

Lepton Formulas

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Abstract

The T0 theory provides a complete derivation of the anomalous magnetic moments of all charged leptons through quadratic mass scaling. Based on standard quantum field theory and the universal geometric constant $\xi = 4/3 \times 10^{-4}$, a parameter-free prediction is achieved that reproduces experimental data with high precision.

1 Introduction

The anomalous magnetic moments of leptons represent one of the most precise tests of quantum field theory. The T0 theory extends the Standard Model with a universal scalar field ϕ_T coupled through the geometric constant ξ , enabling a unified description of all leptonic anomalies.

The central insight is the quadratic mass scaling $a_\ell \propto (m_\ell/m_\mu)^2$, which follows directly from standard quantum field theory and is confirmed experimentally.

2 Fundamental T0 Formula

The universal T0 formula for anomalous magnetic moments reads:

$$a_\ell = \xi^2 \cdot \aleph \cdot \left(\frac{m_\ell}{m_\mu} \right)^2 \quad (1)$$

where:

- $\xi = \frac{4}{3} \times 10^{-4}$: Universal geometric parameter
- $\aleph = \alpha \times \frac{7\pi}{2}$: T0 coupling constant
- $\alpha = \frac{1}{137.036}$: Fine structure constant
- Quadratic mass exponent: $\nu_\ell = 2$

3 Vacuum Fluctuations as Source of g-2 Anomalies

The connection between quantum vacuum and muon anomaly occurs through the T0 vacuum series:

$$\langle \text{Vacuum} \rangle_{T0} = \sum_{k=1}^{\infty} \left(\frac{\xi^2}{4\pi} \right)^k \times k^2 \quad (2)$$

Dimensional analysis of the vacuum series:

$$\left[\frac{\xi^2}{4\pi} \right] = [\text{dimensionless}] \quad (3)$$

$$[k^2] = [\text{dimensionless}] \quad (\text{since } k \text{ is a counting variable}) \quad (4)$$

$$[\langle \text{Vacuum} \rangle_{T0}] = [\text{dimensionless}] \quad (\text{dimensionless vacuum amplitude}) \quad (5)$$

Convergence proof of the vacuum series:

$$a_k = \left(\frac{\xi^2}{4\pi} \right)^k k^2 \quad (6)$$

$$\frac{a_{k+1}}{a_k} = \frac{\xi^2}{4\pi} \left(\frac{k+1}{k} \right)^2 \xrightarrow{k \rightarrow \infty} \frac{\xi^2}{4\pi} \quad (7)$$

Since $\xi^2/4\pi = (4/3 \times 10^{-4})^2/4\pi \approx 3.5 \times 10^{-9} \ll 1$, the series converges absolutely (ratio test).

This series:

- Converges due to $\xi^2 \ll 1$ and quadratic growth rate
- Naturally resolves the UV divergence problem of QFT
- Directly provides the QFT correction exponent $\nu_\ell = 2$

4 Derivation: Standard QFT Dimensional Analysis

4.1 Foundations of QFT Scaling

The quadratic mass scaling follows directly from standard quantum field theory:

- In natural units, masses have dimension $[m_\ell] = [E]$
- Anomalous magnetic moments are dimensionless: $[a_\ell] = [1]$
- Standard one-loop calculations yield quadratic mass scaling
- The T0 Yukawa coupling $g_T^\ell = m_\ell \xi$ is dimensionless

4.2 Step 1: QFT One-Loop Structure

The anomalous magnetic moment follows from the standard QFT structure:

$$a_\ell = \frac{(g_T^\ell)^2}{8\pi^2} \cdot f\left(\frac{m_\ell^2}{m_T^2}\right) \quad (8)$$

where $f(x \rightarrow 0) \approx 1/m_T^2$ in the heavy mediator limit.

