Where the Patterns Lead: Speculative Interpretations of Benford Deviation in Physics

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Draft — February 2026

Abstract

This paper is entirely speculative. It accompanies two data papers: the first establishes a mathematical framework linking complete monotonicity to Benford's Law and validates it against quantum statistical distributions (Riner 2026a); the second demonstrates that among ten quantum gravity models propagated through a Schwarzschild black hole interior, Causal Set Theory produces the cleanest Benford structure, and that this result survives robustness testing (Riner 2026b). Both papers present measurements. This paper asks what those measurements might mean.

Everything that follows is interpretation — a hobbyist's attempt to trace the implications of patterns that emerged from data. The patterns themselves are real: Bose-Einstein statistics satisfy Benford's Law exactly because their series representation is completely monotonic. Fermi-Dirac statistics deviate with an oscillatory fingerprint governed by the Dirichlet eta function. Causal Set Theory ranks first inside a black hole and ninth inside a wormhole, proving its mechanism is topology-driven rather than curvature-driven. Negative-mass bosons return zero valid occupation numbers before any field equations are written. These are measurements, not opinions.

What follows are opinions — constrained by those measurements, but opinions nonetheless. The speculative interpretation is that Benford's Law may not merely describe physical distributions but may reflect a deeper structural constraint on what is permitted to exist.

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1. Introduction

The first data paper (Riner 2026a) establishes a mathematical identity: a thermal distribution satisfies Benford's Law exactly if and only if its exponential series representation has all non-negative coefficients — the condition of complete monotonicity, formalized through the Bernstein-Widder representation theorem. This is not an approximation or a statistical tendency. It is an algebraic equivalence. The Bose-Einstein distribution satisfies this condition. The Fermi-Dirac distribution does not, and its deviation is precisely quantified by the Dirichlet eta function $\eta(1) = \ln 2$. Deviations from Benford's Law are computable via Fourier decomposition of the series coefficients, and the resulting per-digit signature $\varepsilon(d)$ is sufficient to blindly classify the underlying physics with 96.3% accuracy.

The second data paper (Riner 2026b) takes this measurement instrument — the Euclidean deviation δ_B and per-digit fingerprint $\varepsilon(d)$ — and applies it to ten quantum gravity models inside a Schwarzschild black hole. The models are propagated across forty radial positions from far outside the horizon to the singularity and beyond. Causal Set Theory produces the lowest mean deviation ($\delta\_B = 0.011$), and its fingerprint at the horizon matches the Hawking radiation spectrum with L2 distance 0.004. A control experiment using a Morris-Thorne wormhole (comparable curvature, no singularity, no horizon) drops Causal Set from first to ninth, proving the mechanism requires topological structure — not mere curvature — to activate.

This paper asks: what might those patterns mean?

The honest answer is: we do not know. But the patterns are suggestive enough, and internally consistent enough, that it seems worth laying out the interpretive framework they suggest. Every section below follows the same structure: state the data pattern, then clearly mark where measurement ends and speculation begins.

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2. The Axiom Framework: Benford as Precondition for Existence

The Data Pattern

The "whiteboard" experiment in the measurement paper tested twenty-three exotic physics candidates against the Benford framework. Nineteen returned finite, computable deviation values. Four returned no valid output at all: negative-mass bosons (at every energy scale tested) produced uniformly negative occupation numbers, and phantom dark energy fields (equation of state $w < -1$) suffered the same failure. These candidates did not merely deviate from Benford's Law — they could not be evaluated. The framework returned UNDEFINED before any dynamics were computed.

By contrast, negative-mass *fermions* — which might seem equally problematic — returned a finite $\delta\_B \approx 0.7$. They deviate enormously from Benford's Law, but they exist within the computational framework. The Pauli exclusion principle saves them: fermionic occupation numbers are bounded between 0 and 1 regardless of the sign of the energy, so the distribution remains well-defined even when the mass term is negative.

The Speculative Interpretation

What if Benford conformance is not a description of physical distributions but a precondition for them? The data suggests a hierarchy:

- **CONFORMS** ($\delta\_B < 0.03$): The system exists and is thermodynamically stable. Bose-Einstein statistics, axions, gravitons, anyons.
- **DEVIATES** ($\delta\_B > 0.03$): The system exists but carries a measurable structural cost. Fermi-Dirac statistics, Hawking radiation, massive particles.
- **UNDEFINED** (no valid output): The system cannot exist. Negative-mass bosons, phantom energy.

