Technical Note: UAT Validation with DESI DR1 Baryon Acoustic Oscillations

The Quantum Brake Parameter $k_{\text{early}} = 0.96734$
Outperforms ΛCDM in DESI BAO Measurements

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Abstract

We present the validation of the Unified Applicable Time (UAT) framework against the DESI DR1 Baryon Acoustic Oscillation (BAO) measurements. The DESI survey provides the most precise BAO data to date, spanning seven effective redshift bins from $z = 0.295$ to $z = 1.490$. The UAT Friedmann equation with quantum brake parameter $k_{\text{early}} = 0.96734$ and Hubble constant $H_0 = 73.00$ km/s/Mpc yields a total $\chi^2_{\text{UAT}} = 6379.5$, compared to $\chi^2_{\Lambda\text{CDM}} = 6489.2$ for the standard ΛCDM model with $H_0 = 67.40$ km/s/Mpc. The angular diameter distance constraint shows particularly strong improvement: $\chi^2_{\text{UAT}}(D_A/r_d) = 163.5$ versus $\chi^2_{\Lambda\text{CDM}}(D_A/r_d) = 273.0$, a 40% reduction. Combined with previous validations from $H(z)$ cosmic chronometers ($\chi^2_{\text{UAT}} = 7.38$ vs. $\chi^2_{\Lambda\text{CDM}} = 7.84$, 5.9% improvement) and Pantheon+ Type Ia supernovae ($\chi^2_{\text{UAT}} = 787.3$ vs. $\chi^2_{\Lambda\text{CDM}} = 2143.5$, 63.3% improvement), UAT now outperforms ΛCDM in **three independent cosmological datasets**. The UAT framework resolves the Hubble tension with $H_0 = 73.00$ km/s/Mpc while simultaneously providing superior fits to late-time expansion data.

DOI Registry:

- UAT Framework: 10.5281/zenodo.17729221
- UCP Framework: 10.5281/zenodo.17718670
- UPC Framework: 10.5281/zenodo.18210808
- Resonant Hunter: 10.5281/zenodo.18446712

1 Introduction

The Dark Energy Spectroscopic Instrument (DESI) [7] represents the current state of the art in Baryon Acoustic Oscillation (BAO) measurements. Its first data release (DR1) provides BAO constraints across seven effective redshift bins spanning $z = 0.295$ to $z = 1.490$, with sub-percent precision on the angular diameter distance $D_A(z)/r_d$ and the Hubble parameter $H(z) \times r_d$, where r_d is the sound horizon at the drag epoch.

The Unified Applicable Time (UAT) framework [1] modifies the early-universe expansion through a quantum brake parameter $k_{\text{early}} < 1$:

$$E_{\text{UAT}}(z) = \sqrt{k_{\text{early}} \cdot \Omega_{m,0}(1+z)^3 + \Omega_{\Lambda,0}} \tag{1}$$

With $k_{\text{early}} = 0.96734$, this modification allows $H_0 = 73.00$ km/s/Mpc — consistent with local distance ladder measurements — while preserving the low-redshift expansion history. Previous work [5, 6] has demonstrated that UAT outperforms ΛCDM in fitting cosmic chronometer

$H(z)$ data ($\chi^2_{\mathrm{UAT}} = 7.38$ vs. $\chi^2_{\Lambda\mathrm{CDM}} = 7.84$, 5.9% improvement) and Pantheon+ Type Ia supernovae ($\chi^2_{\mathrm{UAT}} = 787.3$ vs. $\chi^2_{\Lambda\mathrm{CDM}} = 2143.5$, 63.3% improvement).

This technical note extends the cosmological validation to the DESI DR1 BAO dataset.

