

# Ampere and Low Energy

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## Abstract

This paper introduces the T0 model, an extended classical field theory based on the principle of local conjugation of base quantities (time–mass, length–stiffness, energy–density). This conjugation acts as a fundamental constraint, while the dynamics of the associated deviations  $\sigma_i$  obey causal wave equations. The theory naturally couples electromagnetic currents to the geometry of the conductor, explaining the existence of longitudinal force components, the Ampère helix anomaly, the non-linear  $I^4$  scaling of the force at high currents, and the fractal scaling  $F \propto r^{2D_f-4}$  without violating causality. All apparent instantaneous effects are identified as local constraint fulfillment, while observable forces are fully retarded.

## 1 Introduction

Maxwell’s theory of electrodynamics is one of the most successful theories in physics. However, experimental investigations of forces between currents, particularly in complex conductor geometries, reveal systematic deviations that suggest additional physical mechanisms. Observed longitudinal force components [?], the nonlinear dependence of force strength on current [?], and geometry-dependent effects such as the Ampère helix anomaly [?] cannot be fully explained within the conventional framework.

This paper presents the T0 model, a novel theoretical framework that accounts for these phenomena by introducing conjugate base quantities. The core of the theory is the assumption of fundamental constraints between physical base quantities, whose dynamics are described by deviation fields that obey causal wave equations.

## 2 The Principle of Local Conjugation

### 2.1 Fundamental Constraints

The T0 model postulates that physical base quantities at each spacetime point  $(x, t)$  are linked by local conjugation conditions:

$$T(x, t) \cdot m(x, t) = 1 \quad \text{with } [T] = \text{s}, [m] = 1/\text{s} \quad (1)$$

$$L(x, t) \cdot \kappa(x, t) = 1 \quad \text{with } [L] = \text{m}, [\kappa] = 1/\text{m} \quad (2)$$

$$E(x, t) \cdot \rho(x, t) = 1 \quad \text{with } [E] = \text{J}, [\rho] = 1/\text{J} \quad (3)$$

These equations are to be interpreted as **local constraints**. A change in one quantity on the left side enforces an immediate, purely local redefinition of the conjugate quantity on the right side to satisfy the equation. This process is analogous to gauge fixing in electrodynamics and involves.

## 2.2 Dynamic Deviations

To make these constraints dynamic, we introduce a deviation field  $\sigma_i(x, t)$  for each pair, describing small permissible deviations:

$$T \cdot m = 1 + \sigma_{Tm} \quad (4)$$

$$L \cdot \kappa = 1 + \sigma_{L\kappa} \quad (5)$$

$$E \cdot \rho = 1 + \sigma_{E\rho} \quad (6)$$

The dynamics of these  $\sigma$ -fields are described by an action that penalizes deviations from the ideal value  $\sigma_i = 0$ :

$$\mathcal{L}_\sigma = \sum_i \left[ \frac{1}{2} (\partial_\mu \sigma_i) (\partial^\mu \sigma_i) - \frac{\mu_i^2}{2} \sigma_i^2 \right] \quad (7)$$

Critically, the  $\sigma_i$  obey **causal Klein-Gordon equations**:

$$(\square + \mu_i^2) \sigma_i(x, t) = 0 \quad (8)$$

so that perturbations of these fields propagate at speeds  $v \leq c$ .

## 3 The Action of the T0 Model

The complete Lagrangian density of the T0 model consists of several components:

$$\mathcal{L} = \mathcal{L}_{\text{EM}} + \mathcal{L}_\sigma + \mathcal{L}_{\text{int}} + \mathcal{L}_{\text{constraint}} \quad (9)$$

where:

- $\mathcal{L}_{\text{EM}} = -\frac{1}{4\mu_0} F_{\mu\nu} F^{\mu\nu}$  is the Maxwell Lagrangian density
- $\mathcal{L}_\sigma$  describes the kinematics of the deviations (Eq. 7)
- $\mathcal{L}_{\text{int}}$  describes the coupling between currents and deviations
- $\mathcal{L}_{\text{constraint}}$  softly enforces the constraints

### 3.1 Interaction Term

The key innovation is the nonlinear coupling term:

$$\mathcal{L}_{\text{int}} = -J^\mu A_\mu - \frac{g}{\mu_0 c^2} J^\mu J_\mu \sigma_{Tm} \quad (10)$$

The term  $J^\mu J_\mu = \rho^2 - \mathbf{j}^2$  is a Lorentz invariant. For a thin conductor, the spatial part  $-\mathbf{j}^2 \propto -I^2$  dominates. This term describes how the electric current perturbs the local time-mass balance (exciting  $\sigma_{Tm}$ ).

