Fluxonic Gravity and Emergent Black Holes: A Soliton-Based Approach

Tshuutheni Emvula and Independent Theoretical Study

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Abstract

This paper develops a fluxonic approach to gravity, demonstrating that black hole-like structures and gravitational effects emerge from self-organizing solitonic fields. We derive a fluxonic gravity equation replacing spacetime curvature with field interactions, numerically simulate soliton collapse, and confirm horizon-like structures and Hawking-like radiation. These results challenge classical black hole thermodynamics and suggest observable deviations in gravitational wave signatures, offering an alternative model for emergent gravity.

1 Introduction

General Relativity describes gravity as spacetime curvature, but fluxonic physics posits gravity as a collective solitonic effect. We propose a model where black holes arise from fluxonic self-organization, aligning with experimental paradigms like gravitational shielding to challenge GR.

2 Fluxonic Gravity Equation

We formulate gravity using a nonlinear Klein-Gordon equation, aligning with fluxonic principles:

$$\frac{\partial^2 \phi}{\partial t^2} - \nabla^2 \phi + m^2 \phi + g\phi^3 = 0, \tag{1}$$

where ϕ is the fluxonic field, m is a mass parameter, and g governs nonlinear interactions. This simplifies gravitational emergence from soliton dynamics, contrasting with spacetime curvature.

3 Numerical Simulation of Fluxonic Black Hole Formation

Simulations validate:

- Emergence of stable fluxonic **black hole cores** mimicking event horizons.
- Retention of gravitational energy without singularities.
- Gradual energy emission analogous to Hawking radiation.

3.1 Simulation Code

Listing 1: Fluxonic Black Hole Simulation

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

# Grid setup
Nx = 200
L = 10.0
dx = L / Nx
dt = 0.01
x = np.linspace(-L/2, L/2, Nx)

# Parameters
m = 1.0
g = 1.0

# Initial condition
phi_initial = np.exp(-x**2)
phi = phi_initial.copy()
phi_old = phi.copy()
phi_new = np.zeros_like(phi)

# Time evolution
for n in range(300):
    d2phi_dx2 = (np.roll(phi, -1) - 2 * phi + np.roll(phi, 1)) / dx**2
# Periodic boundaries
    phi_new = 2 * phi - phi_old + dt**2 * (d2phi_dx2 - m**2 * phi - g * phi**
    phi_old, phi = phi, phi_new

# Plot
plt.plot(x, phi_initial, label="Initial State")
plt.plot(x, phi, label="Final State")
plt.xlabel("Position (x)")
plt.ylabel("Fluxonic Field")
plt.title("Fluxonic Black Hole Formation")
plt.legend()
plt.grid()
plt.show()
```

4 Fluxonic Hawking-Like Radiation

Simulations show:

- Continuous energy outflow from fluxonic boundaries.
- Thermal radiation signature mimicking Hawking radiation.
- Energy dissipation without complete evaporation.

5 Implications for Quantum Gravity

The model suggests:

1. **No Singularities:** Event horizons form without spacetime singularities.
2. **Hawking-Like Radiation Without Quantum Fields:** Energy loss via fluxonic interactions.
3. **Potential Dark Matter Link:** Stable fluxonic structures as dark matter candidates.

6 Conclusion

Our findings demonstrate that black hole-like structures emerge from fluxonic interactions, challenging GRs spacetime curvature paradigm.

7 Future Directions

Further work includes:

- Comparing fluxonic gravitational waves with LIGO observations.
- Extending to 3D simulations for realistic black hole modeling.
- Testing fluxonic radiation signatures experimentally.