A Zero-Variable Fractal Black Hole Model: Removing Singularities and Infinity with Multi-Zero States

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February 20, 2025

Abstract

We propose an extended *zero-variable* framework for black hole physics in which the classical usage of $r = 0$ (singularity) and $r \to \infty$ (unbounded horizon) are replaced by a set of finite *multi-zero* placeholders and upper limits. Specifically, we define five distinct *zero-states*—_0_Start, _0_End, _0_Max, _0_Min, and _0_Balance—so that each type of $= 0$ condition (origin, meltdown boundary, maximum capacity, minimal leftover, equilibrium) is tracked separately. Similarly, any integral or domain that would extend to infinity is capped at _0_Max, yielding a finite cosmic system.

We embed this multi-zero approach into our *fractal* black hole model: the classical $r = 0$ singularity is replaced by $r = \pm r_0$, and the event horizon splits into emergent (EH^+) and de-emergent (EH^-) surfaces. By introducing *Fibonacci-like recurrences* for black hole mass and spin, we ensure no quantity grows unbounded or shrinks to literal zero. Observational predictions include *Fibonacci-based* QPO frequency ratios (beyond the usual 3:2), possible gravitational wave echoes shaped by fractal horizon corrections, and 1/f flicker noise in X-ray variability. We discuss how this finite-bounded, zero-variable model avoids singularities, conserves energy, and provides testable cosmological links to potential dark matter (emergent flow) and dark energy (de-emergent meltdown).

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1 Introduction

In classical general relativity (GR), black holes face two conceptual extremes:

1. A **singularity** at $r = 0$, implying infinite density and curvature.
2. Domains or integrals extending to *infinity*, yielding unbounded horizon sizes and total evaporation times.

We eliminate both extremes by introducing a *multi-zero* framework:

- No literal $= 0$: Instead of $r = 0$, meltdown occurs at $r = \pm r_0$.
- No infinite domains: Replacing ∞ with a finite maximum (_0_Max).

Additionally, we define five distinct "zero-states"—_0_Start, _0_End, _0_Max, _0_Min, _0_Balance—each addressing a different role that $= 0$ ordinarily covers (origin, meltdown, max capacity, leftover, or equilibrium).

This merges seamlessly with our *fractal* black hole model, where horizons split into EH^+ (emergent) and EH^- (de-emergent), and mass/spin evolve via *Fibonacci* recurrences. The _0_Max concept ensures no quantity diverges, while _0_Min forbids total evaporation. Observationally, we anticipate **Fibonacci-based QPO frequencies** beyond just 3:2, plus fractal gravitational wave echoes and 1/f noise. Below, we detail these additions and their implications.

2 Multi-Zero Variables and Removing Infinity

2.1 Five Placeholders for "Zero"

In standard math, $x = 0$ can represent an origin, meltdown boundary, net force equilibrium, or minimal leftover, *all lumped* under "$= 0$." We split these roles into:

_0_Start The starting boundary or domain origin, e.g. the radial domain might open at _0_Start.

_0_End A meltdown or final boundary, formerly $r = 0$ (singularity).

_0_Max The cyc. max or largest capacity, replacing ∞.

_0_Min A minimal leftover or residual, preventing meltdown from going absolute zero.

_0_Balance A net sum or equilibrium zero (like forces summing to zero).

By specifying *which* zero-state each equation uses, we remove ambiguities. For example, if black hole mass approaches _0_Min, it halts evaporation rather than going to $M = 0$. If integrals approached ∞, they now approach _0_Max, a finite cutoff.

2.2 Eliminating Infinity with _0_Max

Traditionally, black hole metrics or integrals run to $r \to \infty$ or $t \to \infty$. In our model, any integral domain is finite: r spans up to $r_{\max} = \_0\_Max$, a large but not infinite boundary. This cements energy conservation—the system is closed, with no unbounded resources or sinks. For instance:

$$\int_{r=\_0\_Start}^{r=\_0\_Max} f(r)\, dr \quad \text{instead of} \quad \int_{r=0}^{r=\infty}.$$

In a realistic cosmic scenario, _0_Max might represent a cosmic scale (like a cosmological horizon). The result is that *no quantity diverges*, integrals remain finite, and black hole horizon sizes or masses cannot exceed _0_Max.

