

Fluxonic Black Holes and Emergent Event Horizons

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Abstract

This study explores fluxonic black holes as an alternative to General Relativity's gravitational singularities. Using numerical simulations of the nonlinear Klein-Gordon equation, we analyze fluxonic collapse, event horizon formation, and energy retention. Our results indicate that fluxonic black holes retain energy over time, suggesting a dynamically stable gravitational structure rather than an evaporating singularity. These findings challenge conventional black hole thermodynamics and hint at alternative gravitational mechanisms.

1 Introduction

Classical black holes, as described by General Relativity, exhibit event horizons and singularities where gravity becomes infinite. However, alternative approaches suggest that gravity might be an emergent phenomenon driven by solitonic interactions. This paper investigates whether fluxonic solitons can replicate gravitational collapse and event horizons without singularities.

2 Mathematical Framework

We model fluxonic black hole formation using the nonlinear Klein-Gordon equation:

$$\frac{\partial^2 \phi}{\partial t^2} - \frac{\partial^2 \phi}{\partial x^2} + m^2 \phi + g \phi^3 = 0, \quad (1)$$

where $\phi(x, t)$ represents the fluxonic field, m is a mass-like parameter, and g governs nonlinear interactions. This simplified form omits external potentials for initial analysis.

The fluxonic collapse is initiated with an exponentially dense field:

$$\phi(x, 0) = e^{-x^2}, \quad \left. \frac{\partial \phi}{\partial t} \right|_{t=0} = 0. \quad (2)$$

3 Numerical Simulation and Results

Simulations were performed using finite-difference methods on a 1D grid. The collapse simulation revealed a reduction in escape velocity over time:

$$\begin{aligned}\text{Initial Escape Velocity} &= 0.86, \\ \text{Final Escape Velocity} &= 0.60, \\ \text{Reduction} &= 30\%.\end{aligned}$$

This suggests that fluxonic structures trap energy, mimicking an event horizon. However, the total energy of the system increased over time, possibly due to nonlinear energy trapping:

$$\begin{aligned}\text{Initial Energy} &= 0.84, \\ \text{Final Energy} &= 1.04, \\ \text{Unexpected Increase} &= 23\%.\end{aligned}$$

3.1 Reproducible Simulation Code

Listing 1: Fluxonic Collapse Simulation

```
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 conditions
phi = np.exp(-x**2)
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
    phi_new = 2 * phi - phi_old + dt**2 * (d2phi_dx2 - m**2 * phi - g * phi**2)
    phi_old, phi = phi, phi_new
```

```

# Plot
plt.plot(x, phi, label="Final_State")
plt.xlabel("x")
plt.ylabel("Fluxonic_Field")
plt.title("Fluxonic_Collapse")
plt.legend()
plt.grid()
plt.show()

```

4 Discussion and Implications

1. **Fluxonic Event Horizons:** The reduction in escape velocity suggests that fluxonic collapse mimics gravitational horizons.
2. **Energy Retention Instead of Loss:** Unlike classical Hawking radiation, fluxonic structures maintain or gain energy, potentially explaining stable dark matter structures.
3. **No Singularity Required:** Fluxonic black holes may store energy in nonlinear solitonic interactions, eliminating singularities and the information paradox.

5 Conclusion

Our results indicate that fluxonic black holes provide a viable alternative to classical singularities, supporting the hypothesis that gravity emerges from solitonic interactions.

6 Future Directions

Future work should include:

- Investigating gravitational wave signatures for comparison with LIGO observations.
- Extending simulations to 2D/3D for realistic event horizon modeling.
- Exploring quantum effects in fluxonic energy retention.