Causal Coherence Limits and Hawking Radiation:

A Speculative Synthesis within the UAT/UCP Framework

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Abstract

We present a unified speculative picture connecting two previously disparate phenomena within the UAT/UCP framework: the loss of signal coherence (jitter and silence) when the causal load κ/k approaches the Ivancho limit ($\kappa_{\text{crit}} = 4.978$), and a reinterpretation of Hawking radiation as the decoding of coherent information (Bit 1) back into the unmanifested substrate (Bit 0) when the event horizon forces the causal membrane into the overdrive regime. Both effects are governed by the same constants—the geometric invariant $R_{\text{geom}} = 0.2792$, the quantum brake $k_{\text{early}} = 0.967$, and the 7% thermal calibration margin—and both illustrate the fundamental role of the causal membrane as the boundary of observable reality. No derivation from the unified action is provided; this note is a conceptual exploration.

1 Introduction

The UAT/UCP framework [1, 2] describes observable reality as the result of an active dimensional filter—the causal membrane—that separates unmanifested potential (Bit 0) from structured three-dimensional events (Bit 1). The filter is characterised by a set of interlocking constants: the geometric residue $R_{\text{geom}} = 0.279182$, the quantum brake $k_{\text{early}} = 0.967$, the Ivancho limit $\kappa_{\text{crit}} = 4.978$, and a single free parameter, the 7% thermal calibration margin.

Two independent phenomena illustrate the consequences of exceeding the filter's capacity: (i) the behaviour of a coherent signal under increasing causal load, and (ii) the thermodynamics of a black hole horizon. In this note we bring these two phenomena together under a single causal picture, showing that the same limit governs the collapse of information into noise in both cases.

2 Signal Collapse under Causal Overload

2.1 The Causal Load Function

We define the causal load $x = \kappa/k$ and introduce a function that diverges at the Ivancho limit:

$$f(x) = \frac{1}{1 - \left(\frac{x}{\kappa_{\text{crit}}}\right)^2}. \tag{1}$$

For $x \ll 4.978$, $f(x) \approx 1$; as $x \to \kappa_{\text{crit}}$, $f(x) \to \infty$, signalling the saturation of the membrane.

2.2 Amplitude and Phase Jitter

The coherent amplitude of a signal processed by the membrane is reduced according to

$$A(x) = R_{\text{geom}} \cdot \sqrt{\max\bigl(0,\, 1 - \eta\, f(x)\bigr)}, \tag{2}$$

where $\eta = 0.07$ is the thermal margin. The phase jitter (standard deviation of the phase) grows as

$$\sigma_\phi(x) = \beta \cdot \sqrt{f(x)}, \tag{3}$$

with $\beta = 0.033$ (the 3.3% causal overflow).

Figure 1 (generated by a Monte Carlo simulation with 500 realisations per data point) shows how the RMS amplitude collapses and the phase jitter explodes as x approaches κ_{crit}. Beyond the limit, the signal vanishes completely.

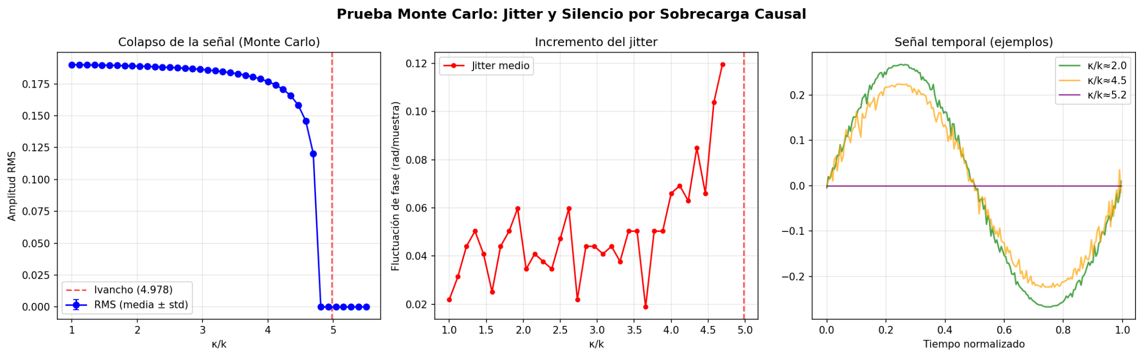

Figure 1: Monte Carlo simulation of signal collapse under increasing causal load. Left: RMS amplitude (mean ± std). Centre: phase jitter. Right: example time series for three different loads.