The speculative leap is this: perhaps what we call "existence" — the capacity of a physical system to manifest stable, observable states — requires that its statistical description be expressible as a Laplace transform of a non-negative measure. This is the Bernstein-Widder condition. Systems that satisfy it exactly (completely monotonic distributions) conform to Benford's Law. Systems that violate it partially (fermionic statistics, massive fields) deviate but survive. Systems that violate it totally (negative-mass bosons) cannot form coherent states at all.

If this interpretation holds, then Benford's Law is not a statistical curiosity but a survivorship filter at the deepest level. Things that exist are things whose digit distributions can be written down. This is not a dynamical statement — it says nothing about forces or interactions. It is a constraint on the space of possibilities, logically prior to physics.

This is, admittedly, a very strong claim for a pattern in first-digit statistics to support. But the pattern is remarkably clean: the boundary between DEFINED and UNDEFINED is sharp, it correlates perfectly with the sign structure of occupation numbers, and it was not built into the framework by assumption. It emerged from the mathematics.

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3. Light, Mass, and the Force Hierarchy

The Data Pattern

The mass dial experiment swept the mass parameter m^2 in the relativistic dispersion relation $E = \sqrt{k^2 + m^2}$ from tachyonic ($m^2 < 0$) through massless ($m^2 = 0$) to massive ($m^2 > 0$). At $m^2 = 0$, the distribution is pure Bose-Einstein with $\delta_B = 0.0056$ — essentially perfect Benford conformance. As $|m^2|$ increases in either direction, δ_B increases monotonically. Mass, in this framework, is literally measurable as deviation from the logarithmic ideal.

Furthermore, the dimension sweep experiment showed that the Planck black-body spectrum — which describes massless photons in three spatial dimensions — deviates from Benford's Law ($\delta_B = 0.028$) purely because of the ν^3 density-of-states prefactor. The underlying Bose-Einstein denominator is perfectly monotonic. The deviation comes entirely from the geometric context (dimensionality) in which the massless field propagates.

The Speculative Interpretation

Consider light first. In the Benford framework, a massless bosonic field in zero dimensions would have $\delta_B = 0$ — exact conformance, zero deviation, no structure. The speculative interpretation is that light's constancy — the fact that c is the same in every reference frame — may reflect the fact that the massless bosonic field represents the *zero-deviation baseline* of the framework. Light doesn't conform to Benford's Law because it happens to be massless. Rather, masslessness *is* the condition of zero deviation, and light is what zero deviation looks like when it propagates.

The speed of light, in this reading, is not a speed at all. It is the propagation rate of the constraint itself — the rate at which the Benford-conformant ground state communicates across spacetime. Nothing exceeds it because nothing can outrun the framework that permits its own existence. "The axiom says no" is not a dynamical barrier but a logical one.

Mass, then, is the measurable signature of deviation. The mass dial experiment shows this directly: δ_B increases monotonically with m^2. A particle's mass is not an independent property bolted onto the framework — it is the framework's own measurement of how far a field's occupation statistics deviate from perfect logarithmic scaling. Heavier particles deviate more. The heaviest particles (top quark, W and Z bosons) would sit at correspondingly higher δ_B values.

This suggests an interpretation of the force hierarchy. The electromagnetic force is mediated by the photon ($\delta_B \approx 0.006$, near-zero). The strong force is mediated by gluons (massless, but confined — their effective δ_B would reflect confinement rather than bare mass). The weak force is mediated by the W and Z bosons ($m_W \approx$ 80 GeV, $m_Z \approx$ 91 GeV), which carry substantial deviation. Gravity is mediated by the graviton (massless spin-2, $\delta_B = 0.028$ in the Planck form).

The speculative question is whether force strength correlates with the δ_B of the mediating boson — whether the hierarchy of forces (strong > electromagnetic > weak > gravity) maps onto a hierarchy of deviations. The data papers do not test this directly, and it remains an open question. But the framework provides a natural language for asking it.

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4. Time, Entropy, and Spacetime

The Data Pattern

Two results from the data papers bear on this section. First, the Bose-Einstein distribution — the completely monotonic baseline — describes thermal equilibrium. Its perfect Benford conformance ($\delta_B = 0.006$) represents the end state of thermalization: the distribution that a bosonic system relaxes *toward* as it approaches thermal equilibrium. Second, the black hole experiment showed that as matter falls through the event horizon, the Causal Set model's deviation drops — the system moves *toward* Benford conformance. Something about the process of gravitational collapse drives the statistical description closer to the completely monotonic ideal.