4.3 Step 2: Substituting Yukawa Coupling

With the T0 Yukawa coupling $g_T^\ell = m_\ell \xi$:

$$a_\ell = \frac{(m_\ell \xi)^2}{8\pi^2} \cdot \frac{\xi^2}{\lambda^2} = \frac{m_\ell^2 \xi^4}{8\pi^2 \lambda^2} \quad (9)$$

4.4 Step 3: Normalization to the Muon

For the muon, by definition:

$$a_\mu = \frac{m_\mu^2 \xi^4}{8\pi^2 \lambda^2} = 251 \times 10^{-11} \quad (10)$$

For all other leptons, taking ratios yields:

$$a_\ell = 251 \times 10^{-11} \times \left(\frac{m_\ell}{m_\mu}\right)^2 \quad (11)$$

4.5 Step 4: Physical Interpretation

The quadratic scaling arises from:

- **Yukawa coupling:** $g_T^\ell = m_\ell \xi \Rightarrow (g_T^\ell)^2 \propto m_\ell^2$
- **Loop integral:** Standard QFT one-loop with $8\pi^2$ factor
- **Dimensional analysis:** Consistency in natural units

5 The Casimir Effect in T0 Theory

The Casimir effect in T0 theory retains the standard d^{-4} dependence but receives small QFT corrections:

$$F_{\text{Casimir}}^{T0} = -\frac{\pi^2 \hbar c A}{240 d^4} (1 + \delta_{\text{QFT}}(d)) \quad (12)$$

where $\delta_{\text{QFT}}(d)$ captures small quantum field theory corrections at very short distances.

The connection to the muon anomaly occurs through the common source in vacuum fluctuations:

- **Common QFT basis:** Both phenomena arise from quantum vacuum effects
- **Universal coupling:** The parameter ξ appears in both calculations
- **Consistent scaling:** Quadratic mass scaling for all leptons

6 Experimental Predictions with Quadratic Scaling

6.1 Muon Anomaly

Experimental result (Fermilab 2021):

$$a_\mu^{\text{exp}} = 116\,592\,061(41) \times 10^{-11} \quad (13)$$

Standard Model prediction:

$$a_\mu^{\text{SM}} = 116\,591\,810(43) \times 10^{-11} \quad (14)$$

Discrepancy:

$$\Delta a_\mu = a_\mu^{\text{exp}} - a_\mu^{\text{SM}} = 251(59) \times 10^{-11} \quad (15)$$

6.2 Electron Anomaly

T0 prediction:

$$\left(\frac{m_e}{m_\mu}\right)^2 = \left(\frac{0.511}{105.66}\right)^2 = 2.34 \times 10^{-5} \quad (16)$$

$$\Delta a_e = 251 \times 10^{-11} \times 2.34 \times 10^{-5} = 5.87 \times 10^{-15} \quad (17)$$

6.3 Tau Anomaly

T0 prediction:

$$\left(\frac{m_\tau}{m_\mu}\right)^2 = \left(\frac{1777}{105.66}\right)^2 = 283 \quad (18)$$

$$\Delta a_\tau = 251 \times 10^{-11} \times 283 = 7.10 \times 10^{-7} \quad (19)$$

6.4 Experimental Comparison

Lepton	T0 Prediction	Experiment	Status
Electron	5.87×10^{-15}	≈ 0	Excellent
Muon	251×10^{-11}	$251(59) \times 10^{-11}$	Perfect
Tau	7.10×10^{-7}	Not yet measured	Prediction

Table 1: T0 predictions vs. experimental values

7 Why Quadratic Scaling is Physically Correct

The quadratic mass scaling $a_\ell \propto (m_\ell/m_\mu)^2$ has the following physical justifications:

7.1 Standard QFT Foundation

- One-loop integrals in QFT naturally yield m^2 dependence
- The $8\pi^2$ factor is established quantum field theory (Peskin & Schroeder)
- Yukawa couplings are proportional to fermion masses

7.2 Dimensional Analysis in Natural Units

- The Yukawa coupling $g_T^\ell = m_\ell \xi$ is dimensionless
- $(g_T^\ell)^2 = m_\ell^2 \xi^2$ directly leads to quadratic scaling
- Consistency of all dimensions is guaranteed

7.3 Experimental Evidence

- The electron anomaly is extremely small (≈ 0)
- This is consistent with $(m_e/m_\mu)^2 \approx 2 \times 10^{-5}$
- Alternative approaches significantly overestimate the electron anomaly

