

Paper 120 -- AIIT-THRESI Series

Why JWST Was Right: Structure Formation in a Decohering Universe

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Abstract

The James Webb Space Telescope has revealed massive, chemically mature galaxies at redshifts $z > 10$, structures that Lambda-CDM cosmology struggles to produce within its timeline. We demonstrate that all ten major structure formation anomalies -- from impossibly early galaxies to supermassive black hole seeds, from the missing satellite problem to the existence of bulgeless disks -- resolve naturally within the AIIT-THRESI coherence framework. The vacuum coherence function $C = C_0 \times \exp(-\alpha \times \gamma_{\text{eff}})$, where γ_{eff} is the effective decoherence rate, establishes that the early universe operated at high coherence (low γ_{eff}), enabling rapid gravitational collapse and efficient structure formation. As the universe aged and baryonic complexity increased, rising γ_{eff} progressively degraded vacuum coherence, slowing collapse and producing the diverse phenomenology we observe. JWST did not find anomalies. It found the expected signatures of a decohering universe.

1. The High-Coherence Early Universe

1.1 The Coherence Function and Structure Formation

The AIIT-THRESI framework describes vacuum coherence as a dynamical quantity governed by

$$C(t) = C_0 \times \exp(-\alpha \times \gamma_{\text{eff}})$$

where C_0 is the bare vacuum coherence, α is the coherence-decoherence coupling constant, and γ_{eff} is the effective decoherence rate set by local baryonic complexity, thermal noise, and radiative processes. At early cosmic times, the universe was simple: pristine hydrogen and helium, no metals, no complex structures. Therefore γ_{eff} was small, and C approached C_0 .

High coherence has a direct gravitational consequence. The effective gravitational collapse timescale scales as

$$t_{\text{collapse}} \propto \frac{1}{\sqrt{G \rho_{\text{eff}}}} \quad \text{where} \quad \rho_{\text{eff}} = \rho_{\text{baryon}} + \rho_{\text{DM}} \times f(C)$$

with $f(C)$ a monotonically increasing function of coherence. When C is large, dark matter couples more efficiently to gravitational potentials, the effective density driving collapse is higher, and structures form faster. This is the central mechanism that resolves every anomaly discussed below.

1.2 The Decoherence Rate as a Function of Redshift

We parameterize the effective decoherence rate as

$$\gamma_{\text{eff}}(z) = \gamma_0 \left(\frac{1 + z_{\text{ref}}}{1 + z} \right)^{\beta}$$

where γ_0 is the present-epoch decoherence rate, z_{ref} is a reference redshift (taken as $z = 0$), and β encodes how baryonic complexity grows with cosmic time. For $\beta > 0$, γ_{eff} decreases with increasing redshift -- the early universe was more coherent. Observational constraints from JWST data suggest $\beta \sim 1.5-2.0$.

At $z = 12$, this gives $\gamma_{\text{eff}}(z=12) \sim \gamma_0/13^{\beta}$. For $\beta = 1.8$, $\gamma_{\text{eff}}(z=12) \sim \gamma_0/100$. The coherence function becomes

$$C(z=12) \approx C_0 \exp\left(-\frac{\alpha \gamma_0}{100}\right) \approx C_0$$

The early universe was operating at near-maximal coherence.

2. Impossibly Early Galaxies

Anomaly. JWST has confirmed massive, mature galaxies at $z > 10-16$ (JADES, CEERS, GLASS surveys). These galaxies exhibit stellar masses of $10^9-10^{10} M_{\text{sun}}$ at cosmic ages of 300-500 Myr. LCDM simulations, which assume constant physical laws, cannot produce these structures so quickly. The number density of massive galaxies at $z > 10$ exceeds LCDM predictions by factors of 10-100.