The Speculative Interpretation

The second law of thermodynamics states that entropy increases in closed systems. In the Benford framework, the completely monotonic distribution (Bose-Einstein) is the maximum-entropy state for bosonic fields. The speculative interpretation is that entropy increase *is* the drive toward Benford conformance — that what we call "the arrow of time" is the statistical tendency of deviating systems to relax toward the logarithmic baseline.

This reframes time not as a fundamental dimension but as a perceived consequence of this relaxation. We experience time passing because deviating structures (matter, energy configurations, information patterns) are constantly trending toward conformance. The "flow" of time is the statistical drift of δ_B toward zero.

This is not a new idea in isolation — the connection between the arrow of time and entropy increase is textbook thermodynamics. What the Benford framework adds is a specific mathematical target: the completely monotonic distribution. Entropy increase is not directionless disorder but directed relaxation toward a particular distribution shape — the one whose series coefficients are all non-negative.

The implication for spacetime is radical. If time is perceived entropy change, and entropy is the drive toward Benford conformance, then spacetime itself may be descriptive rather than fundamental. It is the coordinate system we use to parameterize the relaxation process, not an independent substrate on which physics happens. The "geometry of spacetime" would then be emergent from the statistics of deviation — which is precisely what the Causal Set results suggest. In that model, spacetime is discrete, built from causal relations, and the black hole interior generates new spacetime by consuming mass-energy and converting it to geometric structure. The geometry emerges from the statistics, not the other way around.

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5. Gravity and Dark Energy

The Data Pattern

The black hole experiment revealed a striking asymmetry in the Causal Set model's behavior. Outside the horizon, at large distances from the black hole, δ_B settles to approximately 0.028 — the Planck/Hawking baseline. As the field approaches the horizon, δ_B *drops*, reaching values as low as 0.003. Inside the horizon, it remains low but gradually rises toward the singularity. The wormhole control experiment showed that this restoration mechanism requires topological structure (a horizon or singularity) to activate. Pure curvature, no matter how extreme, does not trigger it.

Meanwhile, the robustness test confirmed that these results are stable under parameter variation (sample sizes from 10,000 to 100,000 modes, varied momentum cutoffs). The Causal Set ranking (first in black holes, ninth in wormholes) is not a numerical artifact.

The Speculative Interpretation

Gravity, in this framework, may be interpretable as a braking mechanism — the process by which deviating systems (massive objects) are drawn toward conformance. Mass deviates from the Benford baseline (Section 3). Gravity is the tendency of deviating configurations to aggregate, and aggregation drives the system closer to the completely monotonic ideal. The black hole is the endpoint: the most extreme gravitational configuration, where δ_B reaches its minimum (at the horizon in the Causal Set model). Gravity does not "attract" in this reading — it *restores*.

This immediately suggests an interpretation of gravity's weakness relative to the other forces. The conventional hierarchy problem asks: why is gravity 10^{36} times weaker than electromagnetism? The speculative answer from the Benford framework is that this may be a category error. Gravity is not a force competing in the same arena as the gauge forces. It is a geometric consequence of the deviation structure — the shape of the relaxation landscape, not a player on it. Comparing gravity's strength to electromagnetism's strength is like comparing the slope of a hill to the speed of a ball rolling down it. They have different units, different origins, and different roles.

Dark energy — the observed accelerating expansion of the universe — presents a complementary puzzle. If gravity is the braking mechanism that draws deviating systems toward conformance, then dark energy may be the absence of braking. In regions of spacetime where matter density is low (the voids between galaxy clusters), there is insufficient deviation to drive gravitational restoration. The expansion of spacetime proceeds without braking, and since the Causal Set model generates new spacetime at horizons and singularities throughout the universe, the total volume of spacetime grows. In overdense regions, gravity brakes the expansion. In underdense regions, there is nothing to brake.

The accelerating character of the expansion would then follow from a feedback loop: as the universe expands, voids grow, braking diminishes, and expansion accelerates. This requires no cosmological constant, no dark energy fluid, and no modification of general relativity — only the observation that braking requires deviating structures, and deviating structures are not uniformly distributed.

This is speculative, and it makes predictions that differ from the standard ΛCDM model. In particular, it predicts that the effective equation of state of dark energy should depend on local matter density — something the standard cosmological constant does not do. Future surveys (DESI, Euclid, Rubin Observatory) could test this.

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6. Inside the Black Hole

The Data Pattern

The black hole experiment in Riner (2026b) is the richest dataset in the project, and its results deserve detailed unpacking.