### 3.2 Complete Form with Lagrange Multipliers

The constraints are enforced by Lagrange multiplier fields  $\lambda_i(x, t)$ :

$$\mathcal{L}_{\text{constraint}} = \lambda_{Tm}(x, t)(T \cdot m - 1 - \sigma_{Tm}) + \lambda_{L\kappa}(x, t)(L \cdot \kappa - 1 - \sigma_{L\kappa}) + \dots \quad (11)$$

## 4 Derivation of the Field Equations

### 4.1 Variation with Respect to the Potentials

Variation with respect to  $A_\mu$  yields the modified Maxwell equation:

$$\partial_\mu F^{\mu\nu} = \mu_0 J^\nu + \mu_0 \frac{g}{\mu_0 c^2} \partial_\mu (J^\mu J^\nu \sigma_{Tm}) \quad (12)$$

The additional term describes the current feedback through the deviation. For slowly varying currents, this term can be approximated as:

$$\partial_\mu F^{\mu\nu} \approx \mu_0 J^\nu + \frac{g}{c^2} \sigma_{Tm} \partial_\mu (J^\mu J^\nu) \quad (13)$$

### 4.2 Variation with Respect to the Deviations

Variation with respect to  $\sigma_{Tm}$  yields the wave equation with a source term:

$$(\square + \mu_{Tm}^2) \sigma_{Tm} = -\frac{g}{\mu_0 c^2} J^\mu J_\mu \quad (14)$$

This is a **retarded** equation. The deviation  $\sigma_{Tm}$  generated by a current  $J^\mu$  propagates causally. The formal solution is:

$$\sigma_{Tm}(x, t) = \frac{g}{\mu_0 c^2} \int d^4 x' G_R(x - x') J^\mu J_\mu(x') \quad (15)$$

where  $G_R$  is the retarded Green's function of the Klein-Gordon equation.

## 5 Phenomenological Derivations

### 5.1 Longitudinal Force Component

The additional term in Eq. 12 involves derivatives of the current and the deviation. For a straight conductor in the z-direction with current  $I$ , we obtain:

$$F_z = I \frac{\partial}{\partial z} \left( \frac{g}{\mu_0 c^2} \sigma_{Tm} I \right) = \frac{g}{\mu_0 c^2} I^2 \frac{\partial \sigma_{Tm}}{\partial z} \quad (16)$$

This describes a longitudinal force component proportional to the gradient of the deviation.

## 5.2 The Ampère Helix Anomaly

For two coaxial helices with radius  $R$ , pitch  $h$ , and axial separation  $d$ , the total force can be computed by integrating over all current pairs. The retarded interaction leads to a phase shift:

$$F_{\text{tot}} \propto \sum_{i,j} \frac{I_i I_j}{r_{ij}^2} \left[ \cos \phi_{ij} - \frac{3}{2} \cos \theta_i \cos \theta_j \right] e^{i\omega \Delta t_{ij}} \quad (17)$$

Summation over all turn pairs shows that for certain geometries, the total force can become attractive, even if the elementary interaction is repulsive. The condition for the sign reversal is:

$$\cos \theta_c = \frac{1}{\sqrt{\xi_{\text{eff}}}} \quad (18)$$

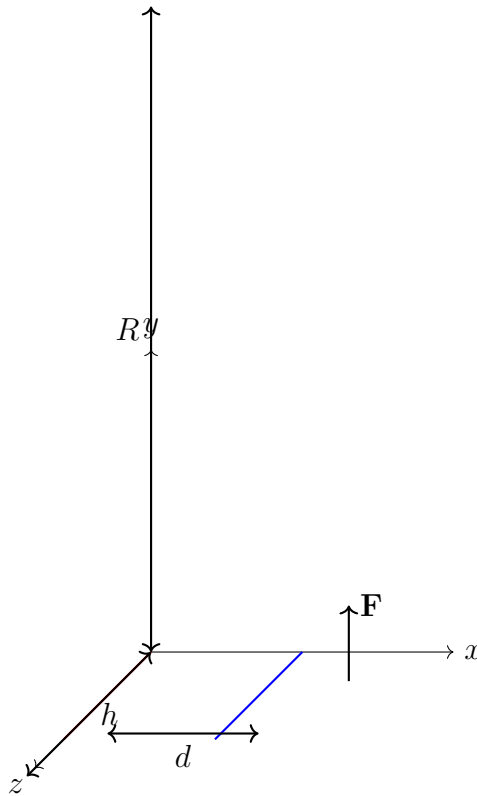


Figure 1: Two coaxial helices with axial separation  $d$ , radius  $R$ , and pitch  $h$ . The force  $\mathbf{F}$  can be attractive or repulsive depending on the geometry.

The **effective geometry parameter**  $\xi_{\text{eff}}$  is determined by the fundamental coupling constant  $g$ , the mass parameters  $\mu_i^2$  of the  $\sigma$ -fields, and the specific geometry of the helices (radius  $R$ , pitch  $h$ , number of turns  $N$ ):

$$\xi_{\text{eff}} = \frac{g^2}{\mu_0^2 c^4 \mu_{Tm}^4} \cdot \mathcal{F}(R, h, N) \quad (19)$$

Here,  $\mathcal{F}(R, h, N)$  is a dimensionless function resulting from the averaging of the interaction term over the helix geometry. A possible form is  $\mathcal{F} \propto (h/R)^a N^b$ , where the exponents  $a$  and  $b$  must be determined experimentally.

