

Unified Predictions of the UAT/UCP Framework:

Cosmological Validation, QCD Confinement, and New Physics Scales
at 1.71 TeV and 682 TeV

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Abstract

We present a comprehensive overview of the predictions derived from the Unified Applicable Time (UAT) and Unified Causal Principle (UCP) framework. Using a single free parameter—the 7% thermal calibration margin—the framework yields a consistent set of results spanning cosmology, strong interaction physics, and high-energy collider phenomenology. We summarize the cosmological validation through the $Om(z)$ diagnostic and cosmic chronometers, which decisively favor UAT over Λ CDM in Bayesian model selection (Bayes factor $B \approx 294$). We detail the Causal Mass Gap equation, which predicts the QCD confinement scale $M_{\text{obs}}(4) = 215.6$ MeV (0.7% agreement with Λ_{QCD}), a resonance at $M_{\text{obs}}(5) = 1.71$ TeV, and a neutrino seesaw scale at $M_{\text{obs}}(6) = 682$ TeV. For the 1.71 TeV resonance, we document a numerical coincidence with four discarded marginal LHC anomalies and demonstrate via a toy Monte Carlo that approximately $13,000 \text{ fb}^{-1}$ would be required for a 5σ discovery—well beyond the HL-LHC reach. This prediction, therefore, cannot be tested with currently planned colliders. We also mention a null result from a seismic search for a predicted 6.18 Hz causal overflow signal. All results are obtained with zero additional free parameters, and the full derivations, along with the original Python scripts, are provided in a supplementary ZIP archive.

1 Introduction

The UAT/UCP framework [1, 2] provides a unified description of cosmic expansion, dark matter, dark energy, and particle physics scales from a single geometric structure: the interference of 8 phase fronts with a quantum brake step $\Delta\theta = 43.515^\circ$. The entire framework contains exactly **one free parameter**—the 7% thermal calibration margin $\phi_*/\eta = 0.07$ [6]—from which all other constants are derived.

The core constants are:

- Golden ratio $\phi = 1.618034$ (from diagonalization of the 8-phase coherence matrix).

- Causal coherence limits: $\kappa_{\text{crit}} = 10^{-78}$ (Planck) and $\kappa_{\text{crit}} = 4.978$ (macro) [2].
- Quantum brake $k_{\text{early}} = 0.967$ (from the UAT Lagrangian [3]).
- 8-phase interference residue $R_{\text{geom}} = 0.279182$ (measured in the laboratory [10]).
- Geometric projection factor $2R_{\text{geom}} = 0.558364$.
- Temporal viscosity $\sigma_{\text{TVI}} = 3.2400$ (from LIGO universal background [12]).

A detailed derivation of each constant can be found in the Supplementary Material.

The unified action $S_{\text{total}} = S_{\text{bulk}} + S_{\text{boundary}} + S_{\text{coherence}}$ [7] leads to three sets of observable predictions:

1. **Cosmology:** expansion history $H(z)$, effective matter density $\Omega_m^{(\text{eff})}$, cosmological constant Λ .
2. **QCD:** confinement scale Λ_{QCD} from the $n = 4$ causal channel.
3. **High-energy physics:** new mass scales at $n = 5, 6, \dots$ via the Causal Mass Gap equation.

In this article, we collect these predictions, present their current experimental status, and emphasize the falsifiability of the framework.

2 Cosmological Validation

The UAT expansion history is given by the modified Friedmann equation

$$H_{\text{UAT}}(z) = H_0 \sqrt{k_{\text{early}} \Omega_r (1+z)^4 + k_{\text{early}} \Omega_m^{(\text{eff})} (1+z)^3 + \Omega_\Lambda^{(\text{UAT})}}, \quad (1)$$

with $H_0 = 73.04$ km/s/Mpc (SH0ES [16]). The effective matter density is derived from the membrane mass,

$$\Omega_m^{(\text{eff})} = \Omega_b \times \kappa_{\text{crit}}^{(\text{macro})} \times \phi \times (1 - 0.07) = 0.04182 \times 4.978 \times 1.618034 \times 0.93 \approx 0.3133, \quad (2)$$

matching Planck 2018 (0.315 ± 0.007) [15] to 0.55%. Dark energy is fixed by geometric closure $\Omega_\Lambda^{(\text{UAT})} = 1 - (\Omega_m^{(\text{eff})} + \Omega_r) = 0.6867$.

Using 31 cosmic chronometer $H(z)$ measurements [19, 20] and 3 BOSS DR12 BAO points [21], we computed the χ^2 and performed a Bayesian model selection analysis (details in the Supplementary Material). The results are summarized in Table 1.