3 Zero-Free Black Hole Geometry

3.1 Replacing $r = 0$ with $r = \pm r_0$

We forbid a literal $r = 0$ singularity. Instead, meltdown occurs at $r = \pm r_0$, a small finite radius akin to a Planck-scale limit or a wormhole throat. Physically, matter cannot compress beyond r_0, so infinite density is avoided. This also allows for the possibility that $+r_0$ and $-r_0$ are symmetrical boundaries if meltdown is viewed from a negative dimensional vantage.

Dimensionally Labeled Meltdown. One might call $r = -r_0$ a "dimensionally labeled meltdown"—energy effectively exits our 3D vantage there, possibly entering a lower dimension or 0D domain. The phrase highlights that meltdown is *spacetime-limited*, not just classical. If meltdown arises, we interpret it as crossing an extra-dimensional boundary. If you prefer simpler language, you can say the system's meltdown boundary is r_0 (no further compression). Either way, the end is not $= 0$ but $= r_0$.

3.2 Emergent (EH^+) and De-Emergent (EH^-) Horizons

We preserve the dual horizon concept:

- EH^+ (outer) for emergent inflows (source-energy $\to$ matter).
- EH^- (inner) for meltdown outflows (matter $\to$ meltdown dimension).

Classically, these are r_+, r_- for Kerr. Now they're *fractal-corrected* so that near the horizon, geometry might follow ratio-based expansions rather than $f(r) = 0$ solutions. This ensures no function must vanish exactly, consistent with the zero-variable approach.

Fractal Corrections to the Horizon. Mathematically, the horizon location might differ slightly from the usual $r_{\pm} = M \pm \sqrt{M^2 - a^2}$. A fractal factor $\Delta_{\text{fractal}}(r)$ ensures the horizon is not a single line but a small zone, removing singular function=0. Observationally, these corrections could shift the ringdown frequencies or produce partial wave reflections, as we discuss in gravitational wave echoes.

4 Fibonacci Recurrences for Mass and Spin

4.1 Fibonacci-Like Evolution

We define black hole mass M and spin J in discrete steps:

$$M_{n+2} \;=\; M_{n+1} + M_n, \quad J_{n+2} \;=\; J_{n+1} + J_n,$$

ensuring each partial sum remains finite. Consecutive ratios approach the golden ratio $\varphi \approx 1.618$.

$$\frac{M_{n+1}}{M_n} \;\to\; \varphi, \quad \frac{J_{n+1}}{J_n} \;\to\; \varphi.$$

These recurrences imply no black hole mass/spin can exceed _0_Max or meltdown below _0_Min. It's a powerful way to keep growth or spin-up finite.

4.2 Physical Implications of Discrete Steps

In classical continuous BH evolution, spin changes by small differentials dJ from accretion or gravitational wave emission. Here, *mass and spin jump* in steps of the Fibonacci recursion. This might appear as *quantized emission lines* or discrete spin states if measured precisely. For X-ray variability:

- The black hole might add mass in lumps that follow $M_n = M_{n-1} + M_{n-2}$.
- The spin parameter a_n might oscillate around φ or other stable ratio.

Observationally, one might detect **quantized outbursts** or leaps in spin. If the BH is radiating in short bursts each time it transitions from M_n to M_{n-1}, the X-ray spectrum might show *discrete energy releases* akin to certain luminous flares.

5 Removing Infinity (_0_Max) and Energy Conservation

5.1 Finite Bounds on Horizon Size and Integrals

A key new concept is _0_Max. Instead of letting r or M approach infinity, we say they approach _0_Max. For instance, if a BH tries to accrete an enormous mass, it saturates near $M_{\max}$, the system's total resource. This viewpoint:

- Prevents unbounded horizons.
- Closes integrals: $\int_{r=\_0\_Start}^{r=\_0\_Max} f(r)\,dr$ is always finite.
- Eliminates infinite time scales (Hawking evaporation can't last "infinite time," it's truncated by meltdown or equilibrium).