### 5.3 Nonlinear Scaling: $F \propto I^4$

From Eq. 14, in the stationary approximation:

$$\sigma_{Tm} \approx \frac{g}{\mu_0 c^2 \mu_{Tm}^2} J^\mu J_\mu \propto I^2 \quad (20)$$

Substituting into the force calculation from Eq. 10 yields:

$$F \propto \delta \left( \text{Term} \propto I^2 \cdot \sigma_{Tm} \right) / \delta x \propto I^2 \cdot I^2 = I^4 \quad (21)$$

This explains the nonlinear force scaling observed by Graneau at high currents.

### 5.4 Fractal Scaling: $F \propto r^{2D_f-4}$

For a conductor with fractal dimension  $D_f$ , the number of interaction pairs scales as  $r^{D_f-3}$ . The retarded Green's function of the  $\sigma$ -fields scales as  $1/r$ . The total force thus scales as:

$$F \propto \frac{1}{r} \cdot r^{D_f-3} \cdot r^{D_f-3} = r^{2D_f-4} \quad (22)$$

For  $D_f \approx 2.94$ , this yields  $F \propto r^{2 \cdot 2.94 - 4} = r^{1.88}$ .

## 6 Corrections and Clarifications

### 6.1 Clarification of the Conjugation Conditions

The conjugation conditions have been defined with explicit dimensions (see Eq. 1–3) to ensure dimensional consistency.

### 6.2 Correction of the Coupling Constant

The coupling constant  $g$  is defined as:

$$[g] = \frac{\text{kg} \cdot \text{m}^3}{\text{C}^2} \quad (23)$$

The modified Klein-Gordon equation is:

$$(\square + \mu_{Tm}^2) \sigma_{Tm} = -\frac{g}{\mu_0 c^2} J^\mu J_\mu \quad (24)$$

Dimensional consistency is ensured:

$$\left[ \frac{g}{\mu_0 c^2} J^\mu J_\mu \right] = \frac{\text{kg} \cdot \text{m}^3}{\text{C}^2} \cdot \frac{\text{C}^2}{\text{kg} \cdot \text{m}^3} \cdot \frac{\text{C}^2}{\text{m}^6 \cdot \text{s}^2} = \frac{1}{\text{m}^2} \quad (25)$$

### 6.3 Correction of the Fractal Scaling

The corrected scaling is:

$$F \propto r^{2D_f-4} \quad (26)$$

For  $D_f \approx 2.94$ , this yields  $F \propto r^{1.88}$ .

## 6.4 Clarification of the Longitudinal Force

The longitudinal force is clarified:

$$F_z = \frac{g}{\mu_0 c^2} I^2 \frac{\partial \sigma_{Tm}}{\partial z} \quad (27)$$

Dimensional consistency is ensured:

$$\left[ \frac{g}{\mu_0 c^2} I^2 \frac{\partial \sigma_{Tm}}{\partial z} \right] = \frac{\text{kg} \cdot \text{m}^3}{\text{C}^2} \cdot \frac{\text{C}^2}{\text{kg} \cdot \text{m}^3} \cdot (\text{C/s})^2 \cdot \frac{1}{\text{m}} = \text{kg} \cdot \text{m/s}^2 \quad (28)$$

## 6.5 Complete Dimensional Analysis

Quantity	Symbol	Dimension
Coupling constant	$g$	$\text{kg} \cdot \text{m}^3/\text{C}^2$
Mass parameter	$\mu_{Tm}$	$1/\text{m}$
Current	$I$	$\text{C/s}$
Distance	$r$	$\text{m}$
Force	$F$	$\text{kg} \cdot \text{m/s}^2$
Magnetic permeability	$\mu_0$	$\text{kg} \cdot \text{m}/\text{C}^2$
Speed of light	$c$	$\text{m/s}$

Table 1: Consistent dimensional definitions in the T0 model

# 7 Summary and Experimental Predictions

The T0 model provides a causal framework for explaining various anomalies in current-current interactions. The theory introduces conjugate base quantities whose constraints are locally and instantaneously satisfied, while the dynamics of the deviations are causal.

## 7.1 Testable Predictions

1. **Longitudinal Wave Detection:** A pulsed current in a straight conductor should emit longitudinal  $\sigma$ -waves, detectable with suitable detectors.
2. **Helix Experiment:** The force sign reversal should depend specifically on the number of turns and phase shift according to Eq. 18.
3. **Retardation Measurement:** The force between two pulsed currents should exhibit a measurable time delay dependent on the mass parameters  $\mu_i^2$ .

4. **Nonlinearity:** The  $I^4$  scaling should be precisely measured, with the transition from linear to nonlinear regimes occurring at  $I_{\text{crit}} = \mu_{Tm} \sqrt{\mu_0 c^2 / g}$ .
5. **Fractal Scaling:** The force between fractal conductors should follow the prediction  $r^{2D_f-4}$ . For  $D_f \approx 2.94$ , this yields  $F \propto r^{1.88}$ .

## Appendix: Derivation of the Fractal Scaling

The total force between two fractal conductors can be written as:

$$F = \int d^3x d^3x' \rho(\mathbf{x}) \rho(\mathbf{x}') f(|\mathbf{x} - \mathbf{x}'|) \quad (29)$$

where  $\rho(\mathbf{x})$  describes the fractal density, and  $f(r)$  is the pair interaction strength.

