# Simplified Description of Fundamental Forces with Time-Mass Duality

Johann Pascher

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## Contents

# 1 Unified Lagrangian Density with Dual Time-Mass Concept

The Lagrangian density for fundamental interactions can be presented in simplified form that accounts for time-mass duality:

$$\mathcal{L}_{\text{total}} = \mathcal{L}_{\text{SM}} + \mathcal{L}_{\text{Higgs}} + \mathcal{L}_{\text{intrinsic}}, \tag{1}$$

where:

- $\mathcal{L}_{\text{SM}}$ represents the Standard Model Lagrangian density (strong, electromagnetic and weak forces),
- $\mathcal{L}_{\text{Higgs}}$ is the Lagrangian density of the Higgs field,
- $\mathcal{L}_{\text{intrinsic}}$ describes the new Lagrangian density for intrinsic time, which implicitly contains gravitational effects.

Gravity is not added as a separate force in this approach since it naturally emerges through intrinsic time field dynamics.

## 1.1 Standard Model

The Standard Model Lagrangian density encompasses the strong, electromagnetic and weak forces and can be formulated dually:

$$\mathcal{L}_{\text{SM}} = \mathcal{L}_{\text{strong}} + \mathcal{L}_{\text{em}} + \mathcal{L}_{\text{weak}}, \tag{2}$$

where:

- $\mathcal{L}_{\text{strong}} = -\frac{1}{4}F^a_{\mu\nu}F^{a\mu\nu} + \bar{\psi}(i\gamma^\mu D_\mu - m_\psi(\phi))\psi$ describes the strong nuclear force,
- $\mathcal{L}_{\text{em}} = -\frac{1}{4}F_{\mu\nu}F^{\mu\nu} + \bar{\psi}(i\gamma^\mu D_\mu - m_\psi(\phi))\psi$ describes the electromagnetic force,
- $\mathcal{L}_{\text{weak}} = -\frac{1}{4}W^a_{\mu\nu}W^{a\mu\nu} + \bar{\psi}(i\gamma^\mu D_\mu - m_\psi(\phi))\psi$ describes the weak nuclear force.

The complementary formulation with intrinsic time is:

$$\mathcal{L}_{\text{SM-T}} = \mathcal{L}_{\text{strong-T}} + \mathcal{L}_{\text{em-T}} + \mathcal{L}_{\text{weak-T}}, \tag{3}$$

where the time derivative is now with respect to intrinsic time $T$: $\partial_t \to \partial_{t/T}$.

## 1.2 Higgs Field

The Lagrangian density of the Higgs field is:

$$\mathcal{L}_{\text{Higgs}} = (D_\mu\phi)^\dagger(D^\mu\phi) - V(\phi), \tag{4}$$

where $\phi$ is the Higgs field and $V(\phi) = \mu^2\phi^\dagger\phi + \lambda(\phi^\dagger\phi)^2$ describes the Higgs potential.
In the complementary formulation with intrinsic time this becomes:

$$\mathcal{L}_{\text{Higgs-T}} = (D_{T\mu}\phi_T)^\dagger(D^\mu_T\phi_T) - V_T(\phi_T), \tag{5}$$

where the covariant derivative $D_{T\mu}$ accounts for intrinsic time.

## 1.3 Lagrangian Density for Intrinsic Time

The new component incorporating time-mass duality is:

$$\mathcal{L}_{\text{intrinsic}} = \bar{\psi}\left(i\hbar\gamma^0\frac{\partial}{\partial(t/T)} - i\hbar\gamma^0\frac{\partial}{\partial t}\right)\psi, \tag{6}$$

where $T = \frac{\hbar}{mc^2}$ is the intrinsic time that depends on the mass of the particle under consideration.

## 2 Simplified Description of Mass Terms with Time-Mass Duality

The mass terms of particles can now be presented in dual forms:

- Standard Model (time dilation): $m_\psi(\phi) = y_\psi \phi$ with constant mass and variable time,
- Complementary Model (mass variation): $m_\psi(\phi_T) = y_\psi \phi_T \cdot \gamma$ with absolute time and variable mass,

where $\gamma = \frac{1}{\sqrt{1-v^2/c^2}}$ is the Lorentz factor.

## 3 The Higgs Field as Universal Medium with Intrinsic Time

The concept of the Higgs field as a medium influencing all other particles and fields is extended by the notion of intrinsic time. The Higgs field might not only be responsible for mass generation but also for the intrinsic time scale of particles:

$$T = \frac{\hbar}{m(\phi)c^2} = \frac{\hbar}{y_\psi \phi \cdot c^2} \tag{7}$$

This relationship shows that a particle's intrinsic time is inversely proportional to its mass generated by the Higgs field.

## 4 The Higgs Field and the Vacuum: A Complex Relationship with Intrinsic Time

The relationship between the Higgs field and the vacuum becomes more complex with the concept of intrinsic time. The vacuum energy could be reinterpreted as:

$$E_{\text{vacuum}} = \sum_i \frac{\hbar\omega_i}{2} = \sum_i \frac{\hbar}{2T_i} \tag{8}$$

This formulation directly links vacuum energy to the intrinsic time of quantum fluctuations.

## 5 Quantum Entanglement and Nonlocality in Time-Mass Duality

The apparent instantaneity in quantum entanglement can be reinterpreted through time-mass duality:

- In the absolute time model ($T_0$-model), correlations don't occur instantaneously but through mass variation.
- In the intrinsic time model, entangled particles of different masses would experience different time evolutions proportional to their intrinsic time scales.
- For photons, intrinsic time could be defined as $T = \frac{\hbar}{E_\gamma} e^{\alpha x}$, where $\alpha = \frac{H_0}{c} \approx 2.3 \times 10^{-28}\ \text{m}^{-1}$ accounts for energy loss over distance $x$, consistent with the T0-model.

## 6 Cosmological Implications of Time-Mass Duality

The time-mass duality framework provides natural explanations for several cosmological phenomena through the following key parameters:

- The absorption coefficient $\alpha = \frac{H_0}{c} \approx 2.3 \times 10^{-28}\ \text{m}^{-1}$ determines the rate of photon energy loss to the dark energy field and explains cosmological redshift beyond the standard Doppler interpretation.
- The parameter $\kappa \approx 4.8 \times 10^{-7}\ \text{GeV/cm} \cdot \text{s}^{-2}$ characterizes the strength of the dark energy field in galactic dynamics and provides a modified gravitational potential that can explain flat rotation curves without dark matter:

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

- The dimensionless coupling constant $\beta \approx 10^{-3}$ describes the interaction strength between the dark energy field and baryonic matter. These parameters are related by:

$$\kappa = \frac{\beta^2 H_0^2 M_{\text{Pl}}^2}{c^2 \rho_0}$$

  where $\rho_0$ is the critical density of the universe.

This leads to the prediction that Bell tests with particles of different masses or photons of different frequencies might reveal measurable delays in correlations, proportional to the mass ratio $\frac{m_1}{m_2}$ or energy ratio $\frac{E_1}{E_2}$.

# 7 Summary of the Unified Theory

The complete unified theory can be described by the following action:

$$S_{\text{unified}} = \int (\mathcal{L}_{\text{standard}} + \mathcal{L}_{\text{complementary}} + \mathcal{L}_{\text{coupling}})\, d^4x \tag{9}$$

where:

$$\mathcal{L}_{\text{standard}} = \mathcal{L}_{\text{SM}} + (D_\mu \phi)^\dagger (D^\mu \phi) - V(\phi) \tag{10}$$

$$\mathcal{L}_{\text{complementary}} = \mathcal{L}_{\text{SM-T}} + (D_{T\mu} \phi_T)^\dagger (D_T^\mu \phi_T) - V_T(\phi_T) \tag{11}$$

$$\mathcal{L}_{\text{coupling}} = \int \mathcal{D}[\Psi]\, \Psi^* \left( i\hbar \frac{\partial}{\partial t} - i\hbar \frac{\partial}{\partial (t/T)} \right) \Psi \tag{12}$$

This unified theory offers several significant advantages:

- It bridges gaps between quantum mechanics and quantum field theory.
- It provides a new perspective on quantum entanglement and nonlocality.
- It opens new pathways for quantum gravity.
- It enables deeper insights into the Higgs field and the vacuum.
- It leads to experimentally testable predictions.

# 8 Experimental Verifiability

The proposed unified theory with time-mass duality leads to several experimentally testable predictions:

1. Measurement of photon energy loss consistent with $\alpha = \frac{H_0}{c}$ at cosmological distances
2. Detection of modified gravitational potentials in galaxies characterized by $\kappa \approx 4.8 \times 10^{-7}$ GeV/cm $\cdot$ s$^{-2}$
3. Precision tests of the matter-dark energy coupling constant $\beta \approx 10^{-3}$
4. Mass-dependent time evolution in quantum systems, measurable as different coherence times.
5. Differences in entanglement speed for particles of different masses.
6. Scale-dependent gravitational constant correlated with intrinsic time.
7. Modified energy-momentum relation for very massive particles.
8. Measurable deviations in high-precision experiments typically explained by time dilation.

# 9 References to Further Works

The unified theory presented here builds upon a series of detailed studies addressing various aspects of time-mass duality and its applications.

# 10 Bibliography

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