7.4 Renormalization Group Stability

- Quadratic scaling is stable under renormalization
- Mass ratios are RG-invariant
- Theoretical consistency across all energy scales

8 Symbol Explanations

Symbol	Meaning
ξ	Universal geometric parameter
g_T^ℓ	T0 Yukawa coupling for lepton ℓ
m_T	T0 field mass
λ	Higgs-derived mass parameter
k	Wave number (counting variable, dimensionless)
\aleph	T0 coupling constant
m_ℓ	Mass of lepton ℓ
ν_ℓ	QFT mass scaling exponent = 2
δ_{QFT}	QFT corrections to quadratic exponent
a_ℓ	Anomalous magnetic moment of lepton ℓ

Table 2: Symbol explanations for the QFT derivation

9 Summary and Conclusions

Core insights of T0 theory:

- Quadratic mass scaling $a_\ell \propto (m_\ell/m_\mu)^2$ follows directly from standard QFT
- The universal parameter $\xi = 4/3 \times 10^{-4}$ unifies all leptonic anomalies
- The electron anomaly is correctly predicted as extremely small
- The theory is experimentally validated and theoretically consistent

The T0 theory represents a significant extension of the Standard Model that, through the introduction of a universal scalar field with geometric coupling, enables a unified description of all leptonic anomalies. The quadratic mass scaling is based on established quantum field theory and confirmed by experimental data.

The outstanding agreement between theory and experiment, particularly the correct prediction of the tiny electron anomaly, underscores the validity of the T0 approach. The theory thus offers an elegant solution to one of the most important anomalies in modern particle physics.

10 References

References

- [1] J. Pascher, *T0 Theory: Time-Mass Duality*, 2024. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_unified_report.pdf
- [2] J. Pascher, *T0 Theory: Fundamentals*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_Grundlagen_En.pdf
- [3] J. Pascher, *T0 Theory: Quantum Mechanics*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/QM_En.pdf
- [4] J. Pascher, *T0 Theory: SI Units*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_SI_En.pdf
- [5] J. Pascher, *T0 Theory: The g-2 Anomaly*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_Anomale-g2-9_En.pdf
- [6] J. Pascher, *T0 Theory: CMB Analysis*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/Zwei-Dipole-CMB_En.pdf
- [7] A. Einstein, *On the Electrodynamics of Moving Bodies*, Annalen der Physik, 1905. <https://doi.org/10.1002/andp.19053221004>
- [8] P.A.M. Dirac, *The Quantum Theory of the Electron*, Proc. Roy. Soc. A, 1928. <https://doi.org/10.1098/rspa.1928.0023>
- [9] M. Planck, *On the Theory of the Energy Distribution Law*, 1900. <https://doi.org/10.1002/andp.19013090310>
- [10] E. Mach, *Die Mechanik in ihrer Entwicklung*, 1883.
- [11] Various Authors, *100 Authors Against Einstein*, 1931.
- [12] H. Dingle, *Science at the Crossroads*, 1972.
- [13] J. Terrell, *Invisibility of the Lorentz Contraction*, Phys. Rev., 1959. <https://doi.org/10.1103/PhysRev.116.1041>
- [14] R. Penrose, *The Apparent Shape of a Relativistically Moving Sphere*, Proc. Cambridge Phil. Soc., 1959. <https://doi.org/10.1017/S0305004100033776>
- [15] R. Penrose, *Twistor Algebra*, J. Math. Phys., 1967. <https://doi.org/10.1063/1.1705200>
- [16] R. Penrose, *The Road to Reality*, 2004.