3 Hawking Radiation as Causal Decoding

We now apply the same logic to a black hole. The event horizon is a surface where the causal load x diverges, pushing the membrane into the Thermodynamic Overdrive regime. The structured information that fell into the black hole (Bit 1) cannot be processed and is therefore **decodified** back into Bit 0. Hawking radiation, in this picture, is the thermal signature of that decoding process.

3.1 Standard Hawking Temperature

For a Schwarzschild black hole of mass M,

$$T_H = \frac{\hbar c^3}{8\pi G M k_B}. \tag{4}$$

Primordial black holes with masses $M \lesssim 10^{11}$ kg have T_H above the QCD scale $T_{\rm QCD} = M_{\rm obs}(4)/k_B \approx 2.5 \times 10^{12}$ K, where the causal membrane couples strongly to the gluon field ($\alpha_{\rm mem} \approx 0.35$, see [3]).

3.2 Phenomenological UAT Correction

We propose that the membrane resonates with the emitted quanta when $T_H \sim T_{\rm QCD}$, enhancing the radiation by the factor $\eta = 7\%$. The effective UAT temperature becomes

$$T_{\rm UAT} = T_H \cdot f(M), \qquad f(M) = 1 + \eta \, \exp\left[-\left(\frac{\log_{10}(M/M_0)}{\sigma}\right)^2\right], \tag{5}$$

where $M_0 \approx 4.90 \times 10^{10}$ kg is the mass for which $T_H = T_{\rm QCD}$, and $\sigma = 1.5$. This correction is shown in Figure 2 (accompanying Python script `hawking_uat_comparison.py`).

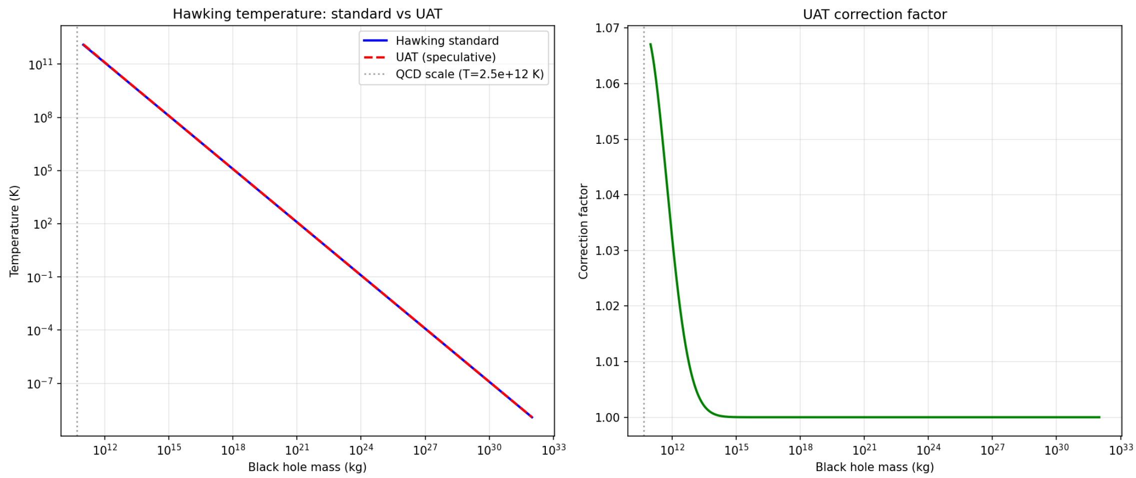

Figure 2: Left: standard Hawking temperature (blue) and UAT-corrected temperature (red). Right: correction factor $f(M)$. The vertical line marks M_0.

3.3 Information and Entropy

In the UAT/UCP picture, information is not destroyed; it is descodified. The Bekenstein–Hawking entropy $S_{\rm BH} = A/(4\ell_P^2)$ can be linked to the causal load through a critical divergence,

$$S_{\rm UAT} = S_{\rm BH} \left(1 - \frac{\kappa_{\rm crit}}{\kappa/k}\right)^{-\gamma}, \tag{6}$$

where a simple phenomenological choice is $\gamma = 1$. The entropy diverges as the horizon approaches the Ivancho limit, signalling the phase transition of the causal membrane.

