

HLV Scalar Field as Dark Component

(Dark Matter & Dark Energy)

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Abstract

This module proposes that the scalar field within the Helix-Light-Vortex (HLV) Theory, which is spiral-modulated by the time function, acts as either Dark Matter (DM) or Dark Energy (DE) depending on its dynamic regime. The form of Spiral Time and the field's potential determine whether the field behaves as pressureless (DM-like) or with negative pressure (DE-like). This interpretation allows for a unified explanation of both dark cosmic components within a topologically coherent spiral model, replacing static cosmological constants with time-modulated spiral states. The module outlines the physical consistency, mathematical formulations, and symbolic connections within the G-HLV grammar, providing a new perspective on the nature of cosmic darkness.

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1 Module: HLV Scalar Field as Dark Component (Dark Matter & Dark Energy)

1.1 1. Hypothesis

The scalar field within the Helix-Light-Vortex (HLV) Theory, which is spiral-modulated by the time function, acts depending on its dynamic regime either as dark matter (DM) or dark energy (DE). The form of Spiral Time and the potential determine whether the field acts as pressureless (DM-like) or with negative pressure (DE-like).

1.2 2. Lagrangian Density

The Lagrangian density for the topological phase field Θ is given by:

$$\mathcal{L}_\Theta = \frac{1}{2}\psi(t)\dot{\Theta}^2 - \frac{1}{2}(\nabla\Theta)^2 - V(\Theta)$$

where $\psi(t)$ is the spiral-modulated time function (e.g., $\psi(t) = \omega_0 + \epsilon \sin(\omega_1 t)$).

1.3 3. Two Dynamic Regimes

A) Dark Matter Behavior (oscillating field):

- **Solution:** $\Theta(t) \approx \Theta_0 \cos(mt)$
- **Mean Energy Density:** $\bar{\rho} = m^2\Theta_0^2/2$
- **Equation of State:** $p \approx 0$
- **Effectively:** Pressureless, cold oscillating field.

B) Dark Energy Behavior (slow roll):

- **Solution:** $\dot{\Theta}^2 \ll V(\Theta)$
- **Equation of State:** $p \approx -\rho$
- **Effectively:** Vacuum-like energy with negative pressure.

1.4 4. Spiral Time Modulation as Control

The Spiral Time function:

$$\psi(t) = \psi_0 + \epsilon \sin(\omega t)$$

- $\psi_0 \gg \epsilon$: kinetically dominant, DM-regime.

Result: The field switches cyclically between DM and DE behavior.

1.5 5. Equation of State of the HLV Field

The energy density ρ , pressure p , and equation of state parameter $w(t)$ for the HLV field are given by:

$$\rho = \frac{1}{2}\psi(t)\dot{\Theta}^2 + V(\Theta), \quad p = \frac{1}{2}\psi(t)\dot{\Theta}^2 - V(\Theta), \quad w(t) = \frac{p}{\rho}$$

The behavior of $w(t)$ depends on the specific form of $V(\Theta)$ and the field regime.

1.6 6. Cosmological Consequence

- The HLV field can provide a dynamic contribution to the total energy density of the universe.
- It replaces static cosmological constants with time-modulated spiral states.
- It allows for a unified explanation of DM and DE within a topologically coherent spiral model.

1.7 7. Connection to G_HLV Symbolism

- $A \oplus$ (Space-Bit activated by Spiral Energy)
- $\psi(t)$ (Spiral Time)
- Θ as an oscillating, time-modulated information unit.

1.8 8. Predictable Observational Features

- Slow temporal variation of the DE contribution, testable via DESI, Euclid.
- Weak gravitational effects due to spiral modulation, testable via lensing, CMB.
- Frequency structure of $\Theta(t)$ indirectly measurable through spectral line shifts.

1.9 9. Conclusion

The spiral-time modulated scalar field in the HLV model can unify both cosmologically dominant dark components. This interpretation allows for a new view on the nature of darkness in the universe, based on geometry, time modulation, and topologically quantized Space-Bits.