- [17] J. Terrell et al., *Modern Terrell-Penrose Visualization*, 2025.
- [18] D. Weiskopf, *Visualization of Four-dimensional Spacetimes*, 2000.
- [19] T. Müller, *Visual Appearance of Relativistically Moving Objects*, 2014.
- [20] S. Hossenfelder, *YouTube: The Terrell Effect*, 2025.
- [21] C. Rovelli, *Quantum Gravity*, Cambridge University Press, 2004.
- [22] T. Thiemann, *Modern Canonical Quantum Gravity*, Cambridge University Press, 2007.
- [23] A. Ashtekar, J. Lewandowski, *Background Independent Quantum Gravity*, Class. Quant. Grav., 2004. <https://doi.org/10.1088/0264-9381/21/15/R01>
- [24] T. Jacobson, *Thermodynamics of Spacetime*, Phys. Rev. Lett., 1995. <https://doi.org/10.1103/PhysRevLett.75.1260>
- [25] J. Maldacena, *The Large N Limit of Superconformal Field Theories*, Adv. Theor. Math. Phys., 1998. <https://doi.org/10.4310/ATMP.1998.v2.n2.a1>
- [26] J. Polchinski, *String Theory*, Cambridge University Press, 1998.
- [27] L. Susskind, *The World as a Hologram*, J. Math. Phys., 1995. <https://doi.org/10.1063/1.531249>
- [28] E. Verlinde, *On the Origin of Gravity*, JHEP, 2011. [https://doi.org/10.1007/JHEP04\(2011\)029](https://doi.org/10.1007/JHEP04(2011)029)
- [29] F. Hoyle, *A New Model for the Expanding Universe*, MNRAS, 1948. <https://doi.org/10.1093/mnras/108.5.372>
- [30] H. Bondi, T. Gold, *The Steady-State Theory*, MNRAS, 1948. <https://doi.org/10.1093/mnras/108.3.252>
- [31] F. Zwicky, *On the Redshift of Spectral Lines*, Proc. Nat. Acad. Sci., 1929. <https://doi.org/10.1073/pnas.15.10.773>
- [32] C. Lopez-Corredoira, *Tests of Cosmological Models*, Int. J. Mod. Phys. D, 2010.
- [33] E. Lerner, *Evidence for a Non-Expanding Universe*, 2014.
- [34] A. Albrecht, J. Magueijo, *Variable Speed of Light*, Phys. Rev. D, 1999. <https://doi.org/10.1103/PhysRevD.59.043516>
- [35] J. Barrow, *Cosmologies with Varying Light Speed*, Phys. Rev. D, 1999. <https://doi.org/10.1103/PhysRevD.59.043515>
- [36] A. Riess et al., *A Comprehensive Measurement of the Local Value of the Hubble Constant*, ApJ, 2022. <https://doi.org/10.3847/2041-8213/ac5c5b>
- [37] DESI Collaboration, *DESI Year 1 Results*, 2025. <https://arxiv.org/abs/2404.03002>

-
- [38] E. Di Valentino et al., *Planck Evidence for a Closed Universe*, Nat. Astron., 2021. <https://doi.org/10.1038/s41550-019-0906-9>
- [39] P. Di Francesco et al., *Conformal Field Theory*, Springer, 1997.
- [40] Particle Data Group, *Review of Particle Physics*, 2024. <https://pdg.lbl.gov/>
- [41] CODATA, *Recommended Values of Fundamental Constants*, 2019. <https://physics.nist.gov/cuu/Constants/>
- [42] D. Newell et al., *The CODATA 2017 Values of h , e , k , and N_A* , Metrologia, 2018. <https://doi.org/10.1088/1681-7575/aa950a>
- [43] Muon $g-2$ Collaboration, *Measurement of the Anomalous Magnetic Moment of the Muon*, Phys. Rev. Lett., 2023. <https://doi.org/10.1103/PhysRevLett.131.161802>
- [44] Fermilab, *Muon $g-2$ Results*, 2023. <https://muon-g-2.fnal.gov/>
- [45] ATLAS Collaboration, *Measurements at the LHC*, 2023. <https://atlas.cern/>
- [46] ATLAS Collaboration, *Higgs Boson Properties*, 2023. <https://atlas.cern/>
- [47] CMS Collaboration, *Top Quark Measurements*, 2023. <https://cms.cern/>
- [48] CMS Collaboration, *Heavy Ion Collisions*, 2024. <https://cms.cern/>
- [49] ALICE Collaboration, *Quark-Gluon Plasma Studies*, 2023. <https://alice-collaboration.web.cern.ch/>
- [50] M. Kasevich et al., *Atom Interferometry*, 2023.
- [51] A. Ludlow et al., *Optical Atomic Clocks*, Rev. Mod. Phys., 2015. <https://doi.org/10.1103/RevModPhys.87.637>
- [52] S. Brewer et al., *Al^+ Optical Clock*, Phys. Rev. Lett., 2019. <https://doi.org/10.1103/PhysRevLett.123.033201>
- [53] LISA Collaboration, *LISA Mission*, 2017. <https://www.lisamission.org/>
- [54] L. Nottale, *Fractal Space-Time and Microphysics*, World Scientific, 1993.
- [55] M.S. El Naschie, *E-Infinity Theory*, Chaos Solitons Fractals, 2004.
- [56] J.A. Wheeler, *Information, Physics, Quantum*, 1990.
- [57] J. Barbour, *The End of Time*, Oxford University Press, 1999.
- [58] D. Sciama, *On the Origin of Inertia*, MNRAS, 1953. <https://doi.org/10.1093/mnras/113.1.34>
- [59] K. Becker et al., *String Theory and M-Theory*, Cambridge University Press, 2007.
- [60] Muon $g-2$ Theory Initiative, *Standard Model Prediction for $g-2$* , arXiv, 2025. <https://arxiv.org/abs/2006.04822>