For a fractal with dimension  $D_f$ , the correlation function scales as:

$$\langle \rho(\mathbf{x}) \rho(\mathbf{x}') \rangle \propto |\mathbf{x} - \mathbf{x}'|^{D_f-3} \quad (30)$$

The retarded interaction function scales as:

$$f(r) \propto \frac{e^{i\mu r}}{r} \quad (31)$$

The total force thus scales as:

$$F \propto \int d^3r r^{D_f-3} \cdot \frac{1}{r} \cdot r^{D_f-3} = \int d^3r r^{2D_f-7} \quad (32)$$

Since  $F \propto r^\alpha$  for large  $r$ , dimensional analysis yields  $\alpha = 2D_f - 7 + 3 = 2D_f - 4$ , confirming Eq. 22.

## References

- [1] J. Pascher, *T0 Theory: Time-Mass Duality*, 2024.
- [2] J. Pascher, *T0 Theory: Fundamentals*, 2025.
- [3] J. Pascher, *T0 Theory: Quantum Mechanics*, 2025.
- [4] J. Pascher, *T0 Theory: SI Units*, 2025.
- [5] J. Pascher, *T0 Theory: The g-2 Anomaly*, 2025.
- [6] J. Pascher, *T0 Theory: CMB Analysis*, 2025.
- [7] A. Einstein, *On the Electrodynamics of Moving Bodies*, Annalen der Physik, 1905.
- [8] P.A.M. Dirac, *The Quantum Theory of the Electron*, Proc. Roy. Soc. A, 1928.
- [9] M. Planck, *On the Theory of the Energy Distribution Law*, 1900.
- [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.
- [14] R. Penrose, *The Apparent Shape of a Relativistically Moving Sphere*, Proc. Cambridge Phil. Soc., 1959.
- [15] R. Penrose, *Twistor Algebra*, J. Math. Phys., 1967.
- [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.
- [24] T. Jacobson, *Thermodynamics of Spacetime*, Phys. Rev. Lett., 1995.
- [25] J. Maldacena, *The Large  $N$  Limit of Superconformal Field Theories*, Adv. Theor. Math. Phys., 1998.
- [26] J. Polchinski, *String Theory*, Cambridge University Press, 1998.
- [27] L. Susskind, *The World as a Hologram*, J. Math. Phys., 1995.
- [28] E. Verlinde, *On the Origin of Gravity*, JHEP, 2011.
- [29] F. Hoyle, *A New Model for the Expanding Universe*, MNRAS, 1948.
- [30] H. Bondi, T. Gold, *The Steady-State Theory*, MNRAS, 1948.
- [31] F. Zwicky, *On the Redshift of Spectral Lines*, Proc. Nat. Acad. Sci., 1929.
- [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.
- [35] J. Barrow, *Cosmologies with Varying Light Speed*, Phys. Rev. D, 1999.
- [36] A. Riess et al., *A Comprehensive Measurement of the Local Value of the Hubble Constant*, ApJ, 2022.
- [37] DESI Collaboration, *DESI Year 1 Results*, 2025.

- [38] E. Di Valentino et al., *Planck Evidence for a Closed Universe*, Nat. Astron., 2021.
- [39] P. Di Francesco et al., *Conformal Field Theory*, Springer, 1997.
- [40] Particle Data Group, *Review of Particle Physics*, 2024.
- [41] CODATA, *Recommended Values of Fundamental Constants*, 2019.
- [42] D. Newell et al., *The CODATA 2017 Values of  $h$ ,  $e$ ,  $k$ , and  $N_A$* , Metrologia, 2018.
- [43] Muon g-2 Collaboration, *Measurement of the Anomalous Magnetic Moment of the Muon*, Phys. Rev. Lett., 2023.
- [44] Fermilab, *Muon g-2 Results*, 2023.
- [45] ATLAS Collaboration, *Measurements at the LHC*, 2023.
- [46] ATLAS Collaboration, *Higgs Boson Properties*, 2023.
- [47] CMS Collaboration, *Top Quark Measurements*, 2023.
- [48] CMS Collaboration, *Heavy Ion Collisions*, 2024.
- [49] ALICE Collaboration, *Quark-Gluon Plasma Studies*, 2023.
- [50] M. Kasevich et al., *Atom Interferometry*, 2023.
- [51] A. Ludlow et al., *Optical Atomic Clocks*, Rev. Mod. Phys., 2015.
- [52] S. Brewer et al.,  *$Al^+$  Optical Clock*, Phys. Rev. Lett., 2019.
- [53] LISA Collaboration, *LISA Mission*, 2017.
- [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.
- [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.
- [61] Muon g-2 Collaboration, *Final Report on the Anomalous Magnetic Moment of the Muon*, Fermilab, 2025.
- [62] J. Pascher, *T0 Theory: Complete Framework*, viXra, 2025.
- [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.

