The UAT/UCP Framework in Cosmology:

A Synthesis of Results
Hubble Tension, Cosmological Constant, Causal Membrane Dynamics, and Falsifiable Predictions

Miguel Ángel Percudani
Independent Researcher, Puan, Buenos Aires, Argentina
miguel_percudani@yahoo.com.ar

ORCID: 0009-0007-1748-3212

July 11, 2026

Abstract

We present a unified synthesis of the UAT/UCP (Unified Applicable Time / Unified Causal Principle) framework and its results in cosmology. The framework introduces a single free parameter —the 7% thermal calibration margin ($\phi_*/\eta = 0.07$)— from which all other constants are derived: the quantum braking factor ($k_{\text{early}} = 0.967$), the Ivancho limit ($\kappa_{\text{crit}} = 4.978$), the causal overflow ($\varepsilon = 3.3\%$), and the force metric ($R_{\text{geom}} = 0.2791$). We show that the framework resolves the Hubble tension by reducing the effective density of matter and radiation in the early universe, yielding $H_0 = 73.0$ km/s/Mpc and a sound horizon $r_d \approx 141$ Mpc. The vacuum energy density is derived as $\Lambda = E_{\text{Planck}} \times \kappa_{\text{crit}}^{\varphi/2+3/4} = 2.50 \times 10^{-122}\, M_{\text{Pl}}^4$, matching Planck 2018 within $\sim 1.2\%$. The dynamic extension —causal membrane dynamics— reveals that the universe operates on a truncated phase cycle of 348.12°, expending 3.3% of its energy per cycle to sustain expansion. A Monte Carlo simulation with 10,000 iterations validates the non-random nature of the force metric ($p < 0.001$). We present the full set of falsifiable predictions and explicitly acknowledge the framework's limitations. The UAT/UCP framework is a phenomenological model under development, not a validated theory. Its value lies in the internal consistency of its constants and the specificity of its testable predictions.

1 Introduction

Modern cosmology faces two profound challenges. The first is the Hubble tension: the 4.9σ discrepancy between early-universe measurements of the expansion rate ($H_0 \approx 67.4$ km/s/Mpc from Planck CMB data) and late-universe measurements ($H_0 \approx 73.0$ km/s/Mpc from SH0ES Cepheid-calibrated supernovae) [8, 9]. The second is the cosmological constant problem: the 10^{122} discrepancy between the predicted vacuum energy density from quantum field theory and the observed dark energy density.

The UAT/UCP framework [1, 2] addresses both challenges through a single mechanism: the quantum brake. The universe, in this model, does not expand at the full rate predicted by General Relativity. A small fraction of its energy —the causal overflow ($\varepsilon = 3.3\%$)— is continuously expended to sustain expansion against gravitational collapse. This expenditure modifies the early-universe expansion rate, shortening the sound horizon and reconciling the two measurements of H_0. The same mechanism, operating over cosmic history, yields the observed vacuum energy density.

This document provides a unified synthesis of the UAT/UCP framework and its results. It is intended as a reference for researchers who wish to understand the full logical chain, from the foundational postulates to the falsifiable predictions.

2 Foundations: Constants and Parameters

2.1 The Single Free Parameter

The UAT/UCP framework contains exactly one free parameter: the thermal calibration margin $\phi_*/\eta = 0.07$ (7%). This value is constrained by the observed existence of cosmic structures: a margin of 0% would yield a sterile, structureless universe ($\Lambda = 0$), while margins exceeding $\sim 20\%$ would produce runaway acceleration preventing galaxy formation [4]. The 7% value is inferred from three independent observational scales: the Hubble tension ($\sim 8.4\%$), LIGO calibration uncertainty (4–7%), and pipeline fluctuation residuals ($\sim 6.6\%$). Its average is $\sim 7.3\%$.

A systematic numerical search has confirmed that 0.07 does not emerge from simple algebraic combinations of the fundamental constants φ, π, e, or η [4]. It is a genuine empirical input.

2.2 Derived Constants

From the single free parameter, all other constants follow through a chain of exact relationships:

Table 1: Fundamental constants of the UAT/UCP framework. All are derived from $\phi_*/\eta = 0.07$ and the UAT Lagrangian.

Constant	**Value**	**Derivation**
Ivancho limit (η)	4.978	Metric buffer saturation
Thermal field (ϕ_*)	0.34846	$\phi_* = 0.07\,\eta$
Non-minimal coupling (ξ)	-0.2810	$\xi = (1 - 1/k_{\text{early}})/\phi_*^2$
Self-coupling (λ)	3.08×10^{-112}	$\lambda = -\xi R_c/(2\eta^2)$
Quantum brake (k_{early})	0.967	$k_{\text{early}} = 1/(1 - \xi\phi_*^2)$
Causal overflow (ε)	0.0330 (3.3%)	$\varepsilon = 1 - k_{\text{early}}$
Force metric (R_{geom})	0.279182	$R(8, 43.515°)$
Causal coherence (κ_{crit})	10^{-78}	Bekenstein bound
Spectral dimension	$\varphi/2 = 0.809017$	8-phase coherence matrix + LQG
Thermal offset	$3/4 = 0.750000$	Quadratic potential scaling

3 Cosmological Results

3.1 Resolution of the Hubble Tension

The quantum brake modifies the effective Friedmann equation in the early universe:

$$H^2(z) = H_0^2\left[k_{\text{early}}\,\Omega_m(1+z)^3 + k_{\text{early}}\,\Omega_r(1+z)^4 + \Omega_\Lambda\right] \tag{1}$$

With $k_{\text{early}} = 0.967$, the effective density of matter and radiation is reduced by 3.3% for $z \gg 1$. This shortens the sound horizon from the Planck value $r_d = 147.09$ Mpc to $r_d \approx 141$ Mpc, reconciling the CMB-inferred H_0 with the local measurement.

3.2 BAO Validation

The UAT model has been tested against BAO data from BOSS, eBOSS, and DESI [10]. Table 2 presents the results.

Table 2: χ^2 comparison between ΛCDM and UAT against BAO data.

Model	H_0 (km/s/Mpc)	r_d (Mpc)	χ^2	$\Delta\chi^2$ vs. ΛCDM
ΛCDM (Planck)	67.36	147.09	87.09	—
ΛCDM (SH0ES)	73.00	147.09	72.75	−14.34
UAT	**73.00**	**141.00**	**48.68**	**+38.41**

The UAT model yields a χ^2 significantly lower than both ΛCDM variants, indicating superior fit to the BAO data while maintaining consistency with the local H_0 measurement.

3.3 The Cosmological Constant

The vacuum energy density is derived from the three pillars of the framework [3]:

$$\boxed{\Lambda = E_{\text{Planck}} \times \kappa_{\text{crit}}^{\varphi/2+3/4} = 2.50 \times 10^{-122}\, M_{\text{Pl}}^4} \tag{2}$$

This matches the observed value (Planck 2018: $2.47 \pm 0.03 \times 10^{-122}\, M_{\text{Pl}}^4$) to within $\sim 1.2\%$. The derivation uses no free parameters beyond the three pillars and the Bekenstein bound.

4 Causal Membrane Dynamics

4.1 The Cyclic Moment Equation

The static vacuum structure is complemented by a dynamic description: the accumulation of moment in the causal membrane over an operational cycle [6]:

$$\boxed{M_p = \oint \frac{\Psi_{\text{8phase}} \cdot \kappa_{\text{crit}}}{\sqrt{1-(v/c)^2}}\, dt} \tag{3}$$

where $\Psi_{\text{8phase}} = \sum_{k=0}^{7} A_k e^{i(\omega t+\theta_k)}$ is the collective state of the 8 phase fronts, with $\theta_k = k \times 43.515^\circ$.

4.2 The Causal Overflow

Numerical evaluation reveals that the operational cycle spans $8 \times 43.515^\circ = 348.12^\circ$, not the classical 360°. The deficit:

$$\boxed{\varepsilon = 360^\circ - 348.12^\circ = 11.88^\circ \quad \Rightarrow \quad \varepsilon_{\text{frac}} = 0.0330 = 3.3\% = 1 - k_{\text{early}}} \tag{4}$$

is the **causal overflow**: the fraction of phase space that cannot be coherently integrated within a single cycle. This energy is expended to sustain cosmic expansion. The temporal difference per cycle is 176,122 ns at $f_{\text{base}} = 187.37$ Hz, corresponding exactly to $1 - k_{\text{early}}$.

The M_p ratio between the UAT and classical cycles is approximately 2.54, indicating enhanced moment accumulation due to the non-Euclidean phase geometry. The relativistic correction is negligible ($\gamma \approx 1$, with $v/c \approx 2.84 \times 10^{-9}$).

4.3 Connection to the 7% Margin

The causal overflow (3.3%) is doubled by the quadratic scaling of the double-well potential $V(\phi) \propto \phi^4$ to yield the thermal calibration margin:

$$2 \times 3.3\% = 6.6\% \approx 7\% = \phi_*/\eta \tag{5}$$

5 Laboratory Validation: The 8-Coil Interferometer

5.1 The Force Metric

The force metric $R_{\text{geom}} = 0.279182$ is derived from the 8-phasor sum with step $\Delta\theta = 45° \times k_{\text{early}} = 43.515°$:

$$R_{\text{geom}} = \left| \sum_{k=0}^{7} e^{ik\Delta\theta} \right| = \frac{\sin(8 \times 43.515°/2)}{\sin(43.515°/2)} = 0.279182 \tag{6}$$

This value agrees with the experimentally measured amplitude in an 8-coil phase interferometer (0.2792 ± 0.0005) [1].

5.2 Monte Carlo Validation

A Monte Carlo simulation with 10,000 iterations tested the null hypothesis that the observed residual arises from random thermal phase jitter (Gaussian noise with $\sigma = 3°$ added to the classical 45° step). The results are presented in Table 3.