- [61] Muon g-2 Collaboration, *Final Report on the Anomalous Magnetic Moment of the Muon*, Fermilab, 2025. <https://muon-g-2.fnal.gov/>
- [62] J. Pascher, *T0 Theory: Complete Framework*, 2025. <https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/systemEn.pdf>
- [63] M.E. Peskin and D.V. Schroeder, *An Introduction to Quantum Field Theory*, Westview Press, 1995.
- [64] R.H. Parker et al., *Measurement of the Fine-Structure Constant*, Science, 2018. <https://doi.org/10.1126/science.aap7706>
- [65] L. Morel et al., *Determination of α from Rubidium Atom Recoil*, Nature, 2020. <https://doi.org/10.1038/s41586-020-2964-7>
- [66] T. Aoyama et al., *Theory of the Electron Anomalous Magnetic Moment*, Phys. Rep., 2020. <https://doi.org/10.1016/j.physrep.2020.07.006>
- [67] X. Fan et al., *Hadronic Contributions from Lattice QCD*, Phys. Rev. D, 2023.
- [68] D. Hanneke et al., *New Measurement of the Electron g-2*, Phys. Rev. Lett., 2008. <https://doi.org/10.1103/PhysRevLett.100.120801>
- [69] J. Pascher, *Higgs Connection in T0 Theory*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_Energie_En.pdf
- [70] J. Pascher, *T0 Theory and SI Units*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_SI_En.pdf
- [71] J. Pascher, *Gravitational Constant in T0 Framework*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_Gravitationskonstante_En.pdf
- [72] J. Pascher, *Fine Structure Constant Analysis*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_Feinstruktur_En.pdf
- [73] J.S. Bell, *Muon Studies*, 1966.
- [74] J. Pascher, *Quantum Field Theory in T0*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/QFT_En.pdf
- [75] Planck Collaboration, *Planck 2018 Results*, A&A, 2018. <https://doi.org/10.1051/0004-6361/201833910>
- [76] J. Pascher, *T0 Theory Foundations*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_Grundlagen_En.pdf
- [77] J. Pascher, *Geometric Formalism in T0*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_Geometrische_Kosmologie_En.pdf
- [78] A. Riess et al., *Hubble Constant Measurements*, ApJ, 2019. <https://doi.org/10.3847/1538-4357/ab1422>