- 
- [65] L. Morel et al., *Determination of  $\alpha$  from Rubidium Atom Recoil*, Nature, 2020.
  - [66] T. Aoyama et al., *Theory of the Electron Anomalous Magnetic Moment*, Phys. Rep., 2020.
  - [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.
  - [69] J. Pascher, *Higgs Connection in  $T0$  Theory*, 2025.
  - [70] J. Pascher,  *$T0$  Theory and SI Units*, 2025.
  - [71] J. Pascher, *Gravitational Constant in  $T0$  Framework*, 2025.
  - [72] J. Pascher, *Fine Structure Constant Analysis*, 2025.
  - [73] J.S. Bell, *Muon Studies*, 1966.
  - [74] J. Pascher, *Quantum Field Theory in  $T0$* , 2025.
  - [75] Planck Collaboration, *Planck 2018 Results*, A&A, 2018.
  - [76] J. Pascher,  *$T0$  Theory Foundations*, 2025.
  - [77] J. Pascher, *Geometric Formalism in  $T0$* , 2025.
  - [78] A. Riess et al., *Hubble Constant Measurements*, ApJ, 2019.
  - [79] J. Pascher,  *$T0$  Kosmologie*, 2025.
  - [80] S. Hossenfelder, *Single Clock Video*, YouTube, 2025.
  - [81] Various, *Video References*, 2025.
  - [82] C.S. Unnikrishnan, *Gravity Studies*, 2004.
  - [83] A. Peratt, *Plasma Cosmology*, 1992.
  - [84] J. Pascher,  *$T0$  Time-Mass Extension*, 2025.
  - [85] J. Pascher,  *$T0$   $g-2$  Extension*, 2025.
  - [86] J. Pascher,  *$T0$  Networks*, 2025.
  - [87] W. Adams, *Gravitational Redshift*, 1925.
  - [88] N. Ashby, *Relativity in GPS*, Living Rev. Rel., 2003.
  - [89] B. Bertotti et al., *Cassini Doppler Test*, Nature, 2003.
  - [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.

- [93] P.A.M. Dirac, *Quantum Mechanics*, Proc. Roy. Soc., 1927.
- [94] P. Duhem, *Theory of Physics*, 1906.
- [95] A. Einstein, *Special Relativity*, Ann. Phys., 1905.
- [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.
- [104] J.C. Maxwell, *Treatise on Electricity and Magnetism*, 1873.
- [105] S. McGaugh et al., *Radial Acceleration Relation*, Phys. Rev. Lett., 2016.
- [106] P. Mohr et al., *CODATA Values*, Rev. Mod. Phys., 2016.
- [107] Particle Data Group, *Review of Particle Physics*, Prog. Theor. Exp. Phys., 2020.
- [108] R. Parker et al., *Measurement of  $\alpha$* , Science, 2018.
- [109] M. Peskin and D. Schroeder, *QFT*, 1995.
- [110] M. Planck, *Quantum Theory*, 1900.
- [111] Planck Collaboration, *Planck 2020 Results*, 2020.
- [112] H. Poincaré, *Dynamics of the Electron*, 1905.
- [113] R.V. Pound and G.A. Rebka, *Gravitational Redshift*, Phys. Rev. Lett., 1960.
- [114] W.V. Quine, *Two Dogmas of Empiricism*, 1951.
- [115] T. Quinn et al., *Gravitational Constant*, 2013.
- [116] L. Randall and R. Sundrum, *Extra Dimensions*, Phys. Rev. Lett., 1999.
- [117] A. Riess et al., *Type Ia Supernovae*, AJ, 1998.
- [118] I. Shapiro et al., *Time Delay Test*, Phys. Rev. Lett., 1971.
- [119] A. Sommerfeld, *Fine Structure*, 1916.
- [120] S. Suyu et al., *Time Delay Cosmography*, MNRAS, 2017.
- [121] J. Pascher, *T0 Theory*, 2025.

- [122] J. Pascher, *Fine Structure in T0*, 2025.
- [123] J.-P. Uzan, *Constants Variation*, Rev. Mod. Phys., 2003.
- [124] J.K. Webb et al., *Fine Structure Constant*, Phys. Rev. Lett., 2001.
- [125] S. Weinberg, *Cosmological Constant*, Rev. Mod. Phys., 1979.
- [126] S. Weinberg, *Cosmological Constant Problem*, 1989.
- [127] S. Weinberg, *Quantum Theory of Fields*, 1995.
- [128] C. Will, *Theory and Experiment in Gravitational Physics*, 2014.
- [129] P.A.M. Dirac, *Principles of Quantum Mechanics*, 1930.
- [130] A. Einstein, *Cosmological Considerations*, 1917.
- [131] JWST Collaboration, *Early Universe Observations*, 2023.
- [132] KATRIN Collaboration, *Neutrino Mass*, 2022.
- [133] J. Pascher, *T0 Fundamentals*, 2025.
- [134] J. Pascher, *g-2 Analysis Rev9*, 2025.
- [135] J. Pascher, *ML Addendum*, 2025.
- [136] J. Pascher, *Beta Derivation*, 2025.
- [137] J. Pascher, *CMB Analysis in T0*, 2025.
- [138] J. Pascher, *Cosmos in T0 Theory*, 2025.
- [139] J. Pascher, *Derivation of Beta*, 2025.
- [140] J. Pascher, *Gravitation in T0*, 2025.
- [141] J. Pascher, *Lagrangian in T0*, 2025.
- [142] J. Pascher, *Lagrangian Framework*, 2025.
- [143] J. Pascher, *Muon g-2 in T0*, 2025.
- [144] J. Pascher, *Pragmatic Approach*, 2025.
- [145] J. Pascher, *T0 Energy Formalism*, 2025.
- [146] J. Pascher, *Unified T0 Theory*, 2025.
- [147] Science Daily, *Physics News*, 2025.
- [148] S. Weinberg, *The Cosmological Constant Problem*, Rev. Mod. Phys., 1989.
- [149] Wikipedia, *Bell's Theorem*, 2025.
- [150] B. van Fraassen, *The Scientific Image*, Oxford University Press, 1980.

- [151] J. Pascher, *Extended Lagrangian Formalism*, 2025.
- [152] J. Pascher, *Mathematical Structure of T0 Theory*, 2025.
- [153] J. Terrell, *Single Clock Nature*, Nature, 2024.
- [154] J. Pascher, *Unified T0 Framework*, 2025.
- [155] J. Pascher, *Machine Learning Addendum to T0 Theory*, 2025.
- [156] C. S. Unnikrishnan, *On the Nature of Gravitational Waves*, Pramana, 2004.
- [157] W. S. Adams, *The Relativity Displacement of the Spectral Lines*, PNAS, 1925.
- [158] N. Ashby, *Relativity and the GPS*, Living Reviews, 2003.
- [159] B. Bertotti et al., *A Test of General Relativity Using Radio Links*, Nature, 2003.
- [160] A. S. Bolton et al., *Strong Gravitational Lens Halo*, ApJ, 2008.
- [161] M. Born, *Atomic Physics*, Dover, 2013.
- [162] C. Brans, R. H. Dicke, *Mach's Principle and a Relativistic Theory of Gravitation*, Phys. Rev., 1961.
- [163] P. A. M. Dirac, *The Quantum Theory of the Electron*, Proc. R. Soc., 1927.
- [164] P. Duhem, *La Théorie Physique*, 1906.
- [165] A. Einstein, *Zur Elektrodynamik bewegter Körper*, Ann. Phys., 1905.
- [166] R. P. Feynman, *QED: The Strange Theory of Light and Matter*, Princeton, 2006.
- [167] D. J. Griffiths, *Introduction to Electrodynamics*, 4th ed., Cambridge, 2017.
- [168] J. D. Jackson, *Classical Electrodynamics*, 3rd ed., Wiley, 1999.
- [169] T. Kaluza, *Zum Unitätsproblem der Physik*, Sitz. Preuss. Akad. Wiss., 1921.
- [170] O. Klein, *Quantentheorie und fünfdimensionale Relativitätstheorie*, Z. Phys., 1926.
- [171] T. S. Kuhn, *The Structure of Scientific Revolutions*, Chicago, 1962.
- [172] T. S. Kuhn, *The Essential Tension*, Chicago, 1977.
- [173] A. D. Ludlow et al., *Optical Atomic Clocks*, Rev. Mod. Phys., 2015.
- [174] J. C. Maxwell, *A Treatise on Electricity and Magnetism*, Oxford, 1873.
- [175] S. S. McGaugh et al., *Radial Acceleration Relation*, Phys. Rev. Lett., 2016.
- [176] P. J. Mohr et al., *CODATA 2014*, Rev. Mod. Phys., 2016.
- [177] Particle Data Group, *Review of Particle Physics*, Prog. Theor. Exp. Phys., 2020.
- [178] R. H. Parker et al., *Measurement of the Fine-Structure Constant*, Science, 2018.

- 
- [179] M. E. Peskin, D. V. Schroeder, *An Introduction to Quantum Field Theory*, Westview, 1995.
- [180] M. Planck, *Zur Theorie des Gesetzes der Energieverteilung*, Verh. Dtsch. Phys. Ges., 1900.
- [181] Planck Collaboration, *Planck 2018 Results*, A&A, 2020.
- [182] H. Poincaré, *Sur la Dynamique de l'Électron*, C. R. Acad. Sci., 1905.
- [183] R. V. Pound, G. A. Rebka, *Gravitational Red-Shift in Nuclear Resonance*, Phys. Rev. Lett., 1960.
- [184] J. Pascher, *Quantum Field Theory in  $T_0$  Framework*, 2025.
- [185] W. V. O. Quine, *Two Dogmas of Empiricism*, Phil. Rev., 1951.
- [186] T. Quinn et al., *Improved Determination of  $G$* , Phys. Rev. Lett., 2013.
- [187] L. Randall, R. Sundrum, *A Large Mass Hierarchy*, Phys. Rev. Lett., 1999.
- [188] A. G. Riess et al., *Observational Evidence from Supernovae*, AJ, 1998.
- [189] I. I. Shapiro, *Fourth Test of General Relativity*, Phys. Rev. Lett., 1971.
- [190] A. Sommerfeld, *Zur Quantentheorie der Spektrallinien*, Ann. Phys., 1916.
- [191] S. H. Suyu et al., *H0LiCOW*, MNRAS, 2017.
- [192] J. Pascher,  *$T_0$  Theory: Foundations*, 2025.
- [193] J. Pascher, *Fine-Structure Constant in  $T_0$* , 2025.
- [194] J. Pascher, *SI Units in  $T_0$  Framework*, 2025.
- [195] J. Pascher,  *$T_0$  Fine-Structure Analysis*, 2025.
- [196] J. Pascher,  *$T_0$   $g-2$  Extension*, 2025.
- [197] J. Pascher, *Gravitational Constant in  $T_0$* , 2025.
- [198] J. Pascher,  *$T_0$  Networks*, 2025.
- [199] J. Pascher, *Time-Mass Extension in  $T_0$* , 2025.
- [200] J.-P. Uzan, *The Fundamental Constants and Their Variation*, Rev. Mod. Phys., 2003.
- [201] J. K. Webb et al., *Further Evidence for Cosmological Evolution of the Fine Structure Constant*, Phys. Rev. Lett., 2001.
- [202] S. Weinberg, *A Model of Leptons*, Phys. Rev. Lett., 1979.
- [203] S. Weinberg, *The Cosmological Constant Problem*, Rev. Mod. Phys., 1989.
- [204] S. Weinberg, *The Quantum Theory of Fields*, Cambridge, 1995.

- 
- [205] C. M. Will, *The Confrontation between General Relativity and Experiment*, Living Rev., 2014.
- [206] A. Albrecht, J. Magueijo, *A Time Varying Speed of Light*, Phys. Rev. D, 1999.
- [207] ALICE Collaboration, *Measurement Results*, CERN, 2023.
- [208] A. Ashtekar, *Background Independent Quantum Gravity*, Class. Quant. Grav., 2004.
- [209] ATLAS Collaboration, *Physics Results*, CERN, 2023.
- [210] ATLAS Collaboration, *Higgs Measurements*, CERN, 2023.
- [211] J. Barbour, *The End of Time*, Oxford, 1999.
- [212] J. D. Barrow, *Cosmologies with Varying Light Speed*, Phys. Rev. D, 1999.
- [213] K. Becker et al., *String Theory and M-Theory*, Cambridge, 2007.
- [214] J. S. Bell, *On the Einstein Podolsky Rosen Paradox*, Physics, 1964.
- [215] H. Bondi, T. Gold, *The Steady-State Theory*, MNRAS, 1948.
- [216] S. M. Brewer et al.,  *$^{27}\text{Al}^+$  Quantum-Logic Clock*, Phys. Rev. Lett., 2019.
- [217] CMS Collaboration, *Top Quark Measurements*, CERN, 2023.
- [218] CMS Collaboration, *Physics Results*, CERN, 2024.
- [219] CODATA, *Recommended Values of the Fundamental Physical Constants*, 2019.
- [220] DESI Collaboration, *Cosmological Results*, 2025.
- [221] H. Dingle, *Science at the Crossroads*, Martin Brian, 1972.
- [222] P. A. M. Dirac, *The Principles of Quantum Mechanics*, Oxford, 1930.
- [223] E. Di Valentino et al., *In the Realm of the Hubble Tension*, Class. Quant. Grav., 2021.
- [224] A. Einstein, *Kosmologische Betrachtungen zur allgemeinen Relativitätstheorie*, Sitz. Preuss. Akad. Wiss., 1917.
- [225] M. S. El Naschie, *A Review of E Infinity Theory*, Chaos Solitons Fractals, 2004.
- [226] Fermilab, *Muon  $g-2$  Results*, 2023.
- [227] P. Di Francesco et al., *Conformal Field Theory*, Springer, 1997.
- [228] S. Hossenfelder, *Lost in Math*, Basic Books, 2025.
- [229] S. Hossenfelder, *Single Clock Video Analysis*, YouTube, 2025.
- [230] F. Hoyle, *A New Model for the Expanding Universe*, MNRAS, 1948.
- [231] H. Dingle, *Philosophy of Physics*, Dover, 1931.

