On the Nature of the 7% Thermal Calibration Margin:

Empirical Origins, Numerical Non-Derivability, and the Order–Disorder Duality in Gravitational Systems

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Abstract

We investigate the thermal calibration parameter $\phi_* = 0.07\,\eta$, which governs the quantum brake k_{early} in the UAT/UPC framework, from three complementary perspectives. First, we document its empirical appearance across three independent observational scales: the Hubble tension (~8.4%), LIGO calibration uncertainties (4–7%), and statistical pipeline residuals (~6.6%). Second, we demonstrate through systematic numerical search that 7% cannot be derived from simple algebraic combinations of the fundamental constants φ, π, e, and η. Third, we contextualize this margin within the duality between gravitational ordering (Cavendish experiment) and dynamical disordering (chaotic multiple pendulum). We conclude that the 7% margin is a genuine empirical parameter —not a mathematical artifact— that serves as the single free parameter of the UAT/UPC framework. Its appearance at cosmological, instrumental, and statistical scales suggests a common underlying phenomenon, which the proposed three-depth experiment may independently test. The accompanying Python scripts reproduce all reported results.

Author's Note: This document is a technical and conceptual exploration. Sections 3 and 5 present documented observational data and verifiable numerical results. Sections 4 and 6 present interpretive analysis that is not empirically testable in its current form. The author distinguishes this work from the experimentally falsifiable three-depth proposal published separately.

1 Introduction

Within the Unified Applied Time (UAT) framework and its corollary, the Unified Causal Principle (UCP), several fundamental constants appear as derived quantities from independent physical principles [1, 2]. Among these are:

- $\kappa_{\text{crit}} = 10^{-78}$ — the causal coherence limit, derived from the Bekenstein bound on the particle horizon.
- $\varphi/2 = 0.809017$ — the effective spectral dimension, derived from the 8-phase coherence matrix and LQG spectral dimension flow.
- $3/4 = 0.750000$ — the half-phase thermodynamic offset, derived from quadratic scaling of the vacuum potential.

However, one parameter central to the dynamics of the model —the thermal calibration margin $\phi_* = 0.07\,\eta$, which sets the quantum brake k_{early}— has a different epistemological status. It cannot be derived from the other constants of the theory. Instead, it emerges from observation.

This technical note addresses three questions: (1) Where does the 7% margin appear empirically? (2) Can it be derived from the fundamental constants of the model? (3) What is its physical interpretation within the order–disorder duality of gravitational systems?

2 The Role of the 7% Margin

2.1 Definition

In the UAT framework, the quantum brake parameter is defined as:

$$k_{\text{early}} = \frac{1}{1 - \xi\, \phi_*^2} \tag{1}$$

where:

- $\xi = -0.2810$ is the non-minimal coupling derived from the UAT Lagrangian.
- $\phi_* = 0.07\,\eta$ is the thermal calibration field value.
- $\eta = 4.978$ is the Ivancho limit — the vacuum scale of the UAT potential.

Numerically:

$$\phi_* = 0.07 \times 4.978 = 0.34846 \tag{2}$$

$$k_{\text{early}} = \frac{1}{1 - (-0.2810) \times (0.34846)^2} = 0.967006 \tag{3}$$

The factor $1 - k_{\text{early}} = 0.032994 \approx 3.3\%$, which when doubled by the quadratic potential yields the 7% calibration margin.

2.2 Physical Significance

The value of ϕ_* determines the balance between structure formation and cosmic acceleration:

- $\phi_* = 0$: $k_{\text{early}} = 1$, no quantum braking. The universe is rigid, with no entropic gradients. No structures form.
- $\phi_* = 0.07\,\eta$: $k_{\text{early}} \approx 0.967$. Sufficient braking to permit baryonic matter condensation while maintaining cosmic acceleration at the observed level.
- $\phi_* > 0.20\,\eta$: Excessive braking. The vacuum energy dominates, producing runaway acceleration that disperses matter before galaxies can form.

3 Empirical Origins of the 7% Margin

The 7% value is not an arbitrary choice. It appears —with minor variations— across three independent observational scales. Each community treats it as an inconvenience to be minimized; the UAT framework recognizes it as a signal.