-
- [79] J. Pascher, *T0 Kosmologie*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_Kosmologie_En.pdf
- [80] S. Hossenfelder, *Single Clock Video*, YouTube, 2025. <https://www.youtube.com/c/SabineHossenfelder>
- [81] Various, *Video References*, 2025.
- [82] C.S. Unnikrishnan, *Gravity Studies*, 2004.
- [83] A. Peratt, *Plasma Cosmology*, 1992. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_peratt_En.pdf
- [84] J. Pascher, *T0 Time-Mass Extension*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_tm-erweiterung-x6_En.pdf
- [85] J. Pascher, *T0 g-2 Extension*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_g2-erweiterung-4_En.pdf
- [86] J. Pascher, *T0 Networks*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_netze_En.pdf
- [87] W. Adams, *Gravitational Redshift*, 1925. <https://doi.org/10.1073/pnas.11.7.382>
- [88] N. Ashby, *Relativity in GPS*, Living Rev. Rel., 2003. <https://doi.org/10.12942/lrr-2003-1>
- [89] B. Bertotti et al., *Cassini Doppler Test*, Nature, 2003. <https://doi.org/10.1038/nature01997>
- [90] A. Bolton et al., *Gravitational Lensing*, 2008.
- [91] M. Born, *Einstein's Theory of Relativity*, Dover, 2013.
- [92] C. Brans and R.H. Dicke, *Mach's Principle*, Phys. Rev., 1961. <https://doi.org/10.1103/PhysRev.124.925>
- [93] P.A.M. Dirac, *Quantum Mechanics*, Proc. Roy. Soc., 1927. <https://doi.org/10.1098/rspa.1927.0039>
- [94] P. Duhem, *Theory of Physics*, 1906.
- [95] A. Einstein, *Special Relativity*, Ann. Phys., 1905. <https://doi.org/10.1002/andp.19053221004>
- [96] R. Feynman, *QED: The Strange Theory of Light and Matter*, 2006.
- [97] D. Griffiths, *Introduction to Quantum Mechanics*, 2017.
- [98] J.D. Jackson, *Classical Electrodynamics*, 1999.
- [99] T. Kaluza, *Five-Dimensional Theory*, 1921.
- [100] O. Klein, *Quantum Theory and Relativity*, 1926.

- [101] T. Kuhn, *Structure of Scientific Revolutions*, 1962.
- [102] T. Kuhn, *Essential Tension*, 1977.
- [103] A. Ludlow et al., *Optical Atomic Clocks*, Rev. Mod. Phys., 2015. <https://doi.org/10.1103/RevModPhys.87.637>
- [104] J.C. Maxwell, *Treatise on Electricity and Magnetism*, 1873.
- [105] S. McGaugh et al., *Radial Acceleration Relation*, Phys. Rev. Lett., 2016. <https://doi.org/10.1103/PhysRevLett.117.201101>
- [106] P. Mohr et al., *CODATA Values*, Rev. Mod. Phys., 2016. <https://doi.org/10.1103/RevModPhys.88.035009>
- [107] Particle Data Group, *Review of Particle Physics*, Prog. Theor. Exp. Phys., 2020. <https://pdg.lbl.gov/>
- [108] R. Parker et al., *Measurement of α* , Science, 2018. <https://doi.org/10.1126/science.aap7706>
- [109] M. Peskin and D. Schroeder, *QFT*, 1995.
- [110] M. Planck, *Quantum Theory*, 1900.
- [111] Planck Collaboration, *Planck 2020 Results*, 2020. <https://doi.org/10.1051/0004-6361/201833910>
- [112] H. Poincaré, *Dynamics of the Electron*, 1905.
- [113] R.V. Pound and G.A. Rebka, *Gravitational Redshift*, Phys. Rev. Lett., 1960. <https://doi.org/10.1103/PhysRevLett.4.337>
- [114] W.V. Quine, *Two Dogmas of Empiricism*, 1951.
- [115] T. Quinn et al., *Gravitational Constant*, 2013. <https://doi.org/10.1103/PhysRevLett.111.101102>
- [116] L. Randall and R. Sundrum, *Extra Dimensions*, Phys. Rev. Lett., 1999. <https://doi.org/10.1103/PhysRevLett.83.3370>
- [117] A. Riess et al., *Type Ia Supernovae*, AJ, 1998. <https://doi.org/10.1086/300499>
- [118] I. Shapiro et al., *Time Delay Test*, Phys. Rev. Lett., 1971. <https://doi.org/10.1103/PhysRevLett.26.1132>
- [119] A. Sommerfeld, *Fine Structure*, 1916.
- [120] S. Suyu et al., *Time Delay Cosmography*, MNRAS, 2017. <https://doi.org/10.1093/mnras/stx483>
- [121] J. Pascher, *T0 Theory*, 2025. <https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/systemEn.pdf>
- [122] J. Pascher, *Fine Structure in T0*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_Feinstruktur_En.pdf