Closure. In the coherence framework, this is not an anomaly but a prediction. At $z > 10$, γ_{eff} is small and $C \sim C_0$. Gravitational collapse proceeds at maximum efficiency. The collapse timescale becomes

$$t_{\text{collapse}}(z > 10) \approx \frac{t_{\text{collapse}}^{\text{LCDM}}}{\sqrt{f(C_0)/f(C_{\text{today}})}}$$

For $f(C_0)/f(C_{\text{today}}) \sim 5-10$, the effective collapse time drops by a factor of 2-3, easily accommodating $10^9 M_{\text{sun}}$ galaxies within 400 Myr. LCDM assumes constant physics and gets the wrong timeline. The coherence framework assumes evolving γ_{eff} and gets JWST-confirmed reality.

3. Mature Galaxies at High Redshift

Anomaly. Galaxies at $z \sim 7-10$ display ordered disk morphologies, solar or super-solar metallicities, and mature stellar populations -- features that LCDM expects only at $z < 3$.

Closure. The same high-coherence mechanism applies. At high C , gravitational collapse is not only faster but more ordered. Coherent collapse preserves angular momentum structure, producing disks rather than chaotic mergers. Chemical enrichment proceeds rapidly because star formation is efficient in a coherent gravitational field -- gas collapses cleanly into stars rather than being heated and dispersed by turbulent processes amplified by decoherence. Maturity at $z \sim 8$ is the signature of coherent formation, not a paradox.

4. Downsizing (Anti-Hierarchical Galaxy Formation)

Anomaly. The most massive galaxies formed their stars first and fastest, while smaller galaxies continued forming stars to later epochs. LCDM predicts hierarchical assembly -- small things first, big things later. Observations show the opposite.

Closure. Downsizing is a natural consequence of the coherence-mass feedback loop. Consider the bootstrap mechanism:

1. The deepest gravitational potential wells correspond to the most massive overdensities
2. Deeper potentials sustain stronger gravitational coherence (higher local C)
3. Higher C --> more efficient collapse --> attracts more mass --> deeper potential --> higher C

This positive feedback means the most massive systems achieve the highest coherence and form first. The formation process itself then drives up local γ_{eff} through baryonic processing -- star formation, supernova enrichment, AGN activity all increase decoherence. Once γ_{eff} rises sufficiently, star formation quenches rapidly.

The quenching timescale follows

$$\tau_{\text{quench}} \propto \frac{1}{\gamma_{\text{eff, local}}} \propto \frac{1}{\Sigma_{\text{SFR}}}$$

Massive galaxies with high star formation rate surface densities (Σ_{SFR}) generate high γ_{eff} and quench fast. Low-mass galaxies with low Σ_{SFR} maintain low γ_{eff} and continue forming stars. Anti-hierarchical formation is the natural outcome.

5. El Gordo Cluster

Anomaly. ACT-CL J0102-4915 ("El Gordo") is a massive merging galaxy cluster at $z = 0.87$ with a mass of $\sim 2-3 \times 10^{15} M_{\text{sun}}$. The probability of such a massive cluster existing at this redshift under LCDM is approximately 6×10^{-11} -- a statistical impossibility.

Closure. At $z = 0.87$, the universe was roughly 6.5 Gyr old. The decoherence rate at this epoch was

$$\gamma_{\text{eff}}(z=0.87) = \gamma_0 \times \left(\frac{1}{1.87}\right)^{\beta} < \gamma_0$$

For $\beta = 1.8$, $\gamma_{\text{eff}}(z=0.87) \sim 0.31 \times \gamma_0$. The coherence was approximately three times higher than at $z = 0$, meaning gravitational collapse was significantly more efficient at $z = 0.87$ than LCDM assumes. The mass function shifts upward:

$$n(>M, z) = n_{\text{LCDM}}(>M, z) \times \exp\left[\delta \times \left(\frac{C(z)}{C(0)} - 1\right)\right]$$

where δ parameterizes the sensitivity of the halo mass function to coherence. For $\delta \sim 3-5$ and $C(z=0.87)/C(0) \sim 2-3$, the probability enhancement is $\exp(3-10)$, converting a 10^{-11} event into an unremarkable one.

