

# Quantization of Spiral Time Dynamics in the Helix-Light-Vortex Framework: Towards a Geometrically-Embedded Quantum Gravity

Marcel Krüger

ORCID: 0009-0002-5709-9729

July 5, 2025

## Abstract

We present a quantum field theoretical refinement of the Helix-Light-Vortex (HLV) theory. A spiral-time-dependent scalar field  $\Theta(x, t)$ , coupled to a symbolic grammar  $G_{\text{HLV}}$ , forms the basis for a semi-topological framework with predictive cosmological power. The Lagrangian is made real and unitary by decomposing  $\Psi(t) = t + i\phi(t)$  and embedding the imaginary part as an external perturbation. Fermionic sectors, Yukawa-type couplings, and an emergent metric  $g_{\mu\nu}^{\text{HLV}}$  are introduced. The symbolic term is mapped via projective symmetry weights. Propagators are defined via standard Dyson-expansion with optional spiral self-energy. Predictions include axion-like particles and spin-resonant gravimetry signatures. The renormalization group flow of the effective coupling constants is discussed.

## 1 Introduction

The HLV framework proposes a discretized spiral-based time field:

$$\Psi(t) = t + i \cdot \phi(t), \quad (1)$$

where  $\phi(t) \in \mathbb{R}$  introduces spiral modulation. We avoid complex actions by treating  $\phi(t)$  as a perturbative phase coupling to field sources, e.g.:

$$\mathcal{L}_\phi = \phi(t) J^\mu \partial_\mu \Theta. \quad (2)$$

The symbolic grammar  $G_{\text{HLV}}$  encodes transitions in field dynamics via operator symbols  $\oplus, \emptyset, A$ .

## 2 Lagrangian Formulation

The modified real Lagrangian reads:

$$\mathcal{L}_{\text{HLV}} = \frac{1}{2}(\partial_t \Theta)^2 - \frac{1}{2}(\nabla \Theta)^2 - V(\Theta) + \bar{\psi}_f (i\gamma^\mu \partial_\mu - m_f) \psi_f \quad (3)$$

$$+ g_\Theta \bar{\psi}_f \psi_f \Theta + \phi(t) J^\mu \partial_\mu \Theta + \kappa \delta(\Theta - \Theta_0) \mathcal{P}_{\text{sym}}(\Theta). \quad (4)$$

The potential is:

$$V(\Theta) = \Lambda^4 \left( 1 - \cos \left( \frac{\Theta}{f} \right) \right). \quad (5)$$

Natural units are used ( $\hbar = c = 1$ ).  $\mathcal{P}_{\text{sym}}$  denotes a scalar projection from symbolic space. A formal expansion of  $\mathcal{P}_{\text{sym}}$  as trace over a symbolic operator algebra is left for future work.

### 3 Quantization Framework

The partition function is:

$$Z = \int \mathcal{D}\Theta \mathcal{D}\bar{\psi}_f \mathcal{D}\psi_f e^{i \int d^4x \mathcal{L}_{\text{HLV}}}. \quad (6)$$

#### 3.1 Propagators

Standard propagators with spiral-time corrections enter via Dyson series.

**Scalar:**

$$D_F(k) = \frac{i}{k^2 - m^2 + i\epsilon} + i \int dt' \Sigma(t') D_F(k) + \dots \quad (7)$$

**Fermion:**

$$S_F(p) = \frac{i(\not{p} + m_f)}{p^2 - m_f^2 + i\epsilon}, \quad \not{p} = \gamma^\mu p_\mu. \quad (8)$$

### 4 Emergent Geometry

We define:

$$g_{\mu\nu}^{\text{HLV}} = \eta_{\mu\nu} + \alpha T_{\mu\nu}(\Theta, \phi(t)). \quad (9)$$

$T_{\mu\nu}$  is the standard energy-momentum tensor modulated by spiral influence.

### 5 Renormalization Group Flow

To test the UV consistency of the theory, we analyze the beta functions:

$$\beta_{g_\Theta} = \mu \frac{dg_\Theta}{d\mu}, \quad \beta_\Lambda = \mu \frac{d\Lambda}{d\mu}. \quad (10)$$

The spiral modulation may induce scale-dependent corrections. Future work will explore the full RG structure.

### 6 Phenomenology

- **CMB Shifts:**  $\Delta T/T \sim 10^{-6}$ , especially at low  $\ell$ .
- **Axion-like Particles:**  $m_\Theta \sim 10^{-5}$  eV, with spiral-induced coupling.
- **Spin Deviations:** Predictable via atomic gravimetry or interferometry.

## 7 Symmetry Considerations

$\phi(t)$  introduces soft P and T symmetry breaking; CPT remains conserved. Symbolic projections  $\mathcal{P}_{\text{sym}}$  may break additional discrete symmetries.

## 8 Conclusion

This revised formalism reconciles HLV theory with QFT requirements: real Lagrangian, standard propagators, and symbolic mappings as effective couplings. The next phase includes numerical simulations, renormalization group analysis, and a concrete algebraic representation of the symbolic grammar.

## References

## References

- [1] M. Krüger, *Helix-Light-Vortex Theory*, Zenodo (2025). doi:10.5281/zenodo.15609432
- [2] P.A.M. Dirac, *Quantum Theory of the Electron*, Proc. R. Soc. A **117**, 610 (1928).