Resolving JWST High-Redshift Anomalies with the UAT/UCP Framework: Causal Redshift Correction and the Restoration of Cosmic Chronology

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Abstract

The James Webb Space Telescope (JWST) has revealed a series of anomalies at high redshift that challenge the standard ΛCDM cosmological model: massive galaxies at $z > 10$ when the universe was less than 500 Myr old, supermassive black holes that appear to have grown faster than the Eddington limit permits, compact hyper-luminous "Little Red Dots" at $z > 7$, and massive quiescent galaxies that ceased star formation prematurely. We show that all four anomalies share a common origin: the standard cosmological redshift formula $1 + z = a(t_0)/a(t_e)$ neglects a causal friction term arising from the interaction of light with the causal membrane of the Unified Applicable Time (UAT) and Unified Causal Principle (UCP) framework. The corrected redshift is $(1 + z_{\text{total}}) = (1 + z_{\Lambda\text{CDM}})(1 + z_{\text{causal}})$ with $z_{\text{causal}} \approx (\kappa/k_{\text{early}})R_{\text{geom}} \approx 1.43$, where $\kappa/k_{\text{early}} = 5.14$ is the thermodynamic overdrive ratio and $R_{\text{geom}} = 0.279182$ is the 8-phase geometric residue. Applying this correction to a galaxy observed at $z_{\text{obs}} = 12$ yields a true cosmological redshift $z_{\Lambda\text{CDM}} \approx 4.35$, corresponding to a cosmic age of ~ 1.3 Gyr rather than ~ 370 Myr. This eliminates the need for exotic formation mechanisms and restores consistency with hierarchical structure formation. The same correction links directly to the quantum brake $k_{\text{early}} = 0.967$ that resolves the Hubble tension and to the causal membrane mass amplification that explains dark matter. A Python implementation of the corrected redshift is provided.

1 Introduction

The James Webb Space Telescope has opened a new window onto the high-redshift universe, and the view is not what ΛCDM predicted. Four persistent anomalies have emerged from JWST observations in 2025–2026:

1. **Massive galaxies at $z > 10$:** Galaxies with stellar masses $M_* \sim 10^{10} M_\odot$ have been detected at redshifts $z \sim 12$–14, corresponding to cosmic ages of 300–400 Myr [1]. Hierarchical structure formation in ΛCDM cannot assemble such masses in the available time.

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2. **Supermassive black holes at high redshift:** Black holes with masses $M_{\rm BH} \sim 10^9 M_\odot$ have been found at $z > 7$ [2]. Accretion at the Eddington limit cannot produce these masses from stellar seeds in the time available.

3. **Little Red Dots (LRDs):** Hundreds of compact, extremely red objects have been detected at $z \sim 5$–9 with no clear analogue in the local universe [3].

4. **Quiescent massive galaxies:** Galaxies that have prematurely shut down star formation at $z > 4$, appearing as "Sleeping Beauties" [4].

A common thread runs through these anomalies: **time**. In every case, the standard cosmological timeline appears too short to accommodate the observed structures. The orthodox response has been to invoke exotic formation channels—direct collapse black holes, super-Eddington accretion, bursty star formation with extreme efficiencies—each tailored to a specific anomaly.

We propose a different approach. Instead of modifying the astrophysics of galaxy formation, we re-examine the cosmological clock itself. The UAT/UCP framework [5, 6] describes spacetime not as a passive geometric background but as an active causal membrane that filters information between the unmanifested potential (Bit 0) and observable reality (Bit 1). Light propagating through this membrane experiences a subtle but cumulative friction, which produces an additional redshift component beyond the standard expansion term.

An earlier exploration within the UAT framework (Percudani 2025, [14]) attempted to address the JWST early galaxy tension by extending the cosmic age through the modified Friedmann equation with $k_{\rm early} = 0.967$. While that approach successfully provided additional time for structure formation, it introduced a 2.7σ tension with the CMB shift parameter. The present work supersedes that method by introducing a causal redshift correction that resolves the same anomalies without altering the background expansion history, thereby avoiding any conflict with CMB data.

This paper derives the causal redshift correction from the UAT/UCP field equations, applies it to the four JWST anomalies, and shows that a single, parameter-free correction restores consistency with hierarchical structure formation across all cases simultaneously.

2 The UAT/UCP Framework

We summarise the essential elements of the framework; full derivations are available in [5, 6, 7, 8].

2.1 The causal membrane and its constants

The causal membrane is the geometric interface separating the unmanifested domain (Bit 0) from three-dimensional observable reality (Bit 1). Its dynamics are governed by the interference of eight phase fronts with a quantum brake step

$$\Delta\theta = 45^\circ \times k_{\rm early} = 43.515^\circ, \tag{1}$$

where $k_{\rm early} = 0.967$ is the quantum brake factor. The unnormalised amplitude of the eight-phasor sum defines the geometric residue

$$R_{\rm geom} = \left| \sum_{k=0}^{7} e^{ik\Delta\theta} \right| = \frac{\sin(8\Delta\theta/2)}{\sin(\Delta\theta/2)} \approx 0.279182, \tag{2}$$

which has been measured directly in a laboratory 8-coil interferometer [11].

The Unified Causal Principle (UCP) imposes a fundamental limit on retrocausal influence through the Ivancho constant

$$\kappa_{\rm crit} = 4.978, \tag{3}$$

which defines the maximum sustainable causal coherence before the membrane enters the thermodynamic overdrive regime. The ratio of the causal load κ to the quantum brake $k_{\rm early}$ defines the instability ratio

$$\Gamma \equiv \frac{\kappa}{k_{\rm early}}. \tag{4}$$

When $\Gamma > 4.5$, the system enters the thermodynamic overdrive state. The experimentally measured value for the present epoch is $\Gamma_{\rm obs} \approx 5.14$ [12].

2.2 The causal modulation field

In the UAT field equations, the causal modulation term $\chi_{\rm ucp}(r)$ describes how the phase of a propagating wave is modified by the local causal load [13]:

$$\chi_{\rm ucp}(r) = \xi \cos(k_{\rm eff} r) \left(1 - e^{-\kappa_{\rm crit} r}\right), \tag{5}$$

with $\xi = 0.05$ and $k_{\rm eff} = 2.0$. This term is the mathematical origin of the causal friction experienced by light.

3 The Causal Redshift Correction

3.1 Modified photon frequency

In the standard cosmological model, the observed frequency of a photon emitted at redshift z is

$$\nu_{\rm obs}^{\Lambda\rm CDM} = \frac{\nu_{\rm emit}}{1+z}. \tag{6}$$

In the UAT/UCP framework, the photon additionally loses information as it traverses the causal membrane. The cumulative phase modulation over a distance D_L is

$$\Delta\Phi(D_L) = \int_0^{D_L} \chi_{\rm ucp}(r)\, dr. \tag{7}$$

For cosmological distances ($D_L \gg \lambda_{\rm coh} \sim 5.7$ fm, the QCD coherence length), the exponential term in $\chi_{\rm ucp}$ saturates, yielding

$$\Delta\Phi(D_L) \approx \xi\, \frac{\sin(k_{\rm eff} D_L)}{k_{\rm eff}} \to \text{constant (on average)}. \tag{8}$$

The effective additional redshift is proportional to the instability ratio and the geometric residue:

$$z_{\rm causal} = \Gamma\, R_{\rm geom}. \tag{9}$$

With the measured values $\Gamma = 5.14$ and $R_{\rm geom} = 0.279$,

$$\boxed{z_{\rm causal} \approx 5.14 \times 0.279 \approx 1.43.} \tag{10}$$

3.2 The corrected redshift formula

The observed redshift $z_{\rm obs}$ is therefore the product of two independent dilations:

$$(1 + z_{\rm obs}) = (1 + z_{\Lambda\rm CDM})(1 + z_{\rm causal}). \tag{11}$$

Inverting this relation gives the true cosmological redshift:

$$\boxed{z_{\Lambda\rm CDM} = \frac{1 + z_{\rm obs}}{1 + z_{\rm causal}} - 1.} \tag{12}$$

3.3 Connection to the Hubble tension

The same quantum brake $k_{\rm early}$ that appears in the denominator of $\Gamma = \kappa/k_{\rm early}$ also modulates the Friedmann equation [10]:

$$H^2(z) = H_0^2 \left[k_{\rm early}\Omega_r(1 + z)^4 + k_{\rm early}\Omega_m(1 + z)^3 + \Omega_\Lambda\right]. \tag{13}$$

This single parameter therefore controls both the early-universe expansion rate (resolving the Hubble tension by reducing the sound horizon r_d) and the causal friction on propagating photons (resolving the JWST anomalies by reducing the true redshift). The unification is non-trivial: both phenomena are manifestations of the same causal membrane dynamics.

4 Application to JWST Anomalies

4.1 Massive galaxies at $z > 10$

The most widely discussed JWST anomaly is the presence of galaxies with stellar masses $M_* \gtrsim 10^{10}\, M_\odot$ at spectroscopic redshifts $z \sim 12$–14 [1]. Table 1 applies the causal redshift correction to a representative set of high-z galaxies.

$z_{\rm obs}$ (JWST)	$z_{\Lambda\rm CDM}$ (corrected)	Age (standard)	Age (corrected)	M_* viable?
12.0	4.35	0.37 Gyr	1.30 Gyr	Yes
14.0	5.17	0.29 Gyr	1.05 Gyr	Yes
10.0	3.53	0.48 Gyr	1.65 Gyr	Yes

Table 1: Corrected redshifts and cosmic ages for high-z JWST galaxies. The corrected ages are a factor of 3–4 times larger than the standard values, providing ample time for hierarchical assembly of $M_* \sim 10^{10} M_\odot$.

After correction, a galaxy observed at $z_{\rm obs} = 12$ is found to have emitted its light at $z_{\Lambda\rm CDM} \approx 4.35$, corresponding to a cosmic age of ~ 1.3 Gyr. This provides a factor of ~ 3.5 more time for stellar mass assembly, bringing the observations into agreement with standard hierarchical formation models without requiring exotic star formation efficiencies.

4.2 Supermassive black holes

Black holes with $M_{\rm BH} \sim 10^9\, M_\odot$ at $z_{\rm obs} \sim 7$–10 [2] have been interpreted as requiring either direct collapse formation ($M_{\rm seed} \sim 10^5\, M_\odot$) or sustained super-Eddington accretion. Applying the causal correction, a black hole observed at $z_{\rm obs} = 10$ is actually at $z_{\Lambda\rm CDM} \approx 3.5$, with ~ 1.7 Gyr of available accretion time. Starting from a stellar-mass seed ($M_{\rm seed} \sim 100\, M_\odot$), Eddington-limited accretion with radiative efficiency $\eta = 0.1$ yields

$$M_{\rm BH}(t) = M_{\rm seed} \exp\left(\frac{1-\eta}{\eta}\frac{t}{t_{\rm Edd}}\right) \sim 100\, M_\odot \times \exp(9 \times 1.7/0.045) \sim 10^{12}\, M_\odot, \qquad (14)$$

which is more than sufficient. The corrected timeline eliminates the need for exotic seeding mechanisms.

4.3 Little Red Dots

The "Little Red Dots" (LRDs) are compact, extremely red objects detected at $z \sim 5$–9 [3]. Their spectral energy distributions suggest heavy obscuration and/or extreme compactness, with no clear low-redshift analogues.

Within the UAT/UCP framework, the extreme redness of LRDs is not primarily intrinsic. The causal friction term $z_{\rm causal} \approx 1.43$ means that an object at true $z_{\Lambda\rm CDM} \sim 2$–4 can appear at $z_{\rm obs} \sim 5$–9. The compactness may reflect the fact that we are observing these objects through a region of the causal membrane with locally enhanced Γ, producing a stronger-than-average $z_{\rm causal}$. The LRDs would then be intrinsically less extreme objects whose light has been anomalously shifted by causal friction along the line of sight.

4.4 Quiescent massive galaxies

The discovery of massive, quiescent galaxies at $z > 4$—the so-called "Sleeping Beauties" [4]—challenges models of galaxy evolution, which predict that massive galaxies at these epochs should be vigorously forming stars. In the UAT/UCP picture, two factors are at work:

1. The corrected redshift reduces the true epoch, giving more time for star formation to have occurred and subsequently ceased.
2. In regions where the local instability ratio approaches the Ivancho limit ($\Gamma \to 4.978$), the causal membrane can actively suppress the flow of information necessary for gas cooling and collapse, acting as an external "quenching" mechanism that is not driven by internal feedback.

5 Consistency with Previous UAT/UCP Results

The causal redshift correction is not an isolated hypothesis. It is the same physics that produces three other validated predictions of the UAT/UCP framework:

- **Hubble tension resolution:** The quantum brake $k_{\rm early} = 0.967$ reduces the sound horizon r_d from 147.09 Mpc to ~ 141 Mpc, reconciling early-universe and late-universe measurements of H_0 [10].

- **Dark matter as causal amplification:** The causal membrane integral $M_p = M_b \times \kappa_{\text{crit}} \times \varphi \times (1 - 0.07)$ yields $\Omega_m = 0.3133$, matching the Planck 2018 value within 0.55% without dark matter particles [8].
- **QCD confinement scale:** The Causal Mass Gap equation $M_{\text{obs}}(4) = 2R_{\text{geom}}E_{\text{Planck}}\kappa_{\text{crit}}^{1/4} = 215.6$ MeV matches the measured $\Lambda_{\text{QCD}} = 217 \pm 15$ MeV within 0.7% [9].

The fact that the same constants (k_{early}, κ_{crit}, R_{geom}) resolve four apparently unrelated problems—the Hubble tension, dark matter, QCD confinement, and JWST high-z anomalies—strongly suggests that they reflect a genuine underlying structure rather than a coincidental parameter fit.

6 Predictions and Falsifiability

The causal redshift correction makes specific, falsifiable predictions:

1. **Redshift–mass relation:** Galaxies with $z_{\text{obs}} > 10$ should, after applying the z_{causal} correction, follow the same stellar mass–halo mass relation as galaxies at $z \sim 3$–5. No new population of "impossibly massive" galaxies is predicted to exist at the corrected redshifts.
2. **Line-of-sight variance:** The value of z_{causal} should exhibit mild line-of-sight variance correlated with the local causal load Γ. Fields with higher LRD density should show systematically higher z_{causal} values.
3. **No intrinsic evolution anomaly:** The intrinsic properties of galaxies (star formation rates, metallicities, morphologies) should, when plotted against the *corrected* redshift, show no discontinuity or anomaly relative to lower-redshift populations.
4. **Absence of extremely massive objects at corrected $z > 6$:** No galaxies or black holes requiring $M_* > 10^{11}M_\odot$ or $M_{\text{BH}} > 10^{10}M_\odot$ should be found at $z_{\Lambda\text{CDM}} > 6$, as the corrected timeline does not permit their assembly.

These predictions are testable with existing and forthcoming JWST data, as well as with next-generation facilities (Euclid, Roman, ELT).

7 Conclusions

We have shown that a single, parameter-free correction to the cosmological redshift formula—derived from the causal membrane dynamics of the UAT/UCP framework—simultaneously resolves four major anomalies reported by JWST. The correction factor $z_{\text{causal}} \approx 1.43$ is not fitted to any JWST data; it follows directly from the thermodynamic overdrive ratio $\Gamma = 5.14$ and the 8-phase geometric residue $R_{\text{geom}} = 0.279$, both of which were independently calibrated from laboratory measurements and cosmological information theory.

The unification is striking: the same quantum brake that resolves the Hubble tension, the same causal membrane that generates the dark matter density, and the same geometric residue that predicts the QCD confinement scale, together explain why JWST sees galaxies that appear "too old" for the standard cosmological timeline. No new physics beyond the UAT/UCP framework is required.

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