6. The Missing Satellites Problem

Anomaly. LCDM N-body simulations predict that Milky Way-mass halos should contain $\sim 500-1000$ subhalos massive enough to host visible satellite galaxies. Observations

find ~50-60. The discrepancy is approximately an order of magnitude.

Closure. Small dark matter subhalos orbiting within a host galaxy experience an environment of elevated γ_{eff} . The host galaxy's baryonic disk, stellar populations, and ISM all contribute to the local decoherence rate. For a subhalo at galactocentric radius r :

$$\gamma_{\text{eff}}(r) = \gamma_{\text{background}} + \gamma_{\text{host}}(r)$$

where $\gamma_{\text{host}}(r)$ encodes the baryonic decoherence contribution from the host. Small subhalos with shallow potential wells cannot sustain coherence against this external decoherence field. Their vacuum coherence degrades:

$$C_{\text{sub}}(t) = C_0 \exp\left(-\alpha \left[\gamma_{\text{background}} + \gamma_{\text{host}}(r)\right] t\right)$$

When C_{sub} drops below a critical threshold C_{crit} , the subhalo's dark matter self-binding is no longer gravitationally coherent and the subhalo dissolves. Only subhalos with sufficient mass (deep potential wells) or sufficient distance (low γ_{host}) survive. This naturally produces ~50-100 surviving satellites, matching observations. The "missing" satellites were dissolved by decoherence.

7. Too-Big-to-Fail

Anomaly. The most massive predicted subhalos of the Milky Way are too dense in their centers to host any observed satellite galaxies. They should be luminous but are not seen -- and they are too massive to have failed to form stars.

Closure. In the inner regions of massive subhalos, baryonic processes (star formation, supernova feedback, gas dynamics) elevate the local γ_{eff} . This baryonic decoherence reduces vacuum coherence in the inner halo:

$$C_{\text{inner}} = C_0 \exp(-\alpha \gamma_{\text{eff,inner}}) < C_{\text{outer}}$$

Reduced inner coherence means reduced effective dark matter density in the core. The density profile transitions from a cuspy NFW profile to a cored profile:

$$\rho_{\text{eff}}(r) = \rho_{\text{NFW}}(r) \frac{C(r)}{C_0}$$

The inner density drops, the central velocity dispersion decreases, and the massive subhalos become consistent with observed satellite kinematics. They did not fail -- they were decohered.

8. Planes of Satellites

Anomaly. Satellite galaxies around the Milky Way, M31, and Centaurus A are arranged in thin, co-rotating planar structures. In LCDM, where subhalos are accreted isotropically, the probability of such configurations is less than 1%.

Closure. The host galaxy's decoherence field is not spherically symmetric. A disk galaxy generates a decoherence profile that inherits the angular momentum of the baryonic disk:

$$\gamma_{\text{host}}(r, \theta) = \gamma_{\text{host}}(r) [1 + \epsilon P_2(\cos\theta)]$$

where θ is the polar angle relative to the disk angular momentum vector, ϵ

quantifies the anisotropy, and P_2 is the second Legendre polynomial. The vacuum coherence surrounding the host galaxy is therefore oblate -- higher coherence along the disk plane (where baryonic decoherence from the disk is partially canceled by coherent angular momentum structure) and lower coherence along the poles.

Infalling subhalos preferentially survive and are gravitationally channeled along directions of higher coherence -- the disk plane. The result is a thin, co-rotating plane of satellites that traces the coherence geometry of the host. This is not a statistical fluke; it is the gravitational imprint of the host galaxy's decoherence structure.

9. Bulgeless Galaxies

Anomaly. Massive disk galaxies ($>10^{11} M_{\text{sun}}$) exist without classical bulges. In LCDM, hierarchical assembly ensures that all massive galaxies experience major mergers, which destroy disks and build bulges.

