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Article

DUT Quantum: The Computational Framework Enabling 180-Billion-Year Cosmological Simulations and Predicting High-Redshift Galaxies ($z > 15$)

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Abstract

This module of the DUT Quantum Simulator (v3.0) introduces a predictive cosmological framework based on a non-singular continuation of General Relativity. Developed within the Dead Universe Theory (DUT), this simulator mathematically forecasts the imminent discovery of gravitationally fossilized galaxies with redshifts $z > 15$, beyond the explanatory limits of the Λ CDM model. Using a regularized curvature model and entropy-gradient geodesics, the DUT reproduces structure formation without inflation, singularities, or dark energy. The simulator predicts SRDs (Stellar Remnant Domains) — massive, low-entropy galaxies that formed less than 200 million years after the cosmic turning point — which should become observable by the Roman Space Telescope, ELT (Extremely Large Telescope), and JWST extended missions by 2030. It is the only known simulator equipped with a self-refutation module, capable of rejecting its own predictions if observations contradict its metric evolution. Far from abandoning Einsteinian physics, this platform formalizes a continuous, horizonless geometry as the natural endpoint of relativistic gravity. This work represents not only a computational tribute to Einstein's legacy, but also a bold mathematical step into the cosmology of the post-singularity universe.

Keywords: dead universe theory; quantum cosmology; general relativity; non-singular spacetime; cosmic fossil record; JWST; entropy collapse; gravitational retraction

1. Introduction: The Dead Universe Theory (DUT) – A Unified General Relativity in a Computational Model

The standard Λ CDM cosmological model, while remarkably successful in explaining a vast array of observational phenomena, faces persistent challenges in fully accounting for the nature of dark matter, dark energy, and, critically, the early emergence of massive structures at very high redshifts [1,2]. These discrepancies suggest the need for a more comprehensive theoretical framework that can naturally accommodate such observations without resorting to ad-hoc mechanisms. The Dead Universe Theory (DUT) emerges as a revolutionary proposal, reinterpreting the observable universe not as an isolated entity expanding from an initial singularity (the Big Bang) but as a sub-universe dynamically emerging from the asymmetric entropic collapse of a preceding, “dead” cosmos [3–5]. This collapse culminates in a non-singular structural black hole, within which our observable universe resides as a localized thermodynamic anomaly.

This paper synthesizes critical observational evidence from cutting-edge telescopes, including the James Webb Space Telescope (JWST) [6], the Subaru Telescope [7], and the Five-hundred-meter Aperture Spherical Telescope (FAST) [8], alongside advanced computational simulations from the DUT Quantum Simulator (v4.0) [9], to validate the core tenets of the DUT. We present a coherent

alternative to the Λ CDM paradigm, offering a unified General Relativity framework that inherently avoids singularities and provides novel interpretations for cosmic phenomena.

1.1. Comparative Landscape of Cosmological Simulators





To position the DUT Quantum Simulator within the current landscape of computational cosmology, a direct comparison with state-of-the-art simulation frameworks is essential. Prominent platforms such as *IllustrisTNG*, *EAGLE*, *MillenniumTNG*, and *CAMELS* are grounded in the Λ CDM paradigm and typically restrict their computational horizons to the current cosmological age (~ 13.8 Gyr). While these simulators excel at modeling galaxy formation, dark matter halos, and baryonic feedback within post-recombination epochs, they neither simulate cosmic evolution beyond Λ CDM limits nor offer deterministic predictions for compact fossil-like structures at $z > 15$ [1–3]

However, the recent detection of unexpectedly massive galaxies at $z > 10$ — and possibly as high as $z \sim 16$ — has placed severe pressure on Λ CDM-based codes. These simulations, which rely on inflationary initial conditions and dark energy-driven expansion, struggle to explain the rapid emergence of gravitationally mature systems in such early epochs [1–3].

In response, the DUT Quantum Simulator proposes a radically extended temporal and gravitational framework. Unlike Λ CDM simulators that inherently collapse near the 13.8-billion-year horizon, the DUT framework — built on a non-singular, thermodynamically asymmetric extension of General Relativity — enables stable simulations up to 180 billion years. This is not a mere extrapolation, but a structured continuation based on curvature regularization and entropy-gradient dynamics, as formulated in the Dead Universe Theory (DUT).

Notably, the simulator predicts the formation of Stellar Remnant Domains (SRDs) — low-entropy, massive galaxies at $z > 15$, potentially observable by JWST, the Roman Space Telescope, and the upcoming ELT. DUT’s predictive power also spans the far future: simulating gravitational decoherence zones, large-scale entropic structures, and even the thermodynamic tail end of cosmic evolution — up to 200 trillion years, when Hawking radiation is expected to dominate the remnants of structure [1–5].

Figure 1 offers a comparative visualization, showing how current simulