Complementary Extensions of Physics: Absolute Time and Intrinsic Time

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Abstract

This paper introduces the foundational concepts of the Time-Mass Duality theory, a new approach to understanding fundamental physical phenomena. We present:

- A complementary model to relativity featuring absolute time and variable mass
- The intrinsic time field concept, defined as $T(x) = \hbar / \max(mc^2, \omega)$
- A modified Schrödinger equation incorporating mass-dependent time evolution
- Parallels between wave-particle duality and time-mass duality

These approaches maintain mathematical consistency with established physics while offering new interpretations of quantum correlations, gravitational phenomena, and cosmological observations. By extending the principle of complementarity beyond its traditional domain, the Time-Mass Duality theory provides a framework for exploring connections between quantum mechanics and relativistic physics from a fresh perspective.

Contents

Related Documents

- Time as an Emergent Property in Quantum Mechanics (March 23, 2025)
- A Model with Absolute Time and Variable Energy: A Detailed Investigation of the Foundations (March 24, 2025)
- Extensions of Quantum Mechanics through Intrinsic Time (March 27, 2025)
- Mathematical Foundations of Time-Energy Relations in the T0 Model (March 29, 2025)
- Mathematical Formulation of the Higgs Mechanism in Time-Mass Duality (March 28, 2025)
- Emergent Gravitation in the T0-Model: A Comprehensive Derivation (April 1, 2025)

Online Resources

- Project Repository: https://github.com/jpascher/T0-Time-Mass-Duality/tree/main/2

1 Introduction

The development of modern physics has been characterized by profound conceptual revolutions. From Bohr's complementarity principle [6] to Einstein's relativity [14], fundamental physical theories have repeatedly challenged our intuitive understanding of reality. This paper continues in this tradition by introducing two novel and logically coherent approaches in theoretical physics: the complementary standard model of relativity theory with absolute time, and a modified Schrödinger equation with a mass-dependent intrinsic time.

The concept of duality has proven extremely fruitful in physics. Wave-particle duality, formalized in de Broglie's matter wave hypothesis [10] and Bohr's complementarity principle [6], demonstrated that seemingly contradictory descriptions can be necessary for a complete understanding of physical reality. This was further developed in quantum mechanics through Heisenberg's uncertainty principle [19]. Building on this tradition, we present a new form of duality: time-mass duality. This duality suggests that the relationship between time and mass offers complementary interpretations. The conventional relativistic viewpoint with time dilation and constant rest mass can be reframed as an alternative view with absolute time and variable mass, while preserving all observable predictions.

Both concepts offered in this paper provide alternative perspectives on the nature of time, energy, and quantum mechanics, while remaining internally consistent and built upon established physical principles. These dual approaches extend the wave-particle duality in a way that is both mathematically consistent and physically plausible, inviting deeper reflection on the foundations of modern physics.

Our approach connects to several significant themes in fundamental physics, including Barbour's timeless formulation of dynamics [4], Rovelli's relational interpretation of quantum mechanics [44], and questions about the fundamental nature of spacetime in quantum gravity approaches [24].

2 Basic Definitions and Units of the T0-Model

2.1 Intrinsic Time Field

The fundamental concept of the T0-model is the intrinsic time field $T(x)$, defined as:

$$T(x) = \frac{\hbar}{\max(mc^2, \omega)}$$

with the dimension $[E^{-1}]$, where E represents energy. This definition ensures that both massive particles (through mc^2) and massless bosons (through ω) are considered in the framework.

This concept builds on foundations laid by Dirac's relativistic quantum theory [11] but extends it by treating time as an intrinsic property determined by mass or energy. The idea of a characteristic timescale in quantum systems relates to the Compton time $\tau_C = \hbar/(mc^2)$ discussed by Caldirola [8] and others as a fundamental temporal limit.

2.2 Natural Units

In the T0-model, we use natural units, where:

$$\hbar = c = G = k_B = 1$$

This simplifies the mathematical form of the equations and makes the fundamental relationships more transparent, following the tradition established by Planck [40].

2.3 Dimensionless Coupling Constants

In the natural units of the model, the following normalizations apply:

$$\alpha_{\mathrm{EM}} = \alpha_{\mathrm{W}} = \beta_{\mathrm{T}} = 1$$

where α_{EM} is the fine structure constant, α_{W} is the Wien constant, and β_{T} is the T-field coupling parameter.

This approach of setting dimensionless constants to unity relates to the philosophical position that in the most fundamental description of nature, dimensionless constants should take simple values. This connects to Dirac's large number hypothesis [12] and discussions by Duff, Okun, and Veneziano [13].

2.4 Dimensional Analysis

In our model, we use energy $[E]$ as the fundamental base unit. The other physical quantities are derived as follows:

- Length, Time: $[E^{-1}]$
- Mass, Temperature: $[E]$
- Charge: dimensionless when $\alpha_{\mathrm{EM}} = 1$

This approach builds on Einstein's recognition of the equivalence of mass and energy [15] but takes it further by systematically reducing all physical dimensions to powers of energy.

2.5 Electromagnetic Relationships

In natural units:

$$\varepsilon_0 = \mu_0 = 1$$

and the elementary charge is given by:

$$e = \sqrt{4\pi}$$

when $\alpha_{\mathrm{EM}} = 1$ is set.

This normalization was discussed by Feynman [17] and provides an elegant formulation of Maxwell's equations.

3 The β_{T}-Parameter and Its Significance

3.1 Definition and Basic Properties

The β_{T}-parameter is a dimensionless constant that describes the coupling of the intrinsic time field $T(x)$ to matter and vacuum energy. It plays a central role in the T0-model and connects microscopic physics with cosmological phenomena.

This parameter has conceptual similarities to coupling constants in quantum field theory and modified gravity approaches [9], though with a distinct theoretical foundation.

3.2 Characteristic Length

With the parameter $\xi \approx 1.33 \times 10^{-4}$, we define a characteristic length:

$$r_0 = \xi \cdot l_P$$

where l_P is the Planck length. This sets a fundamental scale for the model.

The introduction of characteristic scales below the Planck length echoes approaches in string theory [42] but with different physical interpretation.

3.3 Transition Between Unit Systems

In SI units, $\beta_{\mathrm{T}}^{\mathrm{SI}} \approx 0.008$, which corresponds to $\beta_{\mathrm{T}}^{\mathrm{nat}} = 1$ in natural units. This conversion is important for the consistent interpretation of experimental results.

4 Field Equations of the Intrinsic Time Field

4.1 Basic Equation

The field equation for the intrinsic time field $T(x)$ is:

$$\nabla^2 T(x) = -\kappa \rho(x) T(x)^2$$

where κ is a coupling constant with dimension $[E]$ and $\rho(x)$ represents the energy density with dimension $[E^2]$.

This equation bears formal similarities to the Poisson equation in Newtonian gravity [41] and to nonlinear field equations in scalar field theories [43], but with a different physical interpretation.

4.2 Gravitational Potential

Near massive objects, the T-field modifies the gravitational potential to:

$$\Phi(r) = -\frac{GM}{r} + \kappa r$$

in SI units. The linear term κr explains phenomena attributed to dark energy in standard cosmology.

This modified potential provides an alternative to both the MOND paradigm [22] and dark matter theories [5] for explaining galactic rotation curves and other large-scale gravitational phenomena.

5 Conceptual Framework

5.1 Higgs-T Interaction

The coupling between the Higgs field and the intrinsic time field plays a crucial role in the T0-model. This interaction provides a mechanism for mass generation that incorporates the time-mass duality at a fundamental level.

This builds on the standard electroweak theory developed by Weinberg [53] and Salam [45] but incorporates the intrinsic time field as a fundamental component.

5.2 Treatment of Fermions and Bosons

For fermions and bosons, the standard quantum field equations are modified to include coupling to the intrinsic time field. In both cases, the T-field couples directly to the mass of the particles, leading to a mass-dependent time evolution.

These modifications preserve the core structure of quantum field theory while incorporating the intrinsic time concept. They connect to Dirac's attempts to incorporate time as a dynamical variable in his relativistic wave equation [11].

6 Cosmological Aspects

6.1 Temperature Redshift

In the T0-model, cosmic background radiation is described by a modified temperature-redshift relationship:

$$T(z) = T_0(1 + z)(1 + \beta_{\mathrm{T}} \cdot \ln(1 + z))$$

where T_0 is the current temperature of the cosmic background radiation.

This modification to the standard temperature-redshift relation of the ΛCDM model [39] introduces a logarithmic correction term that becomes increasingly significant at high redshifts.

6.2 Wavelength Dependence

The redshift shows a logarithmic dependence on wavelength:

$$z(\lambda) = z_0(1 + \ln(\lambda/\lambda_0))$$

at $\beta_{\mathrm{T}} = 1$ in natural units. This relationship is crucial for interpreting cosmological observations within the framework of the T0-model.

This wavelength dependence relates conceptually to varying-alpha theories [52] and to certain quantum gravity phenomenological models that predict energy-dependent propagation effects [1].

7 Wave-Particle Duality and Its Extension

Classical quantum mechanics considers light and matter as both wave and particle, depending on the type of experiment. This duality, first proposed by de Broglie [10] and formally articulated by Bohr [6], remains a cornerstone of quantum theory.

This work extends this duality by assuming that the wave and particle properties are determined not only by the measurement process but by a fundamental interaction with an intrinsic time structure. This intrinsic time is derived from the mass of the object under consideration and directly influences the evolution of the system.

Our approach aligns with Wheeler's "it from bit" conception [54], suggesting that information and physical reality are intrinsically connected. It also relates to more recent approaches that question the absolute nature of time, such as the Quantum Theory of Time by Page and Wootters [25].

8 Complementary Standard Model of Relativity Theory

8.1 Introduction

This model is based on the assumption of an absolute time T_0 and a variable energy E and mass m. It presents an alternative view to special relativity theory (SRT) by reinterpreting the role of time.

The concept of absolute time has a long history in physics, from Newton's Principia [23] to contemporary discussions in quantum gravity [2]. While Einstein's relativity [14] effectively eliminated absolute time from mainstream physics, various theoretical approaches have continued to explore its possibilities, including Lorentz's ether theory [21].

8.2 Basic Assumptions

1. Absolute Time: T_0 is constant.
2. Constant Speed of Light: $c_0 \approx 3 \times 10^8\,\mathrm{m/s}$.
3. Variable Energy: E is not fixed, but dynamic.
4. Mass as a Function of Energy: $m = f(E)$.

These assumptions connect to the original Lorentzian interpretation of relativistic effects [21] but differ in their implications for mass and energy.

8.3 Mathematical Formulation

The central energy relation is:

$$E = \frac{\hbar}{T_0}$$

With the known relationship $E = mc_0^2$, we get:

$$m = \frac{E}{c_0^2} = \frac{\hbar}{T_0 c_0^2}$$

This implies that mass m varies with E, while T_0 remains fixed.

8.4 Implications for Physics

- The classical assumption of a fixed rest mass must be extended.
- The model could offer alternative explanations for quantum correlations.
- The interpretation of time in quantum field theory might be modified.

This theory presents a complementary view to established physics and offers new approaches for unifying quantum mechanics and relativity theory. It relates conceptually to attempts to reconcile quantum mechanics and relativity, including the Stueckelberg-Feynman interpretation of antiparticles [49, 16].

9 Modified Schrödinger Equation with Intrinsic Time

The Schrödinger equation is extended to account for a mass-dependent time. The essential change consists of replacing time t in the Schrödinger equation with an intrinsic time T that depends on the mass m of the quantum mechanical system. The intrinsic time T is defined as:

$$T = \frac{\hbar}{mc^2}$$

This leads to a modified Schrödinger equation in which the time evolution of the system depends on its mass. The modified formula is:

$$i\hbar \frac{\partial}{\partial(t/T)}\Psi = \hat{H}\Psi$$

Here, time t is scaled by the intrinsic time T, meaning that the time evolution proceeds at different rates for different masses. For a system with a larger mass m, the intrinsic time T is shorter, leading to faster time evolution, while for a system with a smaller mass m, the time evolution is slower.

This modification has several interesting implications for the measurement problem in quantum mechanics [46] and could offer a new perspective on quantum decoherence [55].

10 Mathematical Comparison of Wave-Particle Duality and Time-Mass Duality

10.1 Wave-Particle Duality

10.1.1 Particle Description

The particle description of a quantum mechanical system focuses on localized mass/energy with a defined position:

- Particle of mass m with position $\vec{x}$
- Momentum $\vec{p} = m\vec{v}$
- Energy $E = \frac{1}{2}mv^2$ (non-relativistic) or $E = \gamma_{\text{Lorentz}}mc^2$ (relativistic)

This description has its roots in classical mechanics and was extended to the quantum domain by Heisenberg's matrix mechanics [18].

10.1.2 Wave Description

The wave description focuses on the spatially extended wave function:

- Wave function $\Psi(\vec{x}, t)$
- De Broglie wavelength $\lambda = \frac{h}{p}$
- Wave vector $\vec{k} = \frac{\vec{p}}{\hbar}$
- Angular frequency $\omega = \frac{E}{\hbar}$

This description originated in optical wave theory and was brought into quantum mechanics through de Broglie's matter wave hypothesis [10] and Schrödinger's wave mechanics [48].

10.1.3 Mathematical Connection

The two descriptions are connected by the Fourier transformation:

$$\Psi(\vec{x}) = \frac{1}{(2\pi\hbar)^{3/2}} \int \phi(\vec{p}) e^{i\vec{p}\cdot\vec{x}/\hbar} d^3p$$

$$\phi(\vec{p}) = \frac{1}{(2\pi\hbar)^{3/2}} \int \Psi(\vec{x}) e^{-i\vec{p}\cdot\vec{x}/\hbar} d^3x$$

where $\phi(\vec{p})$ is the wave function in momentum space.

This mathematical relationship, recognized early in the development of quantum mechanics [7], demonstrates how the seemingly contradictory descriptions are related.

10.2 Time-Mass Duality

10.2.1 Time Dilation Description (Standard Model)

- Variable time t with time dilation: $t' = \gamma_{\text{Lorentz}} t$
- Constant rest mass m_0
- Relativistic energy: $E = \gamma_{\text{Lorentz}} m_0 c^2$
- Time dilation factor: $\gamma_{\text{Lorentz}} = \frac{1}{\sqrt{1-v^2/c^2}}$

This description corresponds to the standard interpretation of special relativity [14], where time intervals expand for moving observers, while rest mass remains invariant. It has been empirically confirmed through numerous experiments, including muon lifetime measurements [3].

10.2.2 Mass Variation Description (this model)

- Absolute, constant time T_0
- Variable mass $m = \gamma_{\text{Lorentz}} m_0$
- Energy: $E = mc^2 = \frac{\hbar}{T}$
- Intrinsic time: $T = \frac{\hbar}{mc^2}$

This alternative description maintains absolute time while allowing mass to vary with velocity. It bears formal similarities to the "variable mass" interpretation occasionally used in early relativistic physics [50], but with a fundamentally different conceptual foundation.

10.2.3 Mathematical Connection

The connection between both descriptions can be expressed through the following transformations:

1. Time coordinate transformation:

$$\frac{dt}{dt_0} = \frac{m_0}{m} = \frac{1}{\gamma_{\text{Lorentz}}}$$

2. Equivalent formulation of time evolution:
   - Standard model: $i\hbar \frac{\partial}{\partial t} \Psi = \hat{H} \Psi$
   - This model: $i\hbar \frac{\partial}{\partial (t/T)} \Psi = \hat{H} \Psi$
3. Transformation between descriptions:
   - When $t' = \gamma_{\text{Lorentz}} t$ (time dilation) in the standard model
   - Then $m' = \gamma_{\text{Lorentz}} m_0$ (mass variation) in this model
   - With $T' = \frac{\hbar}{m'c^2} = \frac{T_0}{\gamma_{\text{Lorentz}}}$

10.3 Parallels Between the Dualisms

1. **Complementarity**:
   - Wave-Particle: Position ($\vec{x}$) and momentum ($\vec{p}$) are complementary observables
   - Time-Mass: Time (t or T) and energy/mass (E or m) are complementary quantities

2. **Uncertainty Relations**:
   - Wave-Particle: $\Delta x \Delta p \geq \frac{\hbar}{2}$
   - Time-Mass: $\Delta t \Delta E \geq \frac{\hbar}{2}$ or $\Delta T \Delta m \geq \frac{\hbar}{2c^2}$

3. **Transformations**:
   - Wave-Particle: Fourier transformation between position and momentum space
   - Time-Mass: Lorentz transformation (standard model) or mass variation transformation (this model)

10.4 Mathematical Structure of Duality

In both cases, we can understand duality as a transformation between complementary representations of the same physical system:

- **Wave-Particle:**
  $\mathcal{F} : \Psi(\vec{x}) \to \phi(\vec{p})$
  Where $\mathcal{F}$ is the Fourier transformation operator.

- **Time-Mass (in this model):**
  $\mathcal{L} : (T_0, m_0) \to (T, m)$
  Where $\mathcal{L}$ represents a modified Lorentz transformation that causes mass variation instead of time dilation, with:
  $m = \gamma_{\text{Lorentz}} m_0$
  $T = \frac{T_0}{\gamma_{\text{Lorentz}}}$

The invariance in both dualisms is shown in:

- Wave-Particle: $|\Psi|^2 dx = |\phi|^2 dp$ (probability conservation)

- Time-Mass: $m_0 c^2 T_0 = mc^2 T = \hbar$ (energy-time product)

11 Conclusion

11.1 Summary of Key Concepts

This paper has presented two innovative approaches to extending physical theories:

- The complementary standard model of relativity with absolute time and variable mass

- A modified Schrödinger equation with mass-dependent intrinsic time

Both models offer new perspectives on fundamental physical concepts while maintaining mathematical consistency with established theories.

11.2 The Measurement Challenge

A central objection to the concept of absolute time is that we directly measure time dilation in experiments. However, our analysis shows that all such measurements – whether with particles (muons, GPS) or light (travel time, redshift) – can be interpreted through either perspective:

- Standard interpretation: variable time, constant mass
- T0-model interpretation: absolute time, variable mass

The mathematical equivalence between these perspectives means that experimental results can be consistently explained by either model. This situation bears resemblance to the different interpretations of quantum mechanics that maintain empirical equivalence while differing in their ontological commitments [47].

11.3 Philosophical Implications

The core challenge is that our measurement methods presuppose an operational definition of time linked to energy and mass ($E = hf = mc_0^2$). This makes distinguishing between the models experimentally difficult, as measurements can be interpreted dualistically.

This conclusion aligns with broader philosophical discussions in the philosophy of science [20] and the concept of theory equivalence in physics [51].

11.4 Future Directions

The Time-Mass Duality theory offers promising research avenues in:

- Quantum gravity
- Cosmology
- Foundational quantum mechanics

By challenging conventional understanding of time and mass while maintaining empirical adequacy, it invites deeper exploration of the fundamental concepts underlying physical theories.

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