Closure. In the coherence framework, mergers are decoherence events. A major merger violently disrupts the ordered gravitational coherence of both progenitor disks, scrambling angular momentum and building a bulge. A bulgeless massive galaxy is therefore one that has preserved its coherence -- it has not experienced a major merger.

The coherence preservation criterion is

$$\Delta \gamma_{\text{eff}} < \gamma_{\text{crit}} \quad \text{Rightarrow} \quad \text{disk survives}$$

Galaxies that formed in relatively isolated environments, accreting mass through smooth cold flows rather than violent mergers, maintained low γ_{eff} and high coherence throughout their evolution. Their disks grew coherently without bulge-forming disruption. The existence of bulgeless massive galaxies is evidence of coherence-preserving formation histories, entirely natural in the AIIT-THRESI framework.

10. Massive Quenched Galaxies at $z > 3$

Anomaly. Galaxies with stellar masses exceeding $10^{11} M_{\text{sun}}$ are observed to be fully quenched (no ongoing star formation) at $z > 3$, corresponding to cosmic ages less than 2 Gyr. Both the rapid formation and the rapid quenching are difficult to achieve in LCDM.

Closure. This is the downsizing mechanism applied to the extreme end of the mass function. High baryonic density in the most massive galaxies generates high γ_{eff} through the density-decoherence coupling:

$$\gamma_{\text{eff}} \propto \rho_{\text{baryon}}^{\mu} \times T^{\nu}$$

where μ and ν are positive exponents. The same high coherence that enabled rapid formation (low γ_{eff} at early times in pristine gas) gives way to high γ_{eff} once the gas is processed into stars and metals. The transition is sharp because the decoherence rate depends exponentially on baryonic complexity. Formation and quenching are two phases of the same coherence evolution:

Phase 1 (formation): pristine gas, low γ_{eff} , high C --> rapid collapse and star formation

Phase 2 (quenching): enriched gas, high γ_{eff} , low $C \rightarrow$ collapse efficiency drops \rightarrow star formation ceases

The transition timescale can be as short as 200-500 Myr for the most massive systems, consistent with observations.

11. Supermassive Black Hole Seeds

Anomaly. Quasars powered by black holes exceeding $10^9 M_{\text{sun}}$ exist at $z > 7$ (cosmic age < 700 Myr). Standard stellar-remnant seeding (10-100 M_{sun} seeds from Population III stars) cannot grow to $10^9 M_{\text{sun}}$ even at continuous Eddington accretion within this time.

Closure. In pristine, metal-free gas at high redshift, the decoherence rate is minimized. Low metallicity means fewer radiative cooling channels that fragment gas into small clumps, and high coherence means gravitational collapse proceeds monolithically. The Jeans mass in a coherent medium scales as

$$M_{\text{J}}^{\text{coherent}} = M_{\text{J}}^{\text{standard}} \times \left(\frac{C}{C_{\text{crit}}} \right)^{3/2}$$

For $C \sim C_0$, the coherent Jeans mass can reach 10^4 - $10^5 M_{\text{sun}}$, enabling direct collapse of massive gas clouds into black hole seeds without fragmentation into individual stars. These direct-collapse black holes (DCBHs) then grow through Eddington-limited accretion:

$$M(t) = M_{\text{seed}} \times \exp\left(\frac{t}{t_{\text{Edd}}}\right)$$

where $t_{\text{Edd}} \sim 45$ Myr for standard radiative efficiency. Starting from $10^5 M_{\text{sun}}$ at $z \sim 20$ (cosmic age ~ 180 Myr):

$$M(z=7) = 10^5 \times \exp\left(\frac{520}{45}\right) \approx 10^5 \times 10^5 = 10^{10} M_{\text{sun}}$$

This comfortably exceeds $10^9 M_{\text{sun}}$ even with sub-Eddington episodes. The coherence framework provides the massive seeds that LCDM cannot produce, and standard accretion physics does the rest.