The Causal Set restoration cycle: As a bosonic field falls toward a Schwarzschild black hole in the Causal Set model, its deviation δ_B follows a characteristic arc. Far from the hole ($r/r_s = 10$), $\delta_B \approx 0.028$, matching the Hawking baseline. Approaching the horizon, δ_B drops to 0.003–0.006 — below the thermal equilibrium value. This is remarkable: the field is driven *below* the equilibrium deviation by the approach to the horizon. Inside the horizon, δ_B remains low but slowly rises toward the singularity.

The fingerprint match: At $r/r_s = 0.04$ (deep inside the horizon), the per-digit deviation profile $\varepsilon(d)$ of the Causal Set model matches the Hawking radiation spectrum (with peak frequency $\omega_c = 2.0$ in natural units) with an L2 distance of only 0.004. The fingerprint of the field *inside* the black hole matches the fingerprint of the radiation *outside* it.

The topology dependence: The wormhole control drops Causal Set from first to ninth. The mechanism requires a horizon or singularity — not curvature alone — to activate. This 5× performance degradation is the sharpest model-discriminating result in the dataset.

The Hagedorn transition: The Planck wall experiment showed that the Hagedorn/string model undergoes a violent phase transition at T = 0.94 T_P, with δ_B spiking to 0.438 before collapsing to 0.009 on the other side. Post-transition, the spectrum is nearly completely monotonic — all series coefficients positive. The string model *reorganizes* through the singularity and emerges clean.

The Speculative Interpretation

What does a black hole do?

The standard picture involves an event horizon, a singularity, Hawking radiation, and an information paradox. The Benford data suggests a different narrative — or at least, a complementary one.

Mass-stripping: The drop in δ_B as the field approaches the horizon means that deviation — which we have identified with mass (Section 3) — is being stripped from the field. The black hole is not merely trapping matter. It is actively reducing the deviation content of everything that falls toward it. By the time the field crosses the horizon, it has been driven below the equilibrium deviation.

Evaporation without radiation: The conventional picture of black hole evaporation involves Hawking radiation — thermal emission from the horizon. The Benford data does not contradict this, but it suggests an additional mechanism: the mass-energy consumed by the black hole is not merely stored or radiated. It is *converted* — from deviation (mass) to geometry (spacetime structure). The Causal Set model, which treats spacetime as discrete, provides the natural mechanism: each consumed quantum of deviation generates causal relations, growing the spacetime volume.

Mass and light selectivity: The framework naturally distinguishes between mass (deviation > 0) and light (deviation ≈ 0). Mass is consumed because it carries the deviation that the restoration mechanism targets. Light (massless fields) is not consumed in the same way — it is trapped by the horizon geometry but carries negligible deviation content. The black hole is selective: it consumes mass and traps light. This is precisely what the event horizon does in general relativity, but the Benford framework provides a *statistical* reason for the distinction.

Spacetime factory: If consumed deviation is converted to geometric structure, then black holes are spacetime factories. They take in mass (high δ_B) and produce spacetime (the fabric parameterized by the causal set). The mass of the black hole decreases as it emits Hawking radiation, but the spacetime generated by the interior process persists. This connects black holes to cosmological expansion: every black hole in the universe is a local source of new spacetime, contributing to the total volume.

Gravitational waves: When two black holes merge, the resulting gravitational wave emission carries enormous energy — up to 5% of the total mass-energy of the system. In the Benford framework, gravitational waves would represent the propagation of newly generated spacetime structure. The "ripples in spacetime" are literal: they are the leading edge of the geometric structure produced by the merger's mass-energy conversion process.

The information paradox: The standard paradox asks: if a black hole evaporates completely via thermal (information-free) Hawking radiation, where does the information about the infalling matter go? The Benford framework suggests the paradox may dissolve rather than resolve. If the consumed mass-energy is converted to spacetime geometry (causal set structure), then the information is not lost — it is *encoded in the geometry*. The specific pattern of causal relations generated by the consumed matter retains the information content. This is not recovery of information in the conventional sense (decoding it from Hawking radiation). It is a claim that the information never leaves — it becomes the geometry of the interior and, eventually, of the spacetime generated by the black hole's factory function.

The final light burst: As a black hole shrinks via Hawking radiation, its temperature increases ($T \propto 1/M$). In the final moments, the temperature approaches the Planck scale, and the Hagedorn/string model predicts a violent phase transition. The Planck wall data shows this transition at $T = 0.94\ T_P$, with δ_B spiking before collapsing. The speculative interpretation is that a black hole's final evaporation event is not a quiet thermal fade-out but a phase transition — a burst of reorganization in which the remaining mass-energy is converted explosively to spacetime structure. The "final flash" would not be primarily electromagnetic but gravitational: a pulse of new geometry radiating outward.

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7. Before the Big Bang

The Data Pattern

The Planck wall experiment propagated ten quantum gravity models through the cosmological singularity at the Planck temperature $T_P = 1.4 \times 10^{32}$ K. Five distinct behavioral classes emerged:

1. **Phase Transition** (Hagedorn/string): Violent reorganization at $0.94\ T_P$, emerging clean on the other side ($\delta_B = 0.009$).
2. **Absorption** (Causal Set): The wall barely registers. δ_B holds at 0.015–0.017 throughout. The singularity is absorbed as structure.
3. **Dimensional Reduction** (Asymptotic Safety, CDT): Spectral dimension drops through the wall ($3 \to 2$), then recovers.
4. **Degradation** (Standard GR, LQG, GUP): Continuous worsening, no recovery. The semiclassical framework breaks.
5. **Flat** (DSR, Hořava-Lifshitz, Non-commutative Geometry): No response at all. The models are structurally indifferent to the singularity.

The Causal Set "absorption" behavior is the most distinctive: the theory that treats spacetime as fundamentally discrete does not experience the singularity as a catastrophe. It processes the infinite-density point as input, generating structure from it.

The Speculative Interpretation

If the Benford framework represents a structural constraint logically prior to physics (Section 2), then the question "what came before the Big Bang?" takes a different form. The constraint does not require spacetime to exist — it is a condition on statistical distributions, and distributions are mathematical objects, not physical ones. The constraint is *logically prior* to the Big Bang, even if it is not *temporally prior* to it (since time, in this framework, is emergent).

The Planck wall data offers two pictures of the singularity:

The Hagedorn picture: The Big Bang was a phase transition. Before the transition, the universe was in a high-deviation, high-temperature state (string-dominated, all coefficients scrambled). At $T = 0.94\ T_P$, the system reorganized — the series coefficients snapped into a non-negative configuration (complete monotonicity restored), and the post-transition state was a thermal spectrum with nearly perfect Benford conformance. The Big Bang, in this reading, is the moment the constraint *switched on* — the point at which the system's coefficients became organized enough to support coherent statistical structure. What came before was not nothing, but unstructured pre-geometry — a state that cannot be described in terms of spacetime because spacetime requires the constraint to be active.

The Causal Set picture: There was no transition. The constraint was always active, and the singularity was absorbed as structure. The Big Bang is not a phase transition but a generation event — the initial seed of the causal set, from which spacetime grew by the same factory mechanism that operates inside black holes today. In this picture, white holes (the time-reverse of black holes) are not exotic speculations but descriptions of the pre-Big Bang regime: spacetime *emerging from* a singularity rather than collapsing into one.

Both pictures are consistent with the data. The Hagedorn model shows the singularity as a sharp reorganization; the Causal Set model shows it as smooth absorption. The speculative preference for one over the other depends on whether one believes the Planck-scale transition is real (favoring Hagedorn) or an artifact of the string model's particular mathematics (favoring Causal Set).

What both pictures share is the role of the constraint: something must be logically prior to the Big Bang for the statistical structure of the post-Big Bang universe to have the form it does. Whether that something is a phase transition from pre-geometric chaos or the foundational operation of a causal set growing from a seed, the Benford framework provides the criterion by which the post-Big Bang state is selected: it is the state whose distributions are closest to completely monotonic.

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8. The Quantum-Classical Bridge

The Data Pattern

The fingerprint atlas experiment demonstrated that quantum systems carry distinctive $\varepsilon(d)$ signatures. Bosonic systems produce monotone fingerprints (all deviations same-signed after d = 1). Fermionic systems produce oscillatory fingerprints (alternating signs, reflecting the Pauli exclusion principle). Classical (Maxwell-Boltzmann) statistics produce a weak monotone fingerprint — structurally similar to the bosonic case but with lower amplitude.

The existence filter showed a sharp boundary: systems with well-defined occupation statistics (quantum or classical) return finite δ_B values. Systems with ill-defined occupation statistics (negative occupation numbers) return UNDEFINED. There is no intermediate case — the filter is binary.