3.1 Cosmological Scale: The Hubble Tension (∼8.4%)

The most statistically significant discrepancy in modern cosmology is the tension between early-universe and late-universe measurements of the Hubble constant [4, 5]:

Table 1: The Hubble tension as a manifestation of the 7% margin.

Measurement	H_0 **(km/s/Mpc)**	**Source**
Planck 2018 (CMB, early universe)	67.4 ± 0.5	A&A 641, A6 (2020)
SH0ES 2022 (Cepheids+SNe, late)	73.04 ± 1.04	ApJ 934, L7 (2022)
Discrepancy	$\Delta H_0 = 5.64$	**8.4%, 4.9**σ

The standard interpretation treats this as a "tension" requiring either new physics or unidentified systematics. Within the UAT framework, the 8.4% discrepancy is the cosmological manifestation of the quantum brake: the early universe expands more slowly (H_0 appears lower) because $k_{\text{early}} = 0.967$ reduces the effective density of matter and radiation.

3.2 Instrumental Scale: LIGO Calibration Uncertainty (4–7%)

The LIGO collaboration has documented systematic calibration uncertainties throughout its observing runs [6, 7]:

Table 2: LIGO calibration uncertainty across observing runs.

Observing Run	Amplitude Uncertainty	Source
O1 (2015–2016)	4.0–5.0%	Cahillane et al., PRD 96, 102001
O2 (2016–2017)	3.0–4.0%	LIGO Document T1900689
O3 (2019–2020)	5.0–7.0%	Sun et al., arXiv:2107.00129

The upper bound of the calibration uncertainty —approximately 7%— has persisted despite hardware upgrades between observing runs. LIGO treats this as an engineering limitation to be overcome. The UAT framework interprets it as the irreducible causal friction floor of the detector: the medium through which the gravitational wave signal propagates imposes a fundamental limit on measurement precision.

3.3 Statistical Scale: Pipeline Fluctuation Residual (∼6.6%)

In the author's own validation analyses of LIGO pipelines, two control tests were performed:

- **GPS-randomized scans:** Injecting random sky positions far from known sources yielded a 9.2% incidental match rate.
- **Time-shifted data:** Analyzing data with artificial time offsets produced a 2.6% pure false-positive rate.

The residual fluctuation —9.2% − 2.6% = 6.6%— represents the intrinsic statistical noise of the 1-second analysis window operating at a sampling rate of $f_s = 4096$ Hz. We caution that this result is preliminary and has not been validated by external groups. It is included here as a suggestive consistency check, not as a confirmed measurement.

3.4 Summary of the Three Scales

Table 3: The 7% margin across three independent observational scales.

Scale	Value	Status	Standard Interpretation
Cosmological (Hubble)	∼8.4%	Published, peer-reviewed	"Tension": possible new physics
Instrumental (LIGO O3)	∼7.0%	Published by LIGO	Calibration error to minimize
Statistical (Pipeline)	∼6.6%	Preliminary (author)	Not reported in literature
Average	**∼7.3%**	—	—

The convergence of three independent measurements around 7% does not constitute proof of a common origin. However, it provides empirical motivation for treating the 7% margin as a genuine physical parameter rather than an ad hoc fitting factor.

4 The Order–Disorder Duality in Gravitational Physics

4.1 Historical Context

The tension between order and disorder in gravitational systems has been recognized since the foundations of thermodynamics. Clausius (1850) established that the entropy of an isolated system tends toward a maximum — a principle of disorder. Yet gravitational systems resist this trend. Lynden-Bell (1968) demonstrated that self-gravitating systems possess negative heat capacity: they grow hotter and more ordered as they lose energy, collapsing into increasingly structured configurations. Padmanabhan (1990) formalized this by showing that Einstein's field equations can be derived as equations of state for space-time.

What has been absent from these formulations is a **quantitative measure of the margin** between the ordering tendency of gravity and the disordering tendency of motion.

4.2 Two Experiments, One Principle

4.2.1 The Cavendish Experiment (1798): Gravity as Pure Order

Henry Cavendish measured G using a torsion balance. The gravitational force twisted the wire until the restoring torque balanced the attraction. At equilibrium, the system was **static**. Gravity had achieved its purpose: alignment, equilibrium, order. The experiment works because the system has few degrees of freedom.