Table 1: Cosmological model selection ($N = 31$ chronometers).

Criterion	UAT	ΛCDM	Δ	Preferred
χ^2	20.70	14.90	+5.80	–
k (params)	1	6	+5	–
AIC	22.70	26.90	−4.20	UAT (89.1%)
BIC	24.13	35.50	−11.37	UAT (99.7%)
Bayes Factor	–	–	$B \approx 294$	UAT (decisive)

The $Om(z)$ diagnostic $[H(z)^2/H_0^2 - 1]/[(1+z)^3 - 1]$ shows a mild evolution in UAT (mean 0.2948 ± 0.0104), in contrast to the constant $\Omega_m = 0.315$ expected in ΛCDM . Combined with a previous $f\sigma_8(z)$ growth-rate analysis ($B \approx 1755$) [13], the cosmological data decisively favor the UAT framework when penalizing parametric complexity.

3 The Causal Mass Gap and QCD Confinement

The coherence sector of the unified action couples the UAT scalar field to Standard Model operators, producing observable masses given by the Causal Mass Gap equation [9, 8]:

$$M_{\text{obs}}(n) = 2R_{\text{geom}} \times E_{\text{Planck}} \times \kappa_{\text{crit}}^{1/n}, \quad \kappa_{\text{crit}} = 10^{-78}. \quad (3)$$

For $n = 4$ (the rank of the even-parity coherence matrix), this yields

$$M_{\text{obs}}(4) = 0.558364 \times 1.22 \times 10^{28} \text{ eV} \times 10^{-19.5} = 215.6 \text{ MeV}. \quad (4)$$

The Particle Data Group [22] quotes $\Lambda_{\text{QCD}} = 217 \pm 15 \text{ MeV}$, an agreement of 0.65%. The geometric projection factor $2R_{\text{geom}}$ resolves a previously noted factor-of-1.78 discrepancy between the pure resonance $E(4) = 386 \text{ MeV}$ and Λ_{QCD} .

From this scale one derives a causal coherence length $\lambda_{\text{coh}} \approx 5.7 \text{ fm}$ and a membrane-gluon coupling $\alpha_{\text{mem}} \approx 0.35$, both consistent with hadronic phenomenology (see Supplementary Material for full derivations).

4 New Physics Scales: 1.71 TeV and 682 TeV

The same equation (3) for $n = 5$ and $n = 6$ gives

$$M_{\text{obs}}(5) = 2R_{\text{geom}} \times E_{\text{Planck}} \times (10^{-78})^{1/5} = 0.558364 \times 3.07 \text{ TeV} = 1.71 \text{ TeV}, \quad (5)$$

$$M_{\text{obs}}(6) = 2R_{\text{geom}} \times E_{\text{Planck}} \times (10^{-78})^{1/6} = 0.558364 \times 1.22 \text{ PeV} = 681.7 \text{ TeV} \approx 682 \text{ TeV}. \quad (6)$$

1.71 TeV: This mass lies in a region searched for new resonances at the LHC. A possible signature would be a dijet or dilepton resonance, or mono-jet + missing energy if the membrane couples weakly to the Standard Model.

682 TeV: This is remarkably close to the typical Type I seesaw scale for generating light neutrino masses ($m_\nu \sim v^2/M_R$ with $v = 246 \text{ GeV}$). For $M_R = 682 \text{ TeV}$, one expects $m_\nu \sim 0.09 \text{ eV}$, consistent with oscillation data and cosmological limits.

5 Experimental Status of the 1.71 TeV Resonance

5.1 Coincidence with discarded LHC anomalies

During LHC Run 2, four marginal excesses were reported by ATLAS and CMS in the 1.6–1.9 TeV mass range (Table 2). All were later found to be consistent with background fluctuations and were discarded by the experimental collaborations. Their proximity to the UAT prediction of 1.71 TeV is noted solely for transparency and future reference; it does *not* constitute evidence.

5.2 LHC exclusion limits

The causal membrane couples to matter through the temporal viscosity $\sigma_{\text{TVI}} = 3.2400$, which suppresses the production cross section by $\sigma_{\text{TVI}}^2 \approx 10.5$. Using a reference cross section of 0.5 pb for a standard Z' -like mediator at 1.7 TeV, we estimate

$$\sigma_{\text{UAT}} \times A \approx \frac{0.5 \text{ pb}}{10.5} \times 0.4 \approx 19 \text{ fb}, \quad (7)$$

Table 2: Marginal LHC anomalies in the 1.6–1.9 TeV region (all discarded).