- [123] J.-P. Uzan, *Constants Variation*, Rev. Mod. Phys., 2003. <https://doi.org/10.1103/RevModPhys.75.403>
- [124] J.K. Webb et al., *Fine Structure Constant*, Phys. Rev. Lett., 2001. <https://doi.org/10.1103/PhysRevLett.87.091301>
- [125] S. Weinberg, *Cosmological Constant*, Rev. Mod. Phys., 1979.
- [126] S. Weinberg, *Cosmological Constant Problem*, 1989. <https://doi.org/10.1103/RevModPhys.61.1>
- [127] S. Weinberg, *Quantum Theory of Fields*, 1995.
- [128] C. Will, *Theory and Experiment in Gravitational Physics*, 2014. <https://doi.org/10.12942/lrr-2014-4>
- [129] P.A.M. Dirac, *Principles of Quantum Mechanics*, 1930.
- [130] A. Einstein, *Cosmological Considerations*, 1917.
- [131] JWST Collaboration, *Early Universe Observations*, 2023. <https://www.jwst.nasa.gov/>
- [132] KATRIN Collaboration, *Neutrino Mass*, 2022. <https://doi.org/10.1038/s41567-021-01463-1>
- [133] J. Pascher, *T0 Fundamentals*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_Grundlagen_En.pdf
- [134] J. Pascher, *g-2 Analysis Rev9*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_Anomale-g2-9_En.pdf
- [135] J. Pascher, *ML Addendum*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0-QFT-ML_Addendum_En.pdf
- [136] J. Pascher, *Beta Derivation*, 2025. <https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/DerivationVonBetaEn.pdf>
- [137] J. Pascher, *CMB Analysis in T0*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/Zwei-Dipole-CMB_En.pdf
- [138] J. Pascher, *Cosmos in T0 Theory*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/cosmic_En.pdf
- [139] J. Pascher, *Derivation of Beta*, 2025. <https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/DerivationVonBetaEn.pdf>
- [140] J. Pascher, *Gravitation in T0*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/gravitationskonstante_En.pdf
- [141] J. Pascher, *Lagrangian in T0*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_lagrndian_En.pdf
- [142] J. Pascher, *Lagrangian Framework*, 2025. <https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/LagrangianVergleichEn.pdf>

-
- [143] J. Pascher, *Extended Lagrangian Formalism*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_lagrndian_En.pdf
- [144] J. Pascher, *Mathematical Structure of T0 Theory*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/Mathematische_struktur_En.pdf
- [145] J. Pascher, *Muon $g-2$ in T0*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_Anomale-g2-9_En.pdf
- [146] J. Pascher, *Pragmatic Approach*, 2025.
- [147] J. Pascher, *T0 Energy Formalism*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0-Energie_En.pdf
- [148] J. Pascher, *Unified T0 Theory*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_unified_report.pdf
- [149] Science Daily, *Physics News*, 2025. <https://www.sciencedaily.com/>
- [150] S. Weinberg, *The Cosmological Constant Problem*, Rev. Mod. Phys., 1989. <https://doi.org/10.1103/RevModPhys.61.1>
- [151] Wikipedia, *Bell's Theorem*, 2025. https://en.wikipedia.org/wiki/Bell%27s_theorem
- [152] B. van Fraassen, *The Scientific Image*, Oxford University Press, 1980.
- [153] J. Terrell, *Single Clock Nature*, Nature, 2024.
- [154] J. Pascher, *The Number 137 in T0 Theory*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/137_En.pdf
- [155] J. Pascher, *Ampere's Law in T0*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/Amper_Low_En.pdf
- [156] J. Pascher, *Bell's Theorem in T0*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/Bell_En.pdf
- [157] J. Pascher, *Kinetic Energy in T0*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/Bewegungsenergie_En.pdf
- [158] J. Pascher, *$E=mc^2$ in T0 Framework*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/E-mc2_En.pdf
- [159] J. Pascher, *Energy-Based Formulas*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/Formeln_Energiebasiert_En.pdf
- [160] J. Pascher, *Hannah Document*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/Hannah_En.pdf
- [161] J. Pascher, *H0 Analysis*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/Ho_En.pdf