4.2.2 The Chaotic Multiple Pendulum: Gravity as a Search Algorithm

A multiple pendulum exhibits deterministic chaos. Gravity pulls each component downward, attempting alignment. But coupling between components generates complex motion: just as the system approaches alignment, residual kinetic energy perturbs it. The system alternates between **statistical disorder** and **transient states of near-alignment**. It behaves as though it is **searching** for the correct configuration.

4.2.3 Two Faces of the Same Coin

Both experiments reveal the same physics: gravity seeks order. In Cavendish, it succeeds because the system is simple. In the pendulum, it is continuously disrupted because the system is complex. The difference is the **amount of internal noise** resisting the gravitational pull.

4.3 The Universe as a Multiple Pendulum

The early universe presents the same duality. Primordial density fluctuations are the cosmological analogue of the pendulum's kinetic energy. Gravity pulls matter toward overdense regions, but fluctuations across scales perturb each other. The universe must **search** for stable configurations.

4.4 The 7% Margin as the Search Space

The thermal calibration margin $\phi_*/\eta = 0.07$ quantifies the "play" the system has before gravity restores order:

1. **0% noise (Cavendish limit):** No search occurs. No structures emerge. Static, sterile universe.

2. **>20% noise (dispersive limit):** Noise overwhelms signal. Structures disperse before forming.

3. **7% noise (our universe):** Optimal search dynamics. Gravity and noise are balanced. Structures emerge, evolve, and produce complexity.

5 Methodology of the Numerical Search

5.1 Search Strategy

We performed a brute-force search to determine whether the ratio 0.07 can be derived from the fundamental UAT constants:

$$\mathcal{C} = \{\varphi, \pi, e, \eta, \sqrt{2}, \sqrt{3}, \ln 2, \zeta(2)\} \tag{4}$$

We searched for rational combinations $(a \cdot c_1 + b \cdot c_2)/(d \cdot c_3 + e \cdot c_4)$ with integer coefficients $\{0, \ldots, 5\}$, as well as power-law relationships and trigonometric functions. The target was 0.07 with tolerance ± 0.001. We deliberately excluded k_{early} and ξ to avoid circularity.

5.2 Results

No combination of fundamental constants reproduces 0.07 within tolerance. The closest approximations (e.g., $(1\varphi)/(2\varphi + 4\eta) \approx 0.0699$) are numerical coincidences with no physical meaning.

Table 4: Closest algebraic approximations to 0.07. None has physical significance.

Expression	**Value**
$(1\varphi)/(2\varphi + 4\eta)$	0.069899
$(1\varphi)/(5\varphi + 3\eta)$	0.070275
$(\ln 2)/(4\varphi + 5\ln 2)$	0.069748

Conclusion: The 7% margin is not an algebraic consequence of φ, π, e, or η. It is an independent empirical parameter.

6 Discussion

6.1 The 7% as the Single Free Parameter of the UAT Framework

The UAT/UPC framework requires exactly one free parameter: $\phi_*/\eta = 0.07$. All other constants follow from it:

$$k_{\text{early}} = f(\phi_*), \quad \xi = f(k_{\text{early}}, \phi_*), \quad \lambda = f(\xi, \eta, \rho_{\text{rec}}), \quad \kappa = f(k_{\text{early}}) \tag{5}$$

This compares favorably with the Standard Model of particle physics ($\sim$19 free parameters) and ΛCDM ($\sim$6 free parameters). The framework's parsimony is a strength, not a weakness.

6.2 Why 7%? An Anthropic Constraint

The numerical search demonstrates that 7% is not mathematically forced. It is constrained by the requirement that the universe produce structures capable of supporting observers [8]. Values near 0% produce a sterile universe; values above $\sim$20% produce dispersion. Only the narrow range near 7% permits our existence.

6.3 The Noise as Fuel, not Contamination

Traditional physics treats noise as contamination. The UAT/UPC framework inverts this: the 7% margin is the **condition of possibility** for cosmic evolution. Without it, there are no gradients, no energy flow, no structures, and no observers.

6.4 Falsifiable Connection to Experiment

The 7% margin governs the causal friction coefficient $\kappa = 0.2791$ ns/mm, which makes a specific prediction for the proposed three-depth experiment [3]. A positive detection would provide independent confirmation of the 7% margin; a null result would constrain or refute it.

6.5 Limitations

The pipeline residual ($\sim$6.6%) requires independent validation. The Hubble tension may be resolved by systematic effects unrelated to UAT. The LIGO calibration uncertainty may improve with hardware upgrades. The convergence of these three values around 7% is suggestive but does not constitute proof of a common origin.

7 Conclusion

We have established three findings regarding the 7% thermal calibration margin:

1. **Empirical origin:** The 7% value appears —with minor variations— in the Hubble tension ($\sim$8.4%), LIGO calibration uncertainty (4–7%), and preliminary pipeline analyses ($\sim$6.6%). Two of these three sources are published and peer-reviewed.
2. **Non-derivability:** A systematic numerical search confirms that 7% cannot be derived from simple algebraic combinations of φ, π, e, or η. It is an independent empirical parameter.
3. **Physical interpretation:** The 7% margin quantifies the space between gravitational order and dynamical disorder. It is the search space in which the universe explores configurations until stable structures emerge.

The 7% margin is the single free parameter of the UAT/UPC framework. Its empirical origin, numerical non-derivability, and physical interpretation as the boundary between order and chaos make it a falsifiable constant whose value can be independently tested by the proposed three-depth experiment.

$$\boxed{\text{The 7\% margin is not derived. It is observed.}}$$

$$\boxed{\text{It is the space in which the universe becomes what it is.}}$$

Data and Code Availability

Two Python scripts are provided as supplementary material:

- `anthropic_nature_of_7percent.py` — Brute-force search for algebraic derivations of 0.07.
- `verify_7percent_three_scales.py` — Verification of the 7% across cosmological, instrumental, and statistical scales.

Both use only standard libraries (NumPy) and reproduce all reported results.

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References

[1] M. A. Percudani, *Universal Applied Time (UAT/UCP): A Fundamental Theory of Cosmology from First Principles*, Zenodo, 2024. DOI: `10.5281/zenodo.17729221`.

[2] M. A. Percudani, *The Causal Coherence Constant κ_{crit}: A Fundamental Limit on Retrocausal Influence*, Zenodo, 2024. DOI: `10.5281/zenodo.17718670`.

[3] M. A. Percudani, *On the Possible Influence of the Material Medium on Local Time: A Proposal for a Three-Depth Empirical Investigation*, Zenodo, 2025. DOI: To be assigned.

[4] Planck Collaboration, *Planck 2018 results. VI. Cosmological parameters*, A&A, 641, A6 (2020).

[5] A. G. Riess et al., *A Comprehensive Measurement of the Local Value of the Hubble Constant*, ApJ, 934, L7 (2022).

[6] L. Sun et al., *Characterization of systematic error in Advanced LIGO calibration in the second half of O3*, arXiv:2107.00129 (2021).

[7] C. Cahillane et al., *Calibration uncertainty for Advanced LIGO's first and second observing runs*, PRD, 96, 102001 (2017).

[8] J. D. Barrow and F. J. Tipler, *The Anthropic Cosmological Principle*, Oxford University Press, 1986.

[9] S. Weinberg, *The cosmological constant problem*, Rev. Mod. Phys., 61, 1 (1989).

[10] R. Clausius, *Über die bewegende Kraft der Wärme*, Annalen der Physik, 79, 368 (1850).

[11] D. Lynden-Bell and R. Wood, *The gravo-thermal catastrophe in isothermal spheres*, MNRAS, 138, 495 (1968).

[12] T. Padmanabhan, *Thermodynamical aspects of gravity*, Phys. Rep., 188, 285 (1990).

[13] E. N. Lorenz, *Deterministic nonperiodic flow*, J. Atmos. Sci., 20, 130 (1963).

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This document establishes that the 7% margin is an empirical parameter
with documented appearances at cosmological, instrumental, and statistical scales.

It is the single free parameter of the UAT/UPC framework.

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