Anomaly	Mass [TeV]	ΔM [TeV]	Significance	Status
$t\bar{t}$ resonance (CMS)	1.70	0.01	$\sim 2.0\sigma$ local	Marginal [23]
VV diboson (ATLAS)	1.80	0.09	$\sim 3.4\sigma$ (2015) $\rightarrow < 2\sigma$	Attenuated [24]
Dijet VLQ (CMS)	1.60	0.11	$\sim 2.5\sigma$ local	Unconfirmed [25]
SUSY gluino (ATLAS)	1.90	0.19	$\sim 2.1\sigma$ local	Consistent with background

with a $\pm 7\%$ uncertainty band. Current ATLAS and CMS mono-jet limits at 1.71 TeV are ~ 28 fb [27] and ~ 29 fb [28], respectively. The prediction therefore lies below the exclusion curves, consistent with non-observation.

5.3 Toy Monte Carlo and required luminosity

A simplified counting experiment (mono-jet + missing E_T) was simulated to determine the integrated luminosity needed for a 5σ discovery. The result is

$$\mathcal{L}_{5\sigma} \approx 12,900 \text{ fb}^{-1}, \quad (8)$$

with a range 11,900–14,000 fb^{-1} given the 7% margin. This is **far beyond the HL-LHC reach of 3000 fb^{-1}** and even beyond the projected FCC-hh (up to 20,000 fb^{-1}) in its early stages. Consequently, the $n = 5$ causal membrane resonance **cannot be tested with currently planned collider facilities**. This does not invalidate the framework; it simply establishes that this particular scale is not experimentally accessible in the foreseeable future through proton-proton collisions.

6 Other Falsifiable Predictions

- **6.18 Hz causal overflow signal:** A narrow-band search for a frequency 6.18 Hz with a daily drift of +0.046 Hz/day was performed using 30 days of seismic data from EarthScope station ANMO. A coherent drift-corrected analysis yielded no significant excess; the result is a null limit. This exemplifies the falsifiability of the UAT framework: the predicted signal, if present, is too weak for current seismic sensitivity (see Supplementary Material for full analysis).
- **Lattice QCD tests:** The predicted coherence length ~ 5.7 fm and the membrane-gluon coupling $\alpha_{\text{mem}} \approx 0.35$ can be tested in gluon field correlation functions and the static quark potential.
- **Neutrino physics:** The 682 TeV seesaw scale predicts a neutrino mass sum $\sum m_\nu \approx 0.09$ eV, testable by future CMB-S4 and large-scale structure surveys.

7 Conclusion

We have presented a unified compilation of the cosmological and particle-physics predictions of the UAT/UCP framework, all derived from a single free parameter. The framework correctly reproduces Ω_m , Ω_Λ , the QCD confinement scale, and provides specific new mass scales at 1.71 TeV and 682 TeV. While the 1.71 TeV resonance is currently

inaccessible to colliders, its coincidence with discarded LHC fluctuations is documented transparently. The framework remains falsifiable through multiple independent channels.

All detailed derivations, numerical scripts, and the original technical notes are included in the accompanying **Supplementary Material** (ZIP file), making this document a self-contained reference for the UAT/UCP predictions.

*One parameter. Zero Λ CDM inputs.
Predictions from dark energy to QCD.
Experiment will decide.*

Supplementary Material

The following items are available in the `UAT_UCP_Supplementary.zip` archive:

- `uat_cosmology_omz.py` – Cosmological parameter derivation, $H(z)$, $Om(z)$ diagnostic.
- `uat_bayesian_chronometers.py` – AIC/BIC/Bayes factor analysis for cosmic chronometers.
- `qcd_confinement_215MeV.py` – Calculation of $M_{\text{obs}}(4)$ and derived scales.
- `causal_mass_gap_scales.py` – Full table of $M_{\text{obs}}(n)$ for $n = 1$ to 10.
- `unified_action_verification.py` – Numerical verification of all constants in S_{total} .
- `lhq_1.71TeV_coincidence.py` – Toy Monte Carlo and comparison with ATLAS/CMS limits.
- `seismic_618Hz_search.py` – Coherent drift search in EarthScope data.
- `technical_notes/` – PDF copies of the original detailed reports:
 - Cosmological Validation without Boltzmann Codes
 - The QCD Confinement Scale from Causal Coherence
 - New Physics Scales and QCD Signatures from the Causal Mass Gap Equation
 - Unified Action for the UAT/UCP Framework
 - The Causal Membrane and the QCD Scale
 - New Physics Scales from the Causal Mass Gap Equation (3.07 TeV and 1.22 PeV)
 - A Curious Coincidence: The UAT/UCP Causal Mass Gap Prediction at 1.71 TeV

All scripts use only NumPy and SciPy and can be executed in a standard Python environment. The PDF notes contain the complete derivations and references.

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