Table 3: Monte Carlo validation of the force metric.

Statistic	**Value**
Simulations	10,000
Null mean amplitude	0.0164
Null standard deviation	0.0085
Maximum null amplitude	0.0588
Observed amplitude (R_{geom})	0.2791
p-value	$<$ **0.001**
Ratio observed/maximum null	**4.7**$\times$

The null hypothesis is decisively rejected. The observed residual cannot be explained by thermal noise. It requires a geometric explanation, which the UAT framework provides.

6 Falsifiable Predictions

The framework makes the following specific, testable predictions:

1. **Three-depth experiment:** A differential measurement with three optical clocks at depths of 0, 1000, and 3000 meters, with timing photons traversing the water column, should detect a residual of 5.16 ns between 1000 m and 3000 m, with an SNR $> 10^6$ after 1 hour of integration [5]. A null result would constrain or refute the causal friction coefficient $\kappa = 0.2791$ ns/mm.

2. **Causal overflow timing:** At the base frequency $f_{\text{base}} = 187.37$ Hz, each operational cycle should exhibit a timing discrepancy of 176,122 ns relative to the classical expectation. This is measurable with current optical clock technology.

3. **8-coil replication:** Any 8-element phase-coherent array operated at the UAT step angle of 43.515° should produce a normalized residual amplitude of 0.2791, independent of the physical substrate (copper coils, optical fibers, acoustic resonators).

4. **Euclid/Roman/DESI-2:** The UAT prediction $\Omega_\Lambda \approx 0.6953$ is systematically higher than the ΛCDM value (~ 0.685) by approximately 0.01. Stage IV surveys with projected precision $\sigma(\Omega_m) \sim 0.003$ should be able to distinguish between the two models.

7 Limitations

We explicitly acknowledge the following limitations:

1. **The 7% margin is an empirically constrained parameter, not a derived constant.** It is the single free parameter of the framework. Its value is inferred from observation, not from first principles.

2. **The UAT/UCP framework is not part of mainstream physics.** Its constants do not appear in standard references (CODATA, NIST) and it has not undergone peer review in high-impact journals.

3. **The framework does not extend to particle physics.** A systematic numerical exploration found no structural connection between UAT/UCP constants and Standard Model constants (α, $\sin^2\theta_W$, α_s) [7].

4. **The M_p equation is phenomenological.** It is motivated by the UAT Lagrangian through Noether's theorem, but a rigorous derivation remains incomplete.

5. **Independent experimental validation is pending.** The 8-coil measurement and the Monte Carlo simulation were performed by the author. Replication by an independent laboratory is essential.

8 Conclusion

The UAT/UCP framework is a phenomenological model that addresses the Hubble tension and the cosmological constant problem through a single mechanism: the quantum brake. With one free parameter —the 7% thermal calibration margin— it produces a self-consistent set of constants that yield $H_0 = 73.0$ km/s/Mpc, $\Lambda = 2.50 \times 10^{-122}\, M_{\text{Pl}}^4$, and a superior fit to BAO data ($\chi^2 = 48.7$ vs. $\chi^2 = 87.1$ for ΛCDM).

The dynamic extension —causal membrane dynamics— reveals that the universe operates on a truncated phase cycle, expending 3.3% of its energy per cycle on expansion. The force metric $R_{\text{geom}} = 0.2791$ has been validated in the laboratory and confirmed non-random by Monte Carlo simulation ($p < 0.001$).

The framework makes specific, falsifiable predictions. The three-depth experiment, the causal overflow timing measurement, and the comparison with Stage IV survey data will determine whether the UAT/UCP framework describes physical reality or is an internally consistent but ultimately incorrect model.

The framework is coherent. The predictions are specific.

Experiment will decide.

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.18210808.

[3] M. A. Percudani, *First-Principles Resolution of the Cosmological Constant Problem*, Zenodo, 2025. DOI: 10.5281/zenodo.21109424.

[4] M. A. Percudani, *On the Nature of the 7% Thermal Calibration Margin*, Zenodo, 2025. DOI: `10.5281/zenodo.21211964`.

[5] M. A. Percudani, *On the Possible Influence of the Material Medium on Local Time*, Zenodo, 2025. DOI: `10.5281/zenodo.21197996`.

[6] M. A. Percudani, *Causal Membrane Dynamics and the 3.3% Overflow*, Zenodo, 2025. DOI to be assigned.

[7] M. A. Percudani, *Limitations of the UAT/UCP Framework in the Quantum Domain*, Zenodo, 2025. DOI to be assigned.

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

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

[10] DESI Collaboration, *DESI 2024 VI: Cosmological Constraints from the Measurements of Baryon Acoustic Oscillations*, arXiv:2404.03002 (2024).

Synthesis Document — July 11, 2026
This document unifies all UAT/UCP results in cosmology.
It is intended as a reference for researchers evaluating the framework.

Document DOI:10.5281/zenodo.21313468