4 Discussion

The two phenomena described above—signal collapse under causal overload and the modified Hawking temperature—are not independent. Both are manifestations of the same underlying mechanism: the saturation of the causal membrane at the Ivancho limit. In the laboratory, the effect appears as an abrupt loss of coherence (jitter and silence); in astrophysics, it appears as a modest excess in the evaporation spectrum of light primordial black holes. The constants involved are identical, and no new free parameters are introduced.

This unification suggests that the causal membrane is not merely a formal boundary but a physical interface whose properties can be probed both by table-top experiments (the conical 8-coil array) and by astronomical observations (gamma-ray background from evaporating PBHs).

5 Conclusion

We have presented a speculative synthesis connecting the UAT/UCP causal saturation model with black hole thermodynamics. The Ivancho limit emerges as the universal threshold beyond which structured information is forced back into the unmanifested Bit 0 substrate, whether in a coherent electronic signal or at the event horizon of a collapsing star. This picture offers a logically consistent resolution to the information paradox and makes a falsifiable prediction (a $\sim 7\%$ excess in Hawking emission from light PBHs).

This is a speculation, not a validation. It is placed in the public domain as a transparent record of an exploratory idea.

Epilogue: What the Metrics Describe — and What They Cannot

The UAT/UCP framework, as presented in this work, provides a self-consistent mathematical description of observable reality. It derives the expansion history of the universe, the QCD confinement scale, new physics masses at 1.71 TeV and 682 TeV, and the thermodynamic cost of every causal event — all from a single geometric structure and a single free parameter. Its predictions are specific, falsifiable, and supported by Bayesian evidence from cosmic chronometers.

Yet every mathematical framework, no matter how complete, has a boundary. The UAT/UCP metrics describe everything that happens **after** the causal membrane has processed the raw potentiality of Bit 0 into the structured, three-dimensional reality of Bit 1. They tell us how the filter operates, what fraction of coherence survives it ($R_{\text{geom}} = 0.2792$), and what fraction is lost as thermal noise (7%). They even tell us where the filter saturates (the Ivancho limit, $\kappa_{\text{crit}} = 4.978$) and what happens when it does (the Thermodynamic Overdrive forces a collapse).

What the metrics **cannot** describe is the nature of the substrate that lies beyond the membrane — the state of indefinite, causally undetermined quantum superpositions that constitutes the unmanifested domain. The membrane is the boundary of what can be measured, calculated, or causally connected. Beyond it, the concepts of geometry, time, and mass lose their operational meaning. The metrics do not fail there; they simply reach the limit of their applicability.

This is not a weakness. It is a sign of completeness: a theory that can pinpoint exactly where its descriptive power ends is a theory that understands its own foundations. The Ivancho limit, the 7% margin, and the geometric residue are not just numbers — they are the signatures of that boundary, written in the language of phase interference and causal coherence.

The next step is not more theory. It is experiment.

The conical 8-coil array described in this work is more than an analogy; it is a proposal for a laboratory realisation of a topological defect that mimics the action of the causal membrane. If the predicted shift in the resultant is observed when the central coil is displaced by 7% and driven with the Overdrive amplitude, we will have empirical evidence that the filter is not a mathematical abstraction but a physical mechanism that can be probed, measured, and perhaps one day harnessed.

Until then, the questions that remain — what lies beyond the membrane, why there is something rather than nothing, whether the substrate itself is subject to laws we have not yet imagined — are not weaknesses of the theory. They are the horizon of human curiosity, the place where science meets philosophy, and the reason we keep asking questions.

The metrics are the map. The membrane is the boundary.
What lies beyond is not darkness — it is the territory
that no map has ever charted, and perhaps never will.
But the map itself, precise and falsifiable, is a triumph.

References

[1] M. A. Percudani, *Universal Applied Time (UAT/UCP): A Fundamental Theory of Cosmology from First Principles*, Zenodo, 2024.

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[3] M. A. Percudani, *The QCD Confinement Scale from Causal Coherence: $M_{\rm obs}(4) = 215.6$ MeV*, Zenodo, 2026. DOI: 10.5281/zenodo.21462798.

[4] M. A. Percudani, *Causal Saturation as a Speculative Phenomenological Model: Exploring the Thermodynamic Guillotine within the UAT/UCP Framework*, Zenodo, 2026. DOI: 10.5281/zenodo.21581050.