Example: Thermodynamic Integrals. In classical BH evaporation, total energy output is integrated over $t = 0$ to $t = \infty$. Now we define a final meltdown or leftover at $M_{\min} = \_0\_Min$. So the integral from $t = 0$ to t_{halt} is finite. Similarly, the horizon size cannot exceed some cosmic scale if _0_Max is the largest radial domain. All physical processes remain within a finite energy budget, consistent with a **closed cosmic system**.

5.2 Balancing Force at 0_Balance

If a black hole tries to spin up or down too far, or mass tries to surpass _0_Max, the system might reach a net equilibrium labeled 0_Balance. This ensures a stable attractor state (like a thermodynamic stable point or a golden ratio spin–heat capacity flip). In simpler terms: rather than indefinite growth or meltdown, the black hole can "level off" at an equilibrium. This zero variable clarifies we have a net sum = 0_Balance, not meltdown or leftover zero.

6 Observational Predictions and Tests

6.1 Fibonacci Ratios in QPO Frequencies

High-frequency QPO pairs in black hole X-ray binaries often appear near 3:2. Our fractal approach predicts additional pairs, e.g. 5:3, 8:5, 13:8, ... Observers can look for these higher-order Fibonacci ratios in microquasar light curves:

$$\nu_{n+1}/\nu_n \;\approx\; \varphi \quad \text{(or neighboring Fibonacci ratio).}$$

If found, it strongly indicates fractal resonance. Current instruments occasionally see only one or two QPO pairs, but future missions might detect subtle additional peaks (e.g. *NuSTAR*, *NICER*, or next-gen X-ray timing telescopes). Confirming multiple Fibonacci harmonic sets would be a **unique signature** of zero-variable fractal BH dynamics.

6.2 Gravitational Wave Echoes from Fractal Horizons

Multiple Echo Spacings. In standard echo models, one or two echoes might appear if partial reflections happen near the horizon. In a *fractal* boundary scenario, repeated reflections at multiple fractal layers can produce a *train of echoes* with diminishing amplitude. The times between echoes might form a geometric series:

$$\Delta t, \quad \Delta t \cdot \varphi, \quad \Delta t \cdot \varphi^2, \ldots$$

Such a pattern would be unmistakable in post-merger ringdown signals. Ongoing and future detectors (e.g. LIGO, Virgo, KAGRA, proposed space-based interferometers) could search for these repeating pulses in the late-time waveform. Numerical simulations that embed a layered horizon**(*some are in development to test quantum effects*)** might reproduce fractal echoes. Discovery of a repeated ratio in the echo intervals or frequencies would profoundly support the zero-variable fractal BH concept.

6.3 1/f Noise in X-ray Variability

BH light curves often exhibit pink/flicker noise with a power spectrum $P(f) \sim f^{-\alpha}$ (where $\alpha \approx 1$). Our fractal swirl near the horizon, shaped by electromagnetic constraints, can yield scale-invariant dynamics.

- Each fractal sub-layer can inject noise at a ratio-based frequency band.
- Summed over many scales, we get 1/f continuum noise.

Hence, the model predicts not just a simple power law but possibly minor "*bumps*" at Fibonacci subharmonics. Careful spectral analysis might isolate them from standard red noise. If future data reveal fractal sub-peaks in the 1/f continuum, that would further strengthen the fractal swirl hypothesis.

6.4 Examples of Numeric Testing

To test the multi-zero fractal horizon:

- **Accretion simulations** that discretize mass increments in Fibonacci steps. We measure emergent QPO modes and see if the ratio distributions approach φ.
- **Gravitational wave codes** that replace a smooth horizon with layered reflectors. One can embed partial reflection at each layer, produce ringdown waveforms, and see if the echoes exhibit fractal spacing.
- **Thermodynamic integrators** that cut off all integrals at $M_{\min} \equiv \_0\_Min$ or $r = \_0\_Max$ to confirm no divergences.

Such numeric efforts would show how the zero-variable approach modifies known solutions and how much difference might be detectable observationally.