The anyon interpolation (fractional statistics, $g \in [0, 1)$) provides a continuous bridge between bosonic ($g = 0$, δ_B = 0.006) and fermionic ($g = 1$, δ_B = 0.012) fingerprints. As the exclusion parameter increases from 0 to 1, the fingerprint smoothly rotates from monotone to oscillatory, and δ_B increases proportionally.

The Speculative Interpretation

Quantum mechanics is famously difficult to interpret. The measurement problem — the apparent collapse of the wavefunction upon observation — has generated a century of philosophical debate. The Benford framework does not resolve this debate, but it suggests a way to reframe it.

Decoherence is the process by which quantum superpositions are destroyed through interaction with the environment, producing classical-looking outcomes. In the standard picture, decoherence explains why we observe definite outcomes but does not explain why *those particular* outcomes are selected. The speculative interpretation from the Benford framework is that decoherence is emergence switching on — the moment at which a system's statistical description acquires the structure needed for Benford conformance.

A quantum system in superposition does not have well-defined occupation numbers for all its modes simultaneously. Its statistical description is inherently complex-valued (involving probability amplitudes, not just probabilities). Complex-valued distributions cannot be tested for complete monotonicity in the same way real-valued ones can — the Bernstein-Widder theorem applies to real measures. The speculative leap is that *classical emergence* corresponds to the point at which the system's effective distribution becomes real-valued and testable: when decoherence has eliminated enough off-diagonal terms in the density matrix for the remaining diagonal elements to form a well-defined first-digit distribution.

This also suggests a role for Benford's Law in the string landscape problem. String theory famously predicts an enormous number of possible vacuum states (estimates range from 10^{500} to 10^{10000}). The challenge is explaining why our universe has the particular vacuum it does. The Benford framework's existence filter provides a natural selection criterion: of the vast landscape of possible vacua, only those whose low-energy effective distributions are completely monotonic (or close to it) support stable, emergent structures. The filter does not pick a unique vacuum, but it may dramatically reduce the viable subset — from astronomically many to a tractable number. The 4 UNDEFINED candidates out of 23 exotic physics tests (a 17% rejection rate) hint at how aggressive this filter might be when applied to the full landscape.

9. Conclusion

Everything in this paper is speculation. The measurements are in the data papers. The patterns are real — confirmed by robustness testing across sample sizes from 10,000 to 100,000 modes, across varied momentum cutoffs and grid resolutions. Bose-Einstein statistics really do satisfy Benford's Law exactly. Fermi-Dirac statistics really do deviate with an oscillatory signature governed by the Dirichlet eta function. Causal Set Theory really does rank first inside a black hole and ninth inside a wormhole. Negative-mass bosons really do return UNDEFINED.

The interpretive framework proposed here — Benford conformance as a precondition for existence, mass as deviation, entropy as return toward conformance, gravity as a braking mechanism, black holes as spacetime factories, the Big Bang as the activation of a structural constraint — is a connected narrative that is *consistent with* the data but not *proven by* it. Consistency is the weakest form of support, and extraordinary claims require extraordinary evidence.

What this framework does provide is testable predictions:

1. **Dark energy equation of state**: If dark energy is the absence of gravitational braking, its effective equation of state should depend on local matter density. The standard cosmological constant does not have this property.

2. **Black hole final evaporation**: If the Hagedorn transition is physical, the final stage of black hole evaporation should produce a gravitational wave signature rather than (or in addition to) an electromagnetic burst.

3. **Vacuum selection**: If the Benford existence filter constrains the string landscape, there should be a computable criterion distinguishing viable from non-viable vacua based on the sign structure of their effective low-energy occupation statistics.

4. **Gravitational wave fine structure**: If black holes convert mass to spacetime geometry, the ringdown spectrum of binary black hole mergers should carry fingerprint-like substructure reflecting the mass-to-geometry conversion process.

5. **Anyon continuity**: If the quantum-classical bridge involves smooth rotation of the $\varepsilon(d)$ fingerprint, then systems with tunable statistics (cold atom platforms implementing anyonic excitations) should show continuously rotating Benford fingerprints as the statistics parameter is varied.

These are genuine predictions — falsifiable claims that differ from the consensus expectations of standard physics. If even one of them is confirmed, the speculative framework gains weight. If none of them are confirmed, the speculation was wrong and the data papers remain valid on their own terms.

The honest summary is this: a hobbyist built a measurement tool, pointed it at physics, and found patterns. The patterns survived every robustness test applied to them.

This paper is an attempt to follow where those patterns lead. Whether they lead somewhere real or merely somewhere interesting, only future data can decide.

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