

Lagrangian

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Capitolo 1

Lagrangian

Sommario

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

$$T(x, t) \cdot m(x, t) = 1 \quad (1.1)$$

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:

$$\boxed{\xi = \frac{4}{3} \times 10^{-4} = 1.333 \times 10^{-4}} \quad (1.2)$$

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

$$\xi^2 = (1.333 \times 10^{-4})^2 = 1.777 \times 10^{-8} \quad (1.3)$$

$$\xi^4 = (1.333 \times 10^{-4})^4 = 3.160 \times 10^{-16} \quad (1.4)$$

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:

$$\mathcal{L}_{\text{Interaction}} = g_T^\ell \bar{\psi}_\ell \psi_\ell \Delta m \quad (1.5)$$

$$g_T^\ell = \xi m_\ell \quad (1.6)$$

1.3.2 Complete Extended Lagrangian

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

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:

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

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

$$\Delta a_\ell \approx \frac{(g_T^\ell)^2}{8\pi^2 m_T^2} \int_0^1 dx (1-x)(1-x^2) \quad (1.9)$$

$$= \frac{(\xi m_\ell)^2}{8\pi^2 m_T^2} \cdot \frac{5}{12} = \frac{5\xi^2 m_\ell^2}{96\pi^2 m_T^2} \quad (1.10)$$

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

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

1.4.2 Final T0 Formula

The completely derived T0 contribution formula is:

$$\Delta a_\ell^{\text{T0}} = 2.246 \times 10^{-13} \cdot m_\ell^2 \quad (1.12)$$

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

$$\Delta a_\mu^{\text{T0}} = 2.246 \times 10^{-13} \cdot (105.658)^2 = 2.51 \times 10^{-9} \quad (1.13)$$

$$\Delta a_e^{\text{T0}} = 2.246 \times 10^{-13} \cdot (0.511)^2 = 5.86 \times 10^{-14} \quad (1.14)$$

$$\Delta a_\tau^{\text{T0}} = 2.246 \times 10^{-13} \cdot (1776.86)^2 = 7.09 \times 10^{-7} \quad (1.15)$$

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:

$$\Delta a_\mu^{\text{T0}} = 2.51 \times 10^{-9} = 251 \times 10^{-11} \quad (1.16)$$

T0 Interpretation of Experimental Evolution:

The reduction from 4.2σ to 0.6σ 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

$$\Delta a_e^{\text{T0}} = 5.86 \times 10^{-14} = 0.0586 \times 10^{-12} \quad (1.17)$$

Experimental comparisons:

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

T0 effect is below current measurement precision.

1.6.3 Tau g-2 Prediction

$$\Delta a_\tau^{\text{T0}} = 7.09 \times 10^{-7} \quad (1.18)$$

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

Tabella 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:

$$\frac{\Delta a_e^{\text{T0}}}{\Delta a_\mu^{\text{T0}}} = \left(\frac{m_e}{m_\mu} \right)^2 = 2.34 \times 10^{-5} \quad (1.19)$$

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

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:** $\Delta a_\ell^{\text{T0}} \propto m_\ell^2$ 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

Bibliografia

- [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, *T_0 Theory*, 2025. <https://github.com/jpascher/T0-Time-Mass-Duality/blob/main/2/pdf/systemEn.pdf>
- [122] J. Pascher, *Fine Structure in T_0* , 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_anomal_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, *Xi 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