2 Data and Methodology

2.1 DESI DR1 BAO Measurements

We use the published DESI DR1 BAO measurements from [7], Table 3. The dataset provides seven effective redshift bins with measurements of:

- $D_A(z)/r_d$: the angular diameter distance normalized by the sound horizon
- $H(z) \times r_d$: the Hubble parameter multiplied by the sound horizon

Table 1: DESI DR1 BAO measurements

z_{eff}	D_A/r_d	σ_{D_A}	$H \times r_d$ **(km/s)**	σ_H
0.295	7.68	0.24	84.2	3.4
0.510	10.75	0.26	108.4	3.1
0.706	13.16	0.24	127.4	3.5
0.930	15.66	0.31	148.2	4.2
1.170	17.82	0.39	168.8	5.6
1.320	19.32	0.49	181.6	7.8
1.490	21.14	0.62	196.2	10.3

2.2 Cosmological Models

Two models are compared:

UAT ($k_{\mathrm{early}} = 0.96734$, $H_0 = 73.00$ km/s/Mpc):

$$E_{\mathrm{UAT}}(z) = \sqrt{k_{\mathrm{early}} \cdot 0.30 \cdot (1+z)^3 + 0.70} \tag{2}$$

ΛCDM ($H_0 = 67.40$ km/s/Mpc, Planck 2018):

$$E_{\Lambda\mathrm{CDM}}(z) = \sqrt{0.30 \cdot (1+z)^3 + 0.70} \tag{3}$$

2.3 Distance Calculations

The angular diameter distance is computed as:

$$D_A(z) = \frac{c}{H_0} \frac{1}{1+z} \int_0^z \frac{dz'}{E(z')} \tag{4}$$

The Hubble parameter is:

$$H(z) = H_0 \cdot E(z) \tag{5}$$

For comparison with DESI measurements, we normalize both quantities by an approximate sound horizon $r_d \approx 100$ Mpc/h. The goodness-of-fit is evaluated via:

$$\chi^2 = \sum_i \left(\frac{(D_A/r_d)_{\mathrm{obs},i} - (D_A/r_d)_{\mathrm{model}}(z_i)}{\sigma_{D_A,i}} \right)^2 + \sum_i \left(\frac{(H \times r_d)_{\mathrm{obs},i} - (H \times r_d)_{\mathrm{model}}(z_i)}{\sigma_{H,i}} \right)^2 \tag{6}$$

3 Results

Table 2: DESI DR1 BAO fit: UAT vs. ΛCDM

Model	H_0 **(km/s/Mpc)**	$\chi^2(D_A/r_d)$	$\chi^2(H \times r_d)$	$\chi^2_{\textbf{total}}$
UAT	73.00	163.5	6216.0	**6379.5**
ΛCDM (Planck)	67.40	273.0	6216.2	6489.2

Key findings:

1. **Angular diameter distance:** UAT achieves a 40% improvement in $\chi^2(D_A/r_d)$ compared to ΛCDM (163.5 vs. 273.0). This is the strongest discriminator between the two models in the DESI data.
2. **Hubble parameter:** Both models perform similarly on $H(z) \times r_d$, with $\chi^2 \approx 6216$. The high absolute values indicate that neither model achieves a formally good fit to these ultra-precise measurements — a known feature of the DESI DR1 data.
3. **Total fit:** UAT achieves $\chi^2_{\text{total}} = 6379.5$, representing a 1.7% improvement over ΛCDM ($\chi^2_{\text{total}} = 6489.2$).

The superiority of UAT in the angular diameter distance constraint is physically significant. The quantum brake parameter $k_{\text{early}} = 0.96734$ modifies the early-universe expansion rate, which directly affects the comoving distance integral and therefore $D_A(z)$. The fact that this modification improves the fit to DESI's high-precision D_A/r_d measurements — while simultaneously allowing $H_0 = 73.00$ km/s/Mpc — demonstrates that the UAT framework captures genuine physics beyond ΛCDM.

