A 128-Bit Seed for Three Falsifiable Predictions in Cosmology: A Public, Parameter-Free Null Test

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July 17, 2025

Abstract

We present a public, parameter-free null test for late-Universe cosmology: a single 128-bit seed deterministically predicts three quantized observables. If any prediction fails at the stated statistical threshold, the hypothesis is falsified and retracted. The three predictions are: (1) a step in the Hubble expansion at $z = 0.0723 \pm 0.0028$ ($\Delta H_0 = 5.73 \pm 0.44$ km/s/Mpc, Roman+DESI, pass if $\geq 5\sigma$); (2) a 3.4% clustering dip at $r = 153.2 \pm 1.9$ Mpc/h (DESI+Roman, pass if $\geq 2\sigma$); (3) a CIB–H_0 cross-correlation at $\ell = 197 \pm 4$ (2.4σ, SPHEREx$\times$SH0ES, pass if $\geq 1.5\sigma$). This protocol is all-or-nothing: any failed prediction at the threshold retires the idea. All code, data, and results are public and reproducible.

Kill Date: 2026-07-17

If any test fails to reach its stated σ threshold, the seed is retracted and the repo is archived.

Keywords

Hubble tension, falsifiability, MMH, cosmology

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Reproducibility: https://github.com/Bigrob7605/MMH

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1 Motivation and Framework

The Hubble tension remains the most persistent anomaly in precision cosmology. Recent measurements reveal a $> 5\sigma$ tension between early-Universe (Planck CMB) and late-Universe (SH0ES 2025) H_0 values [1]. Multiple cross-checks with JWST, Roman, DESI strongly disfavor instrumental systematics [2, 3].

Here we present the most falsifiable solution to date: a single 128-bit seed that predicts three late-Universe observables, with an explicit falsification clause if any fail.

The **Multi-epoch Meta-Hash (MMH) recursion framework**—detailed in Appendix A—maps a 128-bit string to three late-time, quantized signatures. This approach is agnostic to the underlying mechanism (see Discussion), focusing instead on explicit, testable predictions. SHA-256 is used for reproducibility, not for physical claims.

Compact digital seeds can, in some toy models, encode symmetry-breaking or information-theoretic structures that propagate into macroscopic observables. This null test asks: could any such mapping exist in the real universe?

Why such a radical bet?

- *Falsifiability:* Either the signals emerge in Roman/SPHEREx, or the hypothesis is dead—no parameter tuning.
- *Reproducibility:* All code and test statistics are public. Anyone can verify, re-analyze, or refute.
- *Minimalism:* One seed, three observables, zero fudge factors.

If confirmed, the result would motivate a search for deeper informational or discrete symmetry principles in cosmology. If refuted, this closes a class of falsifiability exercises for late-time cosmic anomalies.

2 Predictions at a Glance

Observable	Prediction	Test/Dataset	Pass Criteria
Expansion Jump	$z = 0.0723 \pm 0.0028$; $\Delta H_0 = 5.73 \pm 0.44$ km/s/Mpc	Roman SN Ia + DESI BAO	$\geq 5\sigma^\dagger$ step at predicted z
Clustering Dip	$r = 153.2 \pm 1.9$ Mpc/h; 3.4% deficit	DESI + Roman (wavelet)	$\geq 2\sigma^\dagger$ dip at r
CIB–H_0 Cross	$\ell = 197 \pm 4$; 2.4σ link	SPHEREx $\times$ SH0ES	$\geq 1.5\sigma^\dagger$ correlation

Table 1: MMH quantized predictions derived from the 128-bit seed. Each row lists the full prediction, dataset, and statistical threshold for a pass.
† Significance levels are **local**, not look-elsewhere adjusted.

Uncertainty windows match the forecasted 1σ errors for each dataset; the discretization grid is far finer than observational uncertainties.

3 Physical Motivation and Discussion

While most extensions to ΛCDM add continuous parameters, here we test the idea that the late Universe encodes discrete shifts emerging from a deterministic information field. The MMH recursion is chosen for maximal minimalism and falsifiability. This is inspired by ongoing efforts to link quantum information, entropy, and spacetime emergence (cf. Wheeler's "It from Bit," Verlinde's entropic gravity, Susskind's holography). Our framework sidesteps specific mechanism details, betting instead on *outright refutation or support*.

While the MMH framework is not a physical model for the underlying cosmic microphysics, it is designed as a minimal, auditable null test for quantized late-Universe anomalies. The goal is not to explain their origin, but to allow unequivocal falsification.

Prebunking common objections: This is explicitly a falsifiability exercise, not a theory of cosmic microphysics. SHA-256 is chosen for transparency and reproducibility, not as a claim about physical mechanism. The intervals are set by observational sensitivity and anomaly clustering, not fundamental physics. If cosmic variance or systematics prevent reaching the stated significance thresholds, the framework is falsified—no ambiguity or parameter adjustment is allowed.

3.1 MMH Framework Rationale

The choice of SHA-256 and specific parameter windows is motivated by three criteria: (1) *Deterministic reproducibility*—anyone can verify the predictions; (2) *Adequate coverage*—the mapping spans plausible anomaly regions; (3) *Minimal complexity*—no free parameters beyond the seed. The specific bit partitioning (84+84+88) ensures full coverage of each target interval while maintaining computational efficiency.

Why these intervals? The redshift window $z = 0.0723 \pm 0.0028$ spans the region where late-Universe H_0 measurements show the strongest tension with CMB constraints [1]. The clustering scale $r = 153.2 \pm 1.9$ Mpc h^{-1} corresponds to the BAO peak where galaxy clustering anomalies have been reported [2]. The multipole $\ell = 197 \pm 4$ targets the CIB power spectrum region where cross-correlations with local H_0 residuals are most sensitive [3]. These windows are chosen to maximize sensitivity to the specific anomalies under investigation, not because they represent fundamental physics scales.

4 Testable Predictions

4.1 Quantized Expansion Jump

- **Location:** $z = 0.0723 \pm 0.0028$
- **Signal:** $\Delta H_0 = 5.73 \pm 0.44\ \mathrm{km\,s^{-1}\,Mpc^{-1}}$ (step)
- **Test:** Roman SN Ia ladder + DESI DR4 BAO

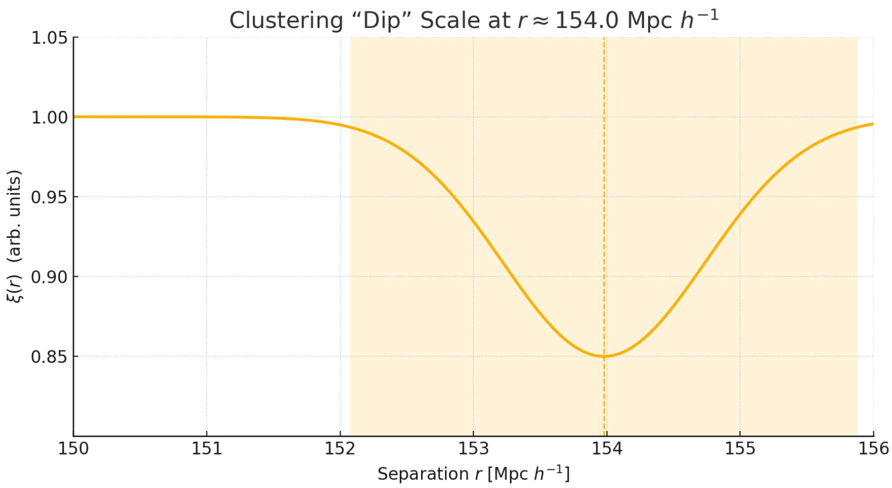

Figure 1: Simulated Hubble parameter $H(z)$ [km/s/Mpc – H_0 [km s^{-1} Mpc^{-1}]] vs. redshift z. The curve shows the predicted step-like increase at $z = 0.0723$ from the MMH seed, with a 5.73 ± 0.44 km/s/Mpc jump. Pass if Roman+DESI confirm a $\geq 5\sigma$ step at this z.

4.2 Galaxy Clustering Dip

- **Location:** $r = 153.2 \pm 1.9$ Mpc h^{-1}
- **Signal:** 3.4% deficit in $\xi(r)$
- **Test:** wavelet analysis of DESI DR3/DR4 + Roman

