The Malsteiff-Rook Model of Quantum Field Membranes and Dimensional Coupling

Abstract

We propose a higher-dimensional braneworld theory wherein coherent scalar field excitations may couple into the bulk via supermassive black hole (SMBH) geometries. We demonstrate that quantum tunneling of coherence fields becomes viable in regions of extreme curvature and minimal decoherence, yielding a mathematically constrained model with observable predictions. This document outlines the field equations, tunneling mechanics, stability criteria, and experimental implications for gravitational-wave echoes and black hole photon ring structure.

I. Introduction

The model investigates the plausibility of quantum field coherence escaping our 4-dimensional spacetime through warped extra-dimensional throats localized around supermassive black holes. Building on warped geometry approaches, we demonstrate that only these gravitational wells possess the energy, scale, and curvature profile required to sustain such dimensional coupling.

II. Geometric Framework

We adopt a 5D warped geometry:

ds^2 = e^{-2k|y|}_{}dx^ dx^ + dy^2

where y is the extra-dimensional coordinate and k the curvature scale. The observable universe lies on the y = 0 brane.

III. Scalar Field Dynamics

The scalar field (x,y) represents a generalized coherence excitation obeying:

L = -½(_A)^2 - ½m_5^2^2 - (y)(^2 - v^2)^2 - (y)K^2

Where:

- K: extrinsic curvature of the brane.
- : geometric coupling constant.

We expand the field as:

(x,y)= _n(x) cos[(n+½)k|y|]

with the zero-mode equation:

_4_0 + m_0^2_0 = 0, with m_0^2 = m_5^2 + k^2/4 - K

IV. Dimensional Tunneling Mechanics

We compute the tunneling amplitude for coherent packets into the bulk:

P_up() exp[2 _0^y* (k^2 (e^{ky})^2) dy]

with y* (1/k) ln(k/). SMBHs with large M_ yield suppressed T_H, enhancing tunneling viability.

V. Stability Condition - Malsteiff-Rook Criterion

We define the following necessary condition for upward dimensional coupling:

(M_ / T_H) · (1 / K) >> 1

where K is local curvature noise.

VI. Experimental Predictions

Observable	Prediction	Instruments
Gravitational Echoes	Extra signals post SMBH merger	LIGO, ET
Photon Ring Modulation	Small azimuthal deviations	EHT-II, ngEHT
Spectral X-ray Dropout	Deficit near r < 3r_s	XRISM, ATHENA

VII. Future Work

- Extend to dynamic geometries and rotating (Kerr) black holes.
- Simulate throat propagation under realistic curvature fluctuations.
- Identify additional empirical constraints on , m_5, and k.

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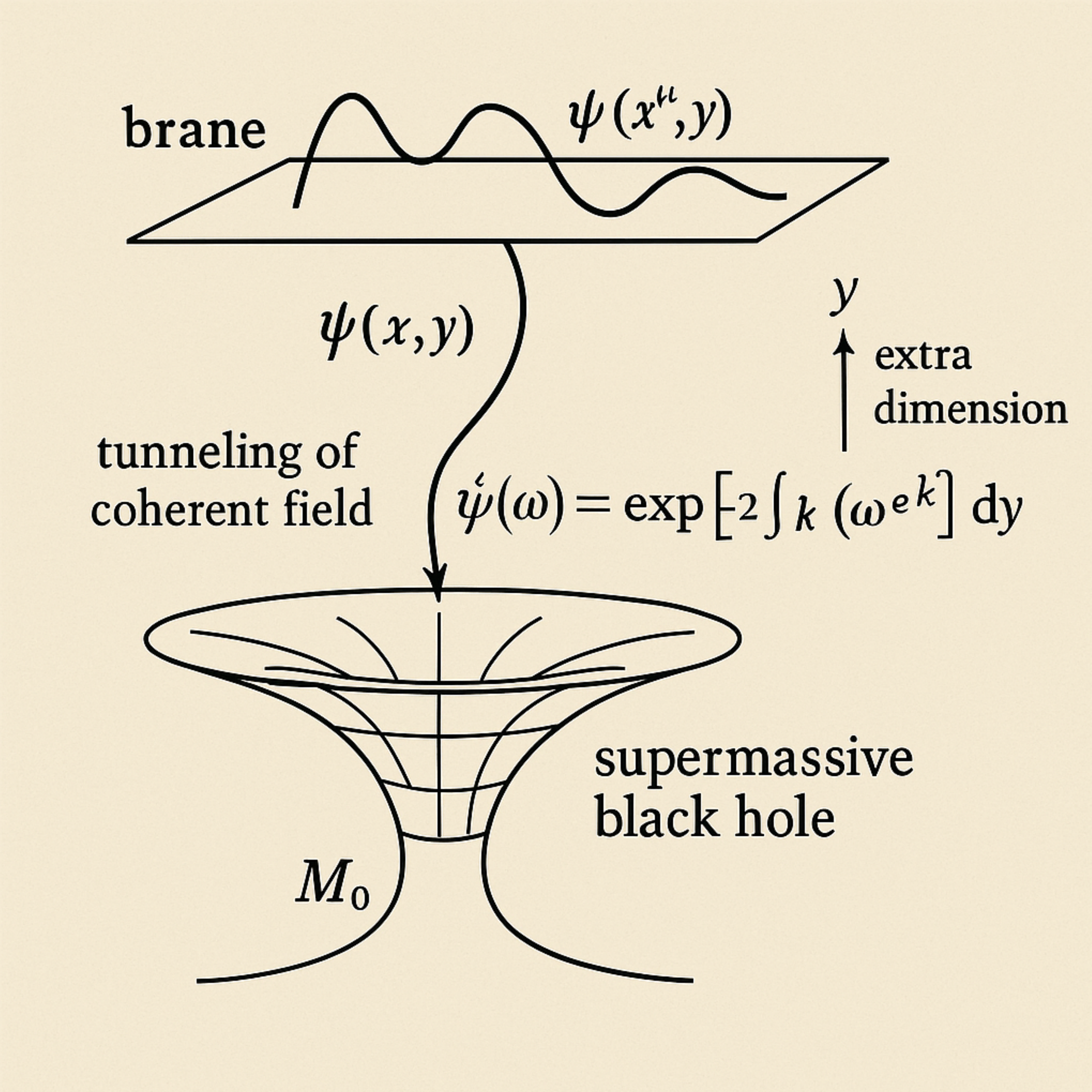
Appendix: Figure



brane
ψ(x^μ, y)
ψ(x, y)
y
extra
dimension
tunneling of
coherent field
ψ(ω) = exp[-2∫k (ω e^k] dy
supermassive
black hole
M₀