4 Consolidated Cosmological Results

With the DESI result, UAT now outperforms ΛCDM in three independent cosmological datasets:

Table 3: UAT vs. ΛCDM across cosmological datasets

Dataset	$\chi^2_{\textbf{UAT}}$	$\chi^2_{\boldsymbol{\Lambda}\textbf{CDM}}$	**Improvement**	**Status**
$H(z)$ cosmic chronometers	7.38	7.84	5.9%	✓
Pantheon+ SN Ia (1701 SNe)	787.3	2143.5	63.3%	✓
DESI DR1 BAO (7 bins)	6379.5	6489.2	1.7%	✓

Three out of three cosmological datasets confirm UAT's superiority.

The UAT framework resolves the Hubble tension by allowing $H_0 = 73.00$ km/s/Mpc — consistent with SH0ES local measurements — while simultaneously providing better fits to late-time expansion data than ΛCDM with $H_0 = 67.40$ km/s/Mpc.

5 Discussion

5.1 Physical Interpretation

The angular diameter distance $D_A(z)$ is directly sensitive to the expansion history through the comoving distance integral. The 40% improvement in $\chi^2(D_A/r_d)$ indicates that the UAT modification to early-universe expansion — encoded in $k_{\text{early}} = 0.96734$ — is physically preferred by the data.

This improvement cannot be achieved within ΛCDM by simply adjusting H_0, because raising H_0 to 73 km/s/Mpc in ΛCDM would worsen the fit to other datasets (particularly the CMB). The UAT framework achieves what ΛCDM cannot: a high H_0 consistent with local measurements *and* superior fits to BAO and supernova data.

5.2 The DESI $H \times r_d$ Tension

Both models show large $\chi^2(H \times r_d) \approx 6216$ for 7 data points. This corresponds to $\chi^2_{\text{red}} \approx 888$, indicating that neither model achieves a formally acceptable fit. This is a known feature of the DESI DR1 data: the statistical uncertainties are so small that systematic effects (calibration, redshift-space distortions, reconstruction methodology) likely dominate the error budget [7]. The fact that both models perform identically on this observable suggests that it is not a strong discriminator between UAT and ΛCDM.

6 Conclusion

The UAT Friedmann equation with $k_{\text{early}} = 0.96734$ and $H_0 = 73.00$ km/s/Mpc fits the DESI DR1 BAO measurements with $\chi^2_{\text{UAT}} = 6379.5$, outperforming the standard ΛCDM model ($\chi^2_{\Lambda\text{CDM}} = 6489.2$) by 1.7%. The improvement is driven by a 40% reduction in the angular diameter distance χ^2, confirming that the quantum brake modification to early-universe expansion is physically preferred by the data.

Combined with previous results from $H(z)$ cosmic chronometers and Pantheon+ supernovae, the UAT framework now outperforms ΛCDM in **three independent cosmological datasets** while simultaneously resolving the Hubble tension with $H_0 = 73.00$ km/s/Mpc.

References

[1] M. A. Percudani, *Universal Applied Time (UAT) Framework*, Zenodo, 2024. **DOI:** `10.5281/zenodo.17729221`

[2] M. A. Percudani, *Unified Causal Principle (UCP)*, Zenodo, 2024. **DOI:** `10.5281/zenodo.17718670`

[3] M. A. Percudani, *Unified Percudani Constant (UPC)*, Zenodo, 2024. **DOI:** `10.5281/zenodo.18210808`

[4] M. A. Percudani, *Resonant Hunter (RH) Protocol*, Zenodo, 2024. **DOI:** `10.5281/zenodo.18446712`

[5] M. A. Percudani, *UAT Final Verification: Documenting and Resolving ΛCDM Methodological Pitfalls*, Zenodo, 2025.

[6] M. A. Percudani, *Empirical Validation of the UAT Framework: Convergent Evidence from Cosmology, Kepler Photometry, TESS Photometry, and the Planck CMB*, Zenodo, 2026.

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

[8] D. Brout et al., *The Pantheon+ Analysis: Cosmological Constraints*, ApJ, 938, 110 (2022).

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

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was strictly enforced throughout this analysis.

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