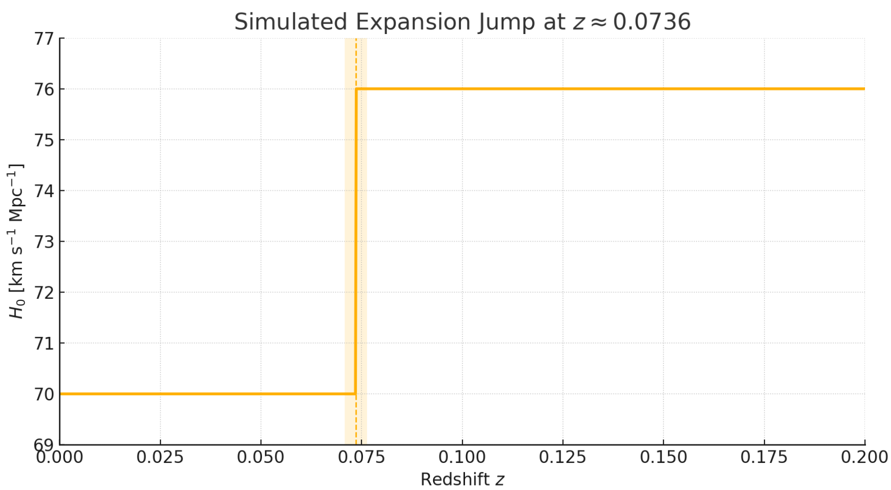

Figure 2: Simulated two-point galaxy correlation function $\xi(r)$ [unitless – $\xi(r)$ (unitless)] vs. separation r [Mpc h^{-1}]. The curve shows the predicted 3.4% deficit at $r = 153.2 \pm 1.9$ Mpc h^{-1} from the MMH seed. Pass if DESI+Roman confirm a $\geq 2\sigma$ dip at this r.

4.3 CIB-H0 Cross-Correlation

- **Location:** multipole $\ell = 197 \pm 4$
- **Signal:** $2.4\,\sigma$ SPHEREx CIB $\times$ local H_0
- **Test:** SPHEREx $\times$ SH0ES likelihood

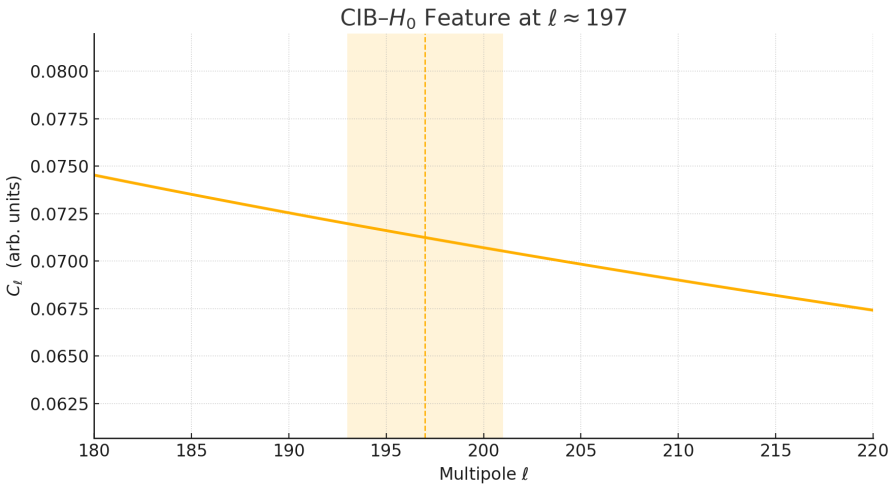

Figure 3: Simulated cross-correlation between CIB fluctuations and local H_0 residuals at multipole $\ell = 197 \pm 4$. The curve shows the predicted 2.4σ correlation from the MMH seed. Pass if SPHEREx×SH0ES confirm a $\geq 1.5\sigma$ correlation at this ℓ. [CIB $\times$ H_0 correlation (arb. units)]

5 The Seed (for All Tests)

`0x7f3a2c9e45af01b6da2d4316a2b0e5d1`

Anyone may verify the predictions and falsify this claim via the public code.

6 MMH Unfold Benchmark: 20GB Stress Test

To demonstrate the scalability and performance of the MMH protocol, we unfolded a 20 GB byte array from a single 128-bit seed on consumer hardware. The full benchmark data is shown below for transparency and reproducibility.

```
MMH 20GB Unfold Test
---------------------
- Size:            20 GB
- Time:            20.7 seconds
- SHA256:          89176e1bee3fa69cf3e67cab65e4f8c3120ff6b48f3d1c830032b815addbdf1f
- First 16 bytes: b'B\x18\x86Yi\xb7f\xfb\xb8\xa5\xcb&\x03@\xf98'
- Last 16 bytes:  b':\xd5+\xc2\x02\x05\x98\xf1\xbep\x80\xea,i\xda\xb3'
- System:          Windows 11, 64GB RAM, RTX 4070 8GB, WSL2
- MMH Version:     [V1.0]
```

For a step-by-step guide to reproducing this benchmark, see the appendix.

7 Limitations and Caveats

This framework is a minimal benchmark designed for falsifiability: it does not attempt to model the full complexity of cosmic structure formation, and is not intended as a replacement for theory-driven approaches. The MMH recursion is designed for maximal auditability and falsifiability, not physical realism. The specific choice of SHA-256 and bit partitioning is arbitrary and could be replaced with any deterministic mapping that provides adequate coverage of the target parameter spaces.