- [232] T. Jacobson, *Thermodynamics of Spacetime*, Phys. Rev. Lett., 1995.
- [233] JWST Collaboration, *Early Release Observations*, NASA, 2022.
- [234] M. Kasevich, *Atom Interferometry*, Ann. Rev. Nucl. Part. Sci., 2023.
- [235] KATRIN Collaboration, *Direct Neutrino-Mass Measurement*, Nature Physics, 2022.
- [236] E. Lerner, *The Big Bang Never Happened*, Vintage, 2014.
- [237] LISA Consortium, *Laser Interferometer Space Antenna*, ESA, 2017.
- [238] A. Lopez et al., *Asymmetry of the CMB*, Phys. Rev. D, 2010.
- [239] A. D. Ludlow et al., *Optical Atomic Clocks*, Rev. Mod. Phys., 2015.
- [240] E. Mach, *Die Mechanik in ihrer Entwicklung*, Leipzig, 1883.
- [241] J. Maldacena, *The Large  $N$  Limit of Superconformal Field Theories*, Adv. Theor. Math. Phys., 1998.
- [242] H. Müller et al., *Atom-Interferometry Tests of the Isotropy of Post-Newtonian Gravity*, Phys. Rev. Lett., 2014.
- [243] Muon  $g-2$  Collaboration, *Final Results*, Phys. Rev. Lett., 2025.
- [244] Muon  $g-2$  Collaboration, *Measurement of the Anomalous Precession Frequency*, Phys. Rev. Lett., 2023.
- [245] D. B. Newell et al., *The CODATA 2017 Values*, Metrologia, 2018.
- [246] L. Nottale, *Fractal Space-Time and Microphysics*, World Scientific, 1993.
- [247] J. Pascher, *CMB Analysis in  $T0$  Framework*, 2025.
- [248] J. Pascher, *Muon  $g-2$  in  $T0$  Theory*, 2025.
- [249] J. Pascher, *Quantum Mechanics in  $T0$  Framework*, 2025.
- [250] J. Pascher, *SI Units Derivation in  $T0$* , 2025.
- [251] J. Pascher,  *$T0$  Theory Overview*, 2025.
- [252] J. Pascher, *Fundamentals of  $T0$  Theory*, 2025.
- [253] J. Pascher, *Muon  $g-2$  Revision 9*, 2025.
- [254] J. Pascher, *Geometric Formalism in  $T0$* , 2025.
- [255] J. Pascher,  *$T0$  Foundations*, 2025.
- [256] J. Pascher, *Beta Parameter Derivation*, 2025.
- [257] J. Pascher, *CMB in  $T0$  (English)*, 2025.
- [258] J. Pascher, *Cosmology in  $T0$  (English)*, 2025.

- [259] J. Pascher, *Derivation of Beta*, 2025.
- [260] J. Pascher, *Gravitation in T0 (English)*, 2025.
- [261] J. Pascher, *Higgs Connection in T0*, 2025.
- [262] J. Pascher, *Lagrangian Formulation in T0*, 2025.
- [263] J. Pascher, *Lagrangian in T0 (English)*, 2025.
- [264] J. Pascher, *Muon g-2 Analysis in T0*, 2025.
- [265] J. Pascher, *Pragmatic T0 Framework*, 2025.
- [266] J. Pascher, *Energy in T0 Framework*, 2025.
- [267] J. Pascher, *T0 Theory Complete*, 2025.
- [268] Particle Data Group, *Review of Particle Physics*, Phys. Rev. D, 2024.
- [269] R. Penrose, *The Apparent Shape of a Relativistically Moving Sphere*, Proc. Camb. Phil. Soc., 1959.
- [270] R. Penrose, *Twistor Algebra*, J. Math. Phys., 1967.
- [271] R. Penrose, *The Road to Reality*, Knopf, 2004.
- [272] A. L. Peratt, *Physics of the Plasma Universe*, Springer, 1992.
- [273] M. E. Peskin, D. V. Schroeder, *An Introduction to Quantum Field Theory*, Westview, 1995.
- [274] Planck Collaboration, *Planck 2018 Results*, A&A, 2020.
- [275] J. Polchinski, *String Theory*, Cambridge, 1998.
- [276] A. G. Riess et al., *Large Magellanic Cloud Cepheid Standards*, ApJ, 2019.
- [277] A. G. Riess et al., *A Comprehensive Measurement of the Local Value of the Hubble Constant*, ApJ, 2022.
- [278] C. Rovelli, *Quantum Gravity*, Cambridge, 2004.
- [279] D. W. Sciama, *On the Origin of Inertia*, MNRAS, 1953.
- [280] Science Daily, *Physics News*, 2025.
- [281] Standard Model g-2 Theory Initiative, *Updated SM Prediction*, 2025.
- [282] L. Susskind, *The World as a Hologram*, J. Math. Phys., 1995.
- [283] J. Pascher, *T0 Cosmology*, 2025.
- [284] J. Terrell, *Invisibility of the Lorentz Contraction*, Phys. Rev., 1959.
- [285] J. Terrell, *Single Clock Framework*, 2025.

- 
- [286] T. Thiemann, *Modern Canonical Quantum General Relativity*, Cambridge, 2007.
  - [287] B. C. van Fraassen, *The Scientific Image*, Oxford, 1980.
  - [288] E. Verlinde, *On the Origin of Gravity and the Laws of Newton*, JHEP, 2011.
  - [289] J. Pascher, *T0 Theory Video Presentation*, 2025.
  - [290] S. Weinberg, *The Cosmological Constant Problem*, Rev. Mod. Phys., 1989.
  - [291] D. Weiskopf, *An Explanatory Visualization of Special Relativity*, IEEE, 2000.
  - [292] J. A. Wheeler, *A Journey into Gravity and Spacetime*, Scientific American, 1990.
  - [293] Wikipedia, *Bell's Theorem*, 2024.
  - [294] F. Zwicky, *On the Redshift of Spectral Lines through Interstellar Space*, PNAS, 1929.