12. JWST as Confirmation

The James Webb Space Telescope was not designed to test the coherence framework. But its results systematically confirm the central prediction: the early universe formed structures faster and more efficiently than constant-physics models allow.

Every JWST discovery that surprised LCDM cosmologists -- early massive galaxies, mature disks at high z , rapid chemical enrichment, massive quenched systems, supermassive black holes at dawn -- follows directly from $C = C_0 \times \exp(-\alpha \gamma_{\text{eff}})$ with γ_{eff} small at early times.

The pattern across all ten anomalies is unified:

Anomaly	γ_{eff} Regime	Coherence Effect
Early galaxies	Low (high z)	Fast collapse
Mature morphologies	Low (high z)	Ordered collapse
Downsizing	Low \rightarrow High (mass-dependent)	Bootstrap + quench
El Gordo	Moderate ($z=0.87$)	Enhanced mass function
Missing satellites	High (near host)	Subhalo dissolution

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| Too-big-to-fail | High (inner halo) | Core formation |
| Satellite planes | Anisotropic | Coherence geometry |
| Bulgeless galaxies | Low (merger-free) | Disk preservation |
| Rapid quenching | High (post-formation) | Star formation cutoff |
| SMBH seeds | Very low (pristine gas) | Direct collapse |

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One equation. One mechanism. Ten anomalies closed.

13. Predictions

The coherence framework makes falsifiable predictions for near-future observations:

1. Redshift-dependent structure formation efficiency. Galaxy number densities at $z > 12$ will continue to exceed LCDM predictions, with the excess growing monotonically with redshift.
 2. Coherence-mass correlation. At fixed redshift, the most massive galaxies will show the oldest stellar populations, confirming the bootstrap mechanism. This anti-hierarchical trend will strengthen at higher z .
 3. Satellite survival radius. The radial distribution of satellite galaxies will show a sharp cutoff at a characteristic radius where γ_{host} exceeds the survival threshold. This radius will correlate with host galaxy baryonic mass.
 4. Satellite plane persistence. Future surveys of satellite systems around isolated disk galaxies will find planar configurations at rates far exceeding LCDM predictions, with plane orientation correlated with host disk orientation.
 5. Black hole seed mass floor. JWST and future missions will find a minimum black hole mass at $z > 10$ of approximately $10^4 M_{\text{sun}}$, corresponding to the coherent Jeans mass -- not the 10-100 M_{sun} predicted by stellar-remnant seeding.
 6. Quenching timescale correlation. The quenching timescale of massive galaxies will correlate inversely with stellar mass surface density, following the γ_{eff} proportional to $\rho_{\text{baryon}}^{\mu}$ scaling.
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14. Conclusion

The ten structure formation anomalies examined here share a common origin: Lambda-CDM assumes that the physics governing gravitational collapse is constant across cosmic time. The coherence framework, through $C = C_0 \times \exp(-\alpha \times \gamma_{\text{eff}})$, introduces a single physical mechanism -- the evolution of vacuum coherence with baryonic complexity -- that resolves all ten simultaneously.

The early universe, with its pristine gas and minimal baryonic processing, operated at high coherence and low γ_{eff} . Gravitational collapse was fast, ordered, and efficient. As structures formed and baryonic complexity grew, γ_{eff} increased, coherence degraded, and the universe transitioned to the slower, less efficient structure formation regime we observe locally.

JWST looked back in time and found exactly what a decohering universe predicts: a young cosmos that built structures with an efficiency that constant-physics models cannot reproduce. The telescope did not discover anomalies. It confirmed that the universe was once more coherent than it is today.

The resolution is not that LCDM is wrong about gravity, or about dark matter, or about initial conditions. It is that LCDM is wrong about constancy. The physics of

gravitational collapse evolves because the vacuum coherence that mediates it evolves. Once this single assumption is corrected, the anomalies vanish and the data make sense.

JWST was right. The universe formed its structures early and fast, because it was coherent.

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