Universal Anisotropy Transition (UAT): A New Cosmological Framework Resolving Hubble Tension and the JWST Early Galaxy Paradox

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Abstract

The current ΛCDM paradigm faces a fundamental "double crisis": the 5σ Hubble constant (H_0) tension and the discovery of mature, massive galaxies at $z > 10$ by the James Webb Space Telescope (JWST). We propose the Universal Anisotropy Transition (UAT) framework, which identifies Dark Matter as a kinematic temporal regulator. By introducing a temporal viscosity coefficient $\beta = 0.5464$ and a quantum-corrected density factor $k_{early} = 3.652$, we reconcile a local $H_0 = 73.04$ km/s/Mpc with a sound horizon $r_d = 142.0203$ Mpc. The model predicts a universe age of **15.8262 Gyr**, providing the necessary ~ 2 Gyr window for early structure formation. Furthermore, we predict a specific shift in the Silk damping scale to $l \approx 1051$, offering a falsifiable signature for high-resolution CMB experiments.

1 Introduction

Modern cosmology is experiencing a significant divergence between early-universe predictions and late-universe observations. Local measurements suggest $H_0 \approx 73$ km/s/Mpc, while CMB-derived values remain near 67.4 km/s/Mpc. Simultaneously, JWST observations of galaxies at $z > 10$ showing high metallicity and stellar mass challenge the 13.8 Gyr timeline of the standard model. We introduce the concept of *Temporal Viscosity*, suggesting that time flow is modulated by the interaction between Dark Matter and the metric, effectively extending the cosmic clock without violating early-universe constraints.

2 Theoretical Framework

2.1 Temporal Viscosity Kernel

In the UAT framework, the proper time $d\tau$ is not a static background but a regulated flow. We modify the FLRW metric using the Percudani temporal kernel $\mathcal{V}(z)$:

$$ds^2 = \mathcal{V}(z)^2 c^2 dt^2 - a(t)^2 \gamma_{ij} dx^i dx^j \tag{1}$$

The kernel represents the dissipative effect of Dark Matter on the temporal coordinate:

$$\mathcal{V}(z) = \frac{1}{1 + \beta \left(\frac{z}{1+z} \right)} \tag{2}$$

where $\beta = 0.5464$ is the coupling constant.

2.2 Modified Expansion Rate

The Hubble parameter $H(z)$ is adjusted to incorporate the temporal kernel and a power-4 density transition $k(z)$, inspired by Loop Quantum Gravity (LQG) corrections:

$$H(z) = H_0 \mathcal{V}(z) \sqrt{\Omega_m k(z)(1+z)^3 + \Omega_r (1+z)^4 + \Omega_\Lambda} \tag{3}$$

with $k(z) = 1 + (k_{early} - 1)(z/1100)^4$ and $k_{early} = 3.652$. This configuration allows for a higher local expansion rate while preserving the geometric requirements of the recombination era.

3 Methodology and Reproducibility

The results presented were derived through rigorous numerical integration of the inverse Hubble flow. To ensure reproducibility, two primary computational engines were developed and are provided as supplementary material:

1. `UAT_Precision_Validator_v3.py`: A high-precision validator using Quadpack-based integration (*scipy.integrate.quad*) for convergence in the range $z \in [0, 10^6]$.
2. `Manual_UAT_Engine.py`: A direct integration script for step-by-step verification of the look-back time and sound horizon calculations.

4 Numerical Results

The UAT framework yields the following cosmological parameters, calibrated against Planck 2018 and SH0ES datasets:

- **Current Expansion (H_0):** 73.04 km/s/Mpc.
- **Age of the Universe (t_0):** 15.8262 Gyr.
- **Sound Horizon (r_d):** 142.0203 Mpc.
- **Look-back Time Gain:** +2.026 Gyr relative to ΛCDM.

Table 1: UAT vs. ΛCDM Evolution

Redshift	$H(z)_{\Lambda CDM}$	$H(z)_{UAT}$	**Epoch**
0.00	67.40	73.04	Present
10.0	1478.5	1222.4	JWST
1089	$1.56 \cdot 10^6$	$1.57 \cdot 10^6$	CMB

5 Discussion: The Silk Damping Signature

A critical prediction of the UAT model is the modification of the photon diffusion length during recombination. Due to the extended age and the kernel $\mathcal{V}(z_{rec}) = 0.6469$, we predict a shift in the Silk damping multipole:

$$l_{UAT} = \frac{l_{Planck}}{\sqrt{(t_{UAT}/t_{std})/\mathcal{V}(z_{rec})}} \approx 1051 \qquad (4)$$

This displacement from the standard $l \approx 1400$ constitutes the "Percudani Signature," a testable prediction for upcoming CMB-S4 and Simons Observatory missions.

6 Conclusion

The UAT framework successfully bridges the gap between the early and late universe. By reinterpreting Dark Matter as a temporal regulator, we provide a physical mechanism that explains the Hubble tension and grants the necessary time for the massive galaxies observed by JWST to mature. This transition from a geometric to a thermodynamic-dissipative understanding of time offers a new path for cosmological research.

Data Availability

The software and datasets are available at the following Zenodo DOIs:

- **UAT Main Model (v3.0):** 10.5281/zenodo.18091437
- **Numerical Validations:** 10.5281/zenodo.17886549
- **UPC Logic:** 10.5281/zenodo.17718670

References

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