$

11 Important Note: No α in T0 g-2 Formulas

IMPORTANT: The T0 formulas for g-2 contain **no** α!
In natural units ($\hbar = c = \alpha = 1$):

$$a_\ell = f(\varphi, \xi, f, \text{generation quantum numbers})$$

The anomalous moment is a **purely geometric quantity**, which follows from the winding structure in the torsion lattice.

Ratios like $\Delta a(\tau - \mu)/\Delta a(\mu - e) = f^{1/3} - 1$ are **independent** of: • α (fine-structure constant) • SI conversion factors • k_{geom} (projection factor)

They depend ONLY on the fractal structure!

12 Summary

12.1 What We Show

1. g-2 follows from **purely geometric principles**:
   - φ (golden ratio)
   - ξ (torsion constant)
   - f (sub-Planck factor)
2. Absolute values: 2% deviation

- Consistent with mass predictions
- Explainable by higher-order quantum effects

3. **Ratios are precise**:

$$\frac{\Delta a(\tau - \mu)}{\Delta a(\mu - e)} = f^{1/3} - 1 = 18.567 \tag{53}$$

4. Testable tau prediction: $a_\tau = 1.28 \times 10^{-3}$

12.2 Core Message

Honesty and Consistency

T0 Theory explains g-2 from the same geometric principles as masses, fundamental constants (G, α, v), and generation structure. The 2% deviation in absolute values is consistent with the precision of all T0 predictions and honestly presented. Ratio predictions such as $\Delta a(\tau - \mu)/\Delta a(\mu - e) = 18.567$ are parameter-free and precise – analogous to the Koide formula for masses. This enables clear experimental tests at Belle II.

Further Literature and Resources

T0 Theory and Python Scripts:

- Repository: github.com/jpascher/T0-Time-Mass-Duality
- Python scripts: github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/python/
- Time-Mass Duality documentation
- Fundamental Fractal Geometric Field Theory (FFGFT)

Experimental Results:

- Fermilab Muon g-2 (2025): muon-g-2.fnal.gov
- Theory Initiative White Paper
- Belle II: www.belle2.org

Related T0 Documents:

- Lepton masses: Systematic derivation from quantum numbers
- Koide formula in T0: Geometric interpretation
- Fractal spacetime: $D_f = 3 - \xi$