Chapter 1

Dynamic Mass of Photons and Its Implications for Nonlocality in the T0 Model: Updated Framework with Complete Geometric Foundations

Abstract

This updated work examines the implications of assigning a dynamic, frequency-dependent effective mass to photons within the comprehensive framework of the T0 model, building upon the complete field-theoretic derivation and natural units system where $\hbar = c = \alpha_{\text{EM}} = \beta_{\text{T}} = 1$. The theory establishes the fundamental relationship $T(x,t) = \frac{1}{\max(m,\omega)}$ with dimension $[E^{-1}]$, providing a unified treatment of massive particles and photons through the three fundamental field geometries. The dynamic photon mass $m_\gamma = \omega$ introduces energy-dependent nonlocality effects, with testable predictions. All formulations maintain strict dimensional consistency with the fixed T0 parameters $\beta = 2Gm/r$, $\xi = 2\sqrt{G} \cdot m$, and the cosmic screening factor $\xi_{\text{eff}} = \xi/2$ for infinite fields.

Contents

1.1 Introduction: T0 Model Foundation for Photon Dynamics

This updated analysis builds upon the comprehensive T0 model framework established in the field-theoretic derivation, incorporating the complete geometric foundations and natural units system. The dynamic effective mass concept for photons emerges naturally from the T0 model's fundamental time-mass duality principle.

1.1.1 Fundamental T0 Model Framework

The T0 model is based on the intrinsic time field definition:

$$\boxed{T(x,t) = \frac{1}{\max(m(\vec{x},t),\omega)}} \tag{1.1}$$

Dimensional verification: $[T(x,t)] = [1/E] = [E^{-1}]$ in natural units ✓
This field satisfies the fundamental field equation:

$$\nabla^2 m(\vec{x},t) = 4\pi G\rho(\vec{x},t)\cdot m(\vec{x},t) \tag{1.2}$$

From this foundation emerge the key parameters:

T0 Model Parameters for Photon Analysis

$$\beta = \frac{2Gm}{r} \quad [1] \text{ (dimensionless)} \tag{1.3}$$

$$\xi = 2\sqrt{G}\cdot m \quad [1] \text{ (dimensionless)} \tag{1.4}$$

$$\beta_T = 1 \quad [1] \text{ (natural units)} \tag{1.5}$$

$$\alpha_{\text{EM}} = 1 \quad [1] \text{ (natural units)} \tag{1.6}$$

1.1.2 Photon Integration in Time-Mass Duality

For photons, the T0 model assigns an effective mass:

$$m_\gamma = \omega \tag{1.7}$$

Dimensional verification: $[m_\gamma] = [\omega] = [E]$ in natural units ✓
This gives the photon's intrinsic time field:

$$T(x,t)_\gamma = \frac{1}{\omega} \tag{1.8}$$

Praktische Vereinfachung

Vereinfachung: Da alle Messungen in unserem endlichen, beobachtbaren Universum lokal erfolgen, wird nur die **lokalisierte Feldgeometrie** verwendet:
$\xi = 2\sqrt{G} \cdot m$ und $\beta = \frac{2Gm}{r}$ für alle Anwendungen.
Der kosmische Abschirmfaktor $\xi_{\text{eff}} = \xi/2$ entfällt.

Physical interpretation: Higher-energy photons have shorter intrinsic time scales, creating energy-dependent temporal dynamics.

1.2 Energy-Dependent Nonlocality and Quantum Correlations

1.2.1 Entangled Photon Systems

For entangled photons with energies ω_1 and ω_2, the time field difference is:

$$\Delta T_\gamma = \left|\frac{1}{\omega_1} - \frac{1}{\omega_2}\right| \tag{1.9}$$

Physical consequence: Quantum correlations experience energy-dependent delays.

1.2.2 Modified Bell Inequality

The energy-dependent time fields lead to a modified Bell inequality:

$$|E(a,b) - E(a,c)| + |E(a',b) + E(a',c)| \leq 2 + \epsilon(\omega_1, \omega_2) \tag{1.10}$$

where:

$$\epsilon(\omega_1, \omega_2) = \alpha_{\text{corr}} \left|\frac{1}{\omega_1} - \frac{1}{\omega_2}\right| \frac{2G\langle m\rangle}{r} \tag{1.11}$$

with α_{corr} being a correlation coupling constant and $\langle m\rangle$ the average mass in the experimental setup.

1.3 Experimental Predictions and Tests

1.3.1 High-Precision Quantum Optics Tests

Energy-Dependent Bell Tests

Predicted time delay between entangled photons:

$$\Delta t_{\text{corr}} = \frac{G\langle m\rangle}{r} \left|\frac{1}{\omega_1} - \frac{1}{\omega_2}\right| \tag{1.12}$$

For laboratory conditions with $\langle m\rangle \sim 10^{-3}$ kg, $r \sim 10$ m, and $\omega_1, \omega_2 \sim 1$ eV:

$$\Delta t_{\text{corr}} \sim 10^{-21} \text{ s} \tag{1.13}$$

Equation	Left Side	Right Side	Status
Photon effective mass	$[m_\gamma] = [E]$	$[\omega] = [E]$	✓
Photon time field	$[T_\gamma] = [E^{-1}]$	$[1/\omega] = [E^{-1}]$	✓
Energy loss rate	$[d\omega/dr] = [E^2]$	$[g_T \omega^2 2G/r^2] = [E^2]$	✓
Time field difference	$[\Delta T_\gamma] = [E^{-1}]$	$[\lvert 1/\omega_1 - 1/\omega_2 \rvert] = [E^{-1}]$	✓
Bell correction	$[\epsilon] = [1]$	$[\alpha_{\text{corr}} \Delta T_\gamma \beta] = [1]$	✓

Table 1.1: Dimensional consistency verification for photon dynamics in T0 model

1.4 Dimensional Consistency Verification

1.5 Conclusions

1.5.1 Summary of Key Results

This updated analysis demonstrates that the dynamic photon mass concept integrates seamlessly into the comprehensive T0 model framework:

1. **Unified treatment**: Photons and massive particles follow the same fundamental relationship $T = 1/\max(m, \omega)$
2. **Energy-dependent effects**: Photon dynamics depend on frequency through the intrinsic time field
3. **Modified nonlocality**: Quantum correlations experience energy-dependent delays
4. **Testable predictions**: Specific experimental signatures distinguish T0 from standard theory
5. **Dimensional consistency**: All equations verified in natural units framework
6. **Parameter-free theory**: All effects determined by fundamental T0 parameters