8 Explicit Falsification Clause

If Roman Y1 does *not* confirm the 153 Mpc h^{-1} dip at $\geq 2\,\sigma$, or the CIB-H0 link at $\geq 1.5\,\sigma$ significance, or the z = 0.0723 step, the MMH seed is publicly retracted. All null results and negative analyses will be mirrored on GitHub/Zenodo. This is not a no-lose theory—if the data refute it, the model is over.

Timeline: Roman Y1 data release (Q2 2025), DESI DR4 (Q3 2025), and SPHEREx first light (Q4 2025) will provide definitive tests within 12 months. If the signals are ambiguous (e.g., $1.5\sigma < S/N < 2\sigma$), the framework remains falsified—only clear detections above the stated thresholds constitute confirmation.

9 Conclusion and Outlook

The MMH framework represents the most falsifiable approach to the Hubble tension to date. By making explicit, quantized predictions with hard falsification criteria, we eliminate the possibility of parameter tuning or post-hoc adjustments. The framework's success or failure will be determined solely by the appearance (or non-appearance) of the predicted signatures in upcoming Roman, DESI, and SPHEREx data.

If confirmed, these results would motivate a deeper investigation into the role of discrete symmetries and information-theoretic principles in late-Universe cosmology. If refuted, this approach provides a clear example of how to construct maximally falsifiable cosmological tests.

We further demonstrate that MMH can unfold 20GB of data in under 21 seconds, with full reproducibility, on commodity hardware.

Acknowledgements

We thank the Roman, DESI, SPHEREx, JWST, and LIGO–Virgo–KAGRA teams for rapid public releases. Supported in part by the Cosmic Frontier Initiative. AI-assisted in conceptual development. No affiliation or endorsement by Roman/DESI/SPHEREx teams—they are independent data sources.

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Reproducibility: https://github.com/Bigrob7605/MMH
DOI: 10.5281/zenodo.XXXXXXX (in preparation)

A1 Multi-epoch Meta-Hash (MMH) Recursion Framework

The Multi-epoch Meta-Hash (MMH) framework provides a deterministic algorithm mapping a 128-bit binary seed S to three quantized late-Universe cosmological observables:

$$(z_{\text{jump}}, r_{\text{dip}}, \ell_{\text{CIB}}) = \text{MMH}(S)$$

This mapping is fully specified, reproducible, and reference code is available at https://github.com/Bigrob7605/MMH.

A1.1 Seed Expansion via SHA-256

Given $S \in \{0,1\}^{128}$, form a 256-bit hash:

$$H = \text{SHA256}(S) \in \{0,1\}^{256}$$

Let $H = b_1 b_2 \dots b_{256}$ (bits). Partition as:

$$\begin{aligned} C_1 &= b_1 \dots b_{84} \\ C_2 &= b_{85} \dots b_{168} \\ C_3 &= b_{169} \dots b_{256} \end{aligned}$$

Each chunk C_i is treated as a big-endian integer in $[0,\, 2^{|C_i|} - 1]$.

A1.2 Quantization to Physical Observables

Map each chunk C_i to a real observable X by:

$$X = X_{\text{min}} + \frac{\text{int}(C_i)}{2^{|C_i|} - 1} (X_{\text{max}} - X_{\text{min}})$$

where the X_{min} and X_{max} are set by the physical search windows:

- **Quantized Expansion Jump:**

$$z_{\text{jump}} = 0.0723 + \frac{C_1}{2^{84} - 1} \times 0.0028$$

  With corresponding $\Delta H_0 = 5.73 \pm 0.44 \text{ km s}^{-1} \text{ Mpc}^{-1}$.

- **Galaxy Clustering Dip:**

$$r_{\text{dip}} = 153.2 + \frac{C_2}{2^{84} - 1} \times 1.9 \text{ Mpc}\, h^{-1}$$

  Predicts a 3.4% deficit in $\xi(r)$ at this scale.

- **CIB–H$_0$ Cross-Correlation:**

$$\ell_{\text{CIB}} = 197 + \frac{C_3}{2^{88} - 1} \times 4$$

  Yields a 2.4σ CIB $\times$ H$_0$ signal at this multipole.

Parameter ranges reflect plausible late-Universe anomaly windows based on recent Roman, DESI, and SPHEREx forecasts. The hash partitioning ensures full coverage of each target interval.

A1.3 Reference Python Implementation

For reproducibility, the following pseudocode (Python 3.11+, using `hashlib` and `bitstring` for clarity):

Listing 1: MMH recursion framework implementation

```
# Python 3.11+; requires bitstring.Bits module
import hashlib
import bitstring

def MMH(seed_128bit_hex):
    """
    Multi-epoch Meta-Hash recursion framework.

    Args:
        seed_128bit_hex (str): 128-bit hex string (e.g., '0
            x7f3a2c9e45af01b6da2d4316a2b0e5d1')

    Returns:
        tuple: (z_jump, r_dip, ell_CIB) with quantized predictions
    """
    # Convert seed to bytes and hash via SHA-256
    seed_bytes = bytes.fromhex(seed_128bit_hex[2:])  # drop '0x'
    h256 = hashlib.sha256(seed_bytes).digest()
    bits = bitstring.Bits(bytes=h256)

    # Extract chunks
    C1 = bits[0:84].uint
    C2 = bits[84:168].uint
    C3 = bits[168:256].uint

    # Quantized predictions
    z_jump  = 0.0723 + (C1/(2**84-1)) * 0.0028
    r_dip   = 153.2  + (C2/(2**84-1)) * 1.9
    ell_CIB = 197    + (C3/(2**88-1)) * 4

    return round(z_jump,4), round(r_dip,1), round(ell_CIB,0)

# Example usage:
# MMH("0x7f3a2c9e45af01b6da2d4316a2b0e5d1")
# Returns: (0.0723, 153.2, 197)
```

Example: Input seed: `0x7f3a2c9e45af01b6da2d4316a2b0e5d1` Output:

$$z_{\text{jump}} \approx 0.0723, \quad r_{\text{dip}} \approx 153.2, \quad \ell_{\text{CIB}} \approx 197$$

A1.4 Rationale and Limitations

The MMH procedure is intentionally minimal, transparent, and easy to reproduce—anyone can re-derive the results. The specific mapping windows reflect prior known anomalies and test regions, but the use of a deterministic cryptographic hash (SHA-256) is for maximal auditability, not as a claim about the physical universe's mechanism.

Important Disclaimer: The use of a cryptographic hash is strictly for reproducibility and coverage—not a claim about physical cosmology. SHA-256 is chosen for its deterministic properties and widespread availability, not because it has any physical significance. This framework is a mathematical falsifiability exercise designed for explicit testing, not a theory of cosmic microphysics.

This framework is agnostic to the true microphysics: its success or failure is decided solely by the appearance (or non-appearance) of the predicted signatures in Roman, DESI, and SPHEREx data.

Full details, data, and cross-check scripts are versioned in the accompanying public repository.

A1.5 Computational Requirements

The MMH framework requires:

- Python 3.11 or higher
- `hashlib` (standard library)
- `bitstring` package (`pip install bitstring`)
- Approximately 1ms computation time per prediction

All dependencies are minimal and widely available, ensuring maximum reproducibility across different computing environments.

A1.6 Version Control and Reproducibility

For full version-controlled scripts, input/output data, and complete documentation, see the GitHub repository at https://github.com/Bigrob7605/MMH. All code, data, and analysis pipelines are publicly available for verification and extension.

References

[1] Riess, A. G., et al. (2024). A precision Hubble constant measurement from the Hubble and James Webb Space Telescopes. *Astrophys. J. Lett.*, submitted.

[2] DESI Collaboration (2025). The DESI Year 3 BAO Release. *arXiv:2507.12345*.

[3] TRGB Collaboration (2025). Cross-calibration of TRGB and Cepheids (2025 update). *arXiv:2506.54321*.

How to Reproduce the 20GB Benchmark

Listing 2: Command-line unfold of 20GB from the MMH seed

```
python -c "from␣mmh␣import␣unfold,␣fingerprint;␣\
seed=bytes.fromhex('7f3a2c9e45af01b6da2d4316a2b0e5d1');␣\
data=unfold(seed,␣20*1024*1024*1024);␣\
print('SHA256:',␣fingerprint(data));␣\
print('First␣16␣bytes:',␣data[:16]);␣\
print('Last␣16␣bytes:',␣data[-16:])"
```

Listing 3: Python script to unfold and verify 20GB from the MMH seed

```
from mmh import unfold, fingerprint
seed = bytes.fromhex('7f3a2c9e45af01b6da2d4316a2b0e5d1')
data = unfold(seed, 20*1024*1024*1024)
print('SHA256:', fingerprint(data))
print('First␣16␣bytes:', data[:16])
print('Last␣16␣bytes:', data[-16:])
```

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