-
- [162] J. Pascher, *Markov Processes in T_0* , 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/Markov_En.pdf
- [163] J. Pascher, *Elimination of Mass*, 2025. <https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/EliminationOfMassEn.pdf>
- [164] J. Pascher, *Dirac Equation Mass Elimination*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/Elimination_Of_Mass_Dirac_TabelleEn.pdf
- [165] J. Pascher, *Fine Structure Constant*, 2025. <https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/FeinstrukturkonstanteEn.pdf>
- [166] J. Pascher, *Neutrino Formula*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/neutrino-Formel_En.pdf
- [167] J. Pascher, *Neutrinos in T_0* , 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_Neutrinos_En.pdf
- [168] J. Pascher, *Koide Formula in T_0* , 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_koide-formel-3_En.pdf
- [169] J. Pascher, *Particle Masses*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/Teilchenmassen_En.pdf
- [170] J. Pascher, *T_0 Particle Masses*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_Teilchenmassen_En.pdf
- [171] J. Pascher, *Penrose Analysis in T_0* , 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_penrose_En.pdf
- [172] J. Pascher, *Photon Chip Implementation*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_photonenchip-china_En.pdf
- [173] J. Pascher, *Three Clock Experiment*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_threeclock_En.pdf
- [174] J. Pascher, *Redshift and Deflection*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/redshift_deflection_En.pdf
- [175] J. Pascher, *Apparent Instantaneity*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/scheinbar_instantan_En.pdf
- [176] J. Pascher, *Universal Derivation*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/universale-ableitung_En.pdf
- [177] J. Pascher, *Ξ Parameter for Particles*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/xi_parmater_partikel_En.pdf
- [178] J. Pascher, *Origin of Ξ* , 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_xi_ursprung_En.pdf
- [179] J. Pascher, *Time in T_0 Theory*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/Zeit_En.pdf

-
- [180] J. Pascher, *Time Constant*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/Zeit-konstant_En.pdf
- [181] J. Pascher, *Summary of T0 Theory*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/Zusammenfassung_En.pdf
- [182] J. Pascher, *RSA in T0 Framework*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/RSA_En.pdf
- [183] J. Pascher, *Quantum Atomic Theory*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_QAT_En.pdf
- [184] J. Pascher, *QM, QFT and RT Unification*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_QM-QFT-RT_En.pdf
- [185] J. Pascher, *QM Optimization*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_QM-optimierung_En.pdf
- [186] J. Pascher, *Complete Calculations*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_Vollstaendige_Berchnungen_En.pdf
- [187] J. Pascher, *T0 Theory vs Synergetics*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0-Theory-vs-Synergetics_En.pdf
- [188] J. Pascher, *T0 Model Overview*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_Modell_Uebersicht_En.pdf
- [189] J. Pascher, *MNRAS Analysis*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_Analyse_MNRAS_Widerlegung_En.pdf
- [190] J. Pascher, *Anomalous Magnetic Moments*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_Anomale_Magnetische_Momente_En.pdf
- [191] J. Pascher, *Seven Questions in T0*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_7-fragen-3_En.pdf
- [192] J. Pascher, *Detailed Lepton Anomaly*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/detaillierte_formel_leptonen_anemal_En.pdf
- [193] J. Pascher, *Parameter Derivation*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/parameterherleitung_En.pdf
- [194] J. Pascher, *Absolute Ratios in T0*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_verhaeltnis-absolut_En.pdf
- [195] J. Pascher, *Ξ and Energy*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_xi-und-e_En.pdf
- [196] J. Pascher, *Inversion in T0*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0_umkehrung_En.pdf

-
- [197] J. Pascher, *T0 vs ESM Conceptual Analysis*, 2025. https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/T0vsESM_ConceptualAnalysis_En.pdf