Numerical Simulation and Experimental Testing of Solitons in the Fluxonic Klein-Gordon System

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Abstract

This paper simulates soliton evolution in the nonlinear Klein-Gordon system within a fluxonic framework, hypothesizing that solitons underpin emergent gravitational effects, testable via Bose-Einstein Condensate (BEC) interactions. We derive a fluxonic equation, simulate soliton stability and interactions, and propose an experimental test to detect gravitational wave modulation, aligning with fluxonic shielding paradigms. These challenge General Relativity and quantum field theory, offering a deterministic unification pathway.

1 Introduction

Physics treats gravity and quantum phenomena separately, yet the fluxonic framework posits solitonic interactions as their basis (OCR Section 1). This mirrors the OCRs shielding challenge to GR (Section 2), extending simulation to experimental validation.

2 Hypothesis

Solitons in a fluxonic Klein-Gordon system:

- Maintain stability and exhibit interactions measurable in a BEC.
- Induce gravitational effects detectable as wave modulation (OCR Section 3).

Equation:

$$\frac{\partial^2 \phi}{\partial t^2} - c^2 \frac{\partial^2 \phi}{\partial x^2} + m^2 \phi + g\phi^3 = 8\pi G \rho, \tag{1}$$

where $\phi(x, t)$ is the fluxonic field, $c = 1$ (simulation units), $m = 1.0$, $g = 1.0$, ρ is mass density (negligible here), and $8\pi G\rho$ couples gravity.

3 Numerical Implementation

Discretized via finite differences:

$$\frac{\partial^2 \phi}{\partial t^2} \approx \frac{\phi_i^{n+1} - 2\phi_i^n + \phi_i^{n-1}}{\Delta t^2}, \tag{2}$$

$$\frac{\partial^2 \phi}{\partial x^2} \approx \frac{\phi_{i+1}^n - 2\phi_i^n + \phi_{i-1}^n}{\Delta x^2}. \tag{3}$$

Initial conditions: Kink soliton:

$$\phi(x, 0) = \tanh\left(\frac{x}{\sqrt{2}}\right), \tag{4}$$

with velocity:

$$\left.\frac{\partial \phi}{\partial t}\right|_{t=0} = v\frac{d\phi}{dx}, \quad v = 0.3. \tag{5}$$

Boundary conditions: Absorbing via damping.

4 Simulation Code

Listing 1: Fluxonic Soliton Evolution Simulation

```
import numpy as np
import matplotlib.pyplot as plt

# Parameters
L = 20.0
Nx = 200
dx = L / Nx
dt = 0.01
Nt = 500
m = 1.0
g = 1.0
v = 0.3
c = 1.0
G = 1.0
rho = np.zeros(Nx)  # No mass density here

# Grids
x = np.linspace(-L/2, L/2, Nx)
phi_initial = np.tanh(x / np.sqrt(2))
phi_old = np.tanh((x - v * dt) / np.sqrt(2))
phi = phi_initial.copy()
phi_new = np.zeros_like(phi)
```

```
# Time evolution
for n in range(Nt):
    # Periodic boundaries with damping at edges
    d2phi_dx2 = (np.roll(phi, -1) - 2 * phi + np.roll(phi, 1)) / dx**2
    phi_new = 2 * phi - phi_old + dt**2 * (c**2 * d2phi_dx2 - m**2 * phi - g * p
    phi_new[0:10] *= 0.9  # Absorbing boundary
    phi_new[-10:] *= 0.9  # Absorbing boundary
    phi_old, phi = phi, phi_new

# Plot
plt.plot(x, phi_initial, label="Initial␣State")
plt.plot(x, phi, label="Final␣State")
plt.xlabel("x")
plt.ylabel("  (x,t)")
plt.title("Fluxonic␣Soliton␣Evolution")
plt.legend()
plt.grid()
plt.show()
```

5 Results and Observations

- **Stability:** Soliton retains shape over time.
- **Drift:** $v = 0.3$ induces rightward motion.
- **Balance:** Dispersion and nonlinearity maintain form.

6 Experimental Proposal

To test fluxonic gravity (OCR Section 3):

- **Setup:** BEC with solitonic excitations (OCR Section 3.2).
- **Source:** Rotating mass (OCR Section 3.1) or LIGO waves.
- **Measurement:** Interferometers (OCR Section 3.3) for wave modulation.

7 Predicted Experimental Outcomes

Standard Prediction	**Fluxonic Prediction**
Unaltered gravitational waves	Partial attenuation (BEC)
No soliton-gravity link	Soliton-induced wave shifts
Stochastic vacuum	Structured fluxonic effects

Table 1: Comparison of Predictions

8 Implications

If confirmed (OCR Section 5):

- Solitons underpin gravity, challenging GR.
- Fluxonic framework unifies QM and gravity.
- New gravitational engineering possibilities (OCR Section 5).

9 Future Directions

(OCR Section 6):

- **Soliton Collisions:** Test interactions (v = 0.3).
- **Phase Shift Analysis:** Measure post-collision shifts.
- **Energy Conservation:** Verify total energy.
- **Scaling Laws:** Vary m and g.