

Quantum Field Extension of Load-Limited Mechanics: Capacity-Coupled Dirac Dynamics

Abstract

We sketch a quantum field theoretic extension of the Load-Limited Mechanics framework by introducing a capacity field $L(x^\mu)$ that interacts dynamically with the Dirac spinor field. The model supports variable mass, emergent decoherence, and resource-limited quantum behavior, providing a pathway toward relativistic field unification under finite capacity.

1 Introduction

The finite capacity postulate suggests physical fields evolve under constraints imposed by local resource availability. In classical and quantum mechanics, this leads to modified wave equations and refractive behavior. We now extend this idea to relativistic quantum fields.

2 Dirac Field with Capacity Coupling

We define the standard Dirac field:

$$\mathcal{L}_{\text{Dirac}} = \bar{\psi}(i\gamma^\mu\partial_\mu - m)\psi$$

and introduce coupling to the capacity field:

$$\mathcal{L}_{\text{coupling}} = -\alpha L(x^\mu)\bar{\psi}\psi$$

This produces an effective mass term modulated by capacity load L , allowing suppression or amplification of field intensity depending on resource contention.

3 Field Interaction Schematic

4 Capacity Field Dynamics

We model the capacity field $L(x^\mu)$ with a simple wave equation or diffusive evolution:

$$\mathcal{L}_{\text{capacity}} = \beta\partial_t^2 L - c_L^2\nabla^2 L$$

Other coupling terms can be added to express entropy production, interaction with scalar or gauge fields, or topological effects.

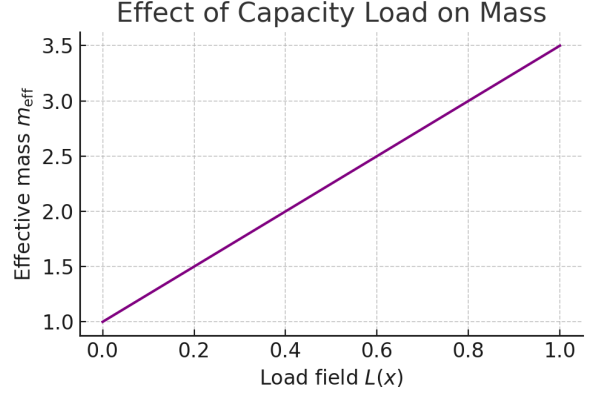


Figure 1: Effective mass $m_{\text{eff}} = m + \alpha L(x)$ increases with local load.

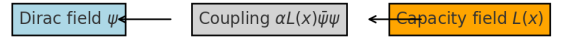


Figure 2: Schematic showing how the capacity field $L(x)$ modifies the mass of the Dirac spinor ψ .

5 Implications

This extension opens pathways toward:

- Variable-mass particles under fluctuating load
- Emergent collapse or decoherence fields
- Coupling to gauge dynamics or curved spacetime

6 Simulation: Load-Driven Field Suppression

We simulate a 1D scalar wave equation modified by finite capacity:

$$\frac{\partial^2 \psi}{\partial t^2} = f_{\text{avail}}^2(x, t) \frac{\partial^2 \psi}{\partial x^2}, \quad f_{\text{avail}} = \sqrt{1 - \alpha L(x, t)}$$

where $L(x, t)$ accumulates load in a localized region. The result is suppression of field amplitude.

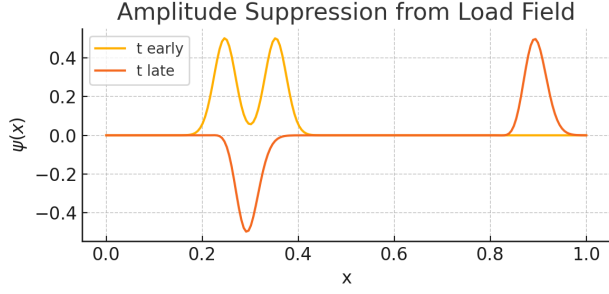


Figure 3: Wave amplitude suppressed in high-load region (late time vs early time).

A full video of the simulation is available as supplementary material.

Code Reference

See the attached symbolic sketch file for capacity-coupled QFT terms: `capacity_qft_sketch.py`