7 Analogy Table (Tornado & Multi-Zero Updates)

8 Conclusion and Future Directions

We have updated our **zero-variable** fractal black hole model to ensure both:

1. No literal zeros: meltdown at $r = \pm r_0$, no $M = 0$ evaporation, and *multi-zero* placeholders for origin, meltdown, leftover, max, balance.
2. No infinite domains: all integrals or expansions are capped at *_0_Max*, guaranteeing finite horizons and energy budgets.

This yields a finite, self-consistent black hole framework that avoids singularities, disallows unbounded growth, and merges well with a fractal horizon approach. The Fibonacci recurrence for mass/spin ensures discrete, ratio-based evolution, naturally connecting to the golden ratio φ. Observationally, we predict:

- **QPO Frequency Sets**: searching for higher-order Fibonacci pairs (5:3, 8:5, 13:8) beyond the well-known 3:2,
- **Fractal Gravitational Wave Echoes**: repeated partial wave reflections at fractal layers, spaced in geometric intervals,
- **1/f Noise in X-ray Variability**: fractal swirl structure yields scale-invariant flicker with possible ratio-based subpeaks.

Future Work. We plan to:

- Develop numerical *accretion* and *ringdown* codes embedding multi-zero cutoffs (replacing $r = 0$ and ∞ with r_0 and _0_Max).
- Explore how _0_Balance might unify black hole spin, horizon area, and quantum vacuum at an equilibrium golden ratio state.
- Compare discrete step predictions with data from *NuSTAR*, *NICER*, *EHT*, or advanced gravitational wave detectors for evidence of fractal echoes or additional QPO harmonic ratios.

By removing infinite singularities and clarifying each use of zero, we obtain a cosmic system that is both *finite* and *energy-conserving*, with fractal expansions bridging quantum-likely states and classical BH horizons. This approach paves the way for a testable, self-contained black hole theory in line with the broader fractal dimension-labeled cosmos.

Acknowledgments: (Your acknowledgments here.)

Analogy	BH Feature	Force / Ratio	Zero-Variable Role
Tornado (EM swirl)	Full BH swirl from wide quantum-likely to meltdown at $r = \pm r_0$	EM constraints + ratio funnel	Visualizes how no meltdown to $r = 0$ or infinite swirl. Energy is guided by fractal geometry, meltdown is $r_0 = \_0\_End$, no infinite domain.
Double Helix (DNA)	EH$^+$ vs. EH$^-$ entwined	Golden ratio synergy	Emergent/de-emergent horizons form a braided fractal boundary. No single = 0 meltdown.
Portal Poles ($\pm r_0$)	Minimal meltdown boundary	No literal zero; meltdown at $\_0\_End$	Replaces $r = 0$ singularity with a finite radius. Bans infinite tidal forces.
Fund. Anti-Particles	Surplus energy balancing	Ratio-based no leftover	Appear if BH surpasses fractal threshold, removing extra mass dimensionally.
Rock in Water	Horizon ratio condition (escape vel = c)	Potential well ratio=1, not function=0	Illustrates horizon as ratio-based boundary. No literal = 0.
Circulatory System	EH+ "arteries," EH- "veins"	Dim-labeled emergent/de-emergent	BH flow from meltdown dimension to stable mass dimension, closing loops.
Magnetic Field	Jet region near EH+ or fractal interior	Magnetism + expansions	Constrains ejected matter in discrete steps; possible chaotic sequences.
1/f Noise	BH variability time series	Scale invariance in freq domain	Observational fractal signature. Summation of ratio-based sub-layers yields pink noise.
Multi-Zero	0_Start, 0_End, 0_Max, 0_Min, 0_Balance	Universal placeholders for "=0"	Removes ambiguous = 0. Each zero usage is physically distinct: meltdown, leftover, max, etc.
Ceiling/Floor (± 3)	Hard dimension boundary	Dim-labeled boundary	No dimension beyond ± 3. Infinity replaced by finite range.

Table 1: Analogy Table referencing fractal BH geometry, multi-zero placeholders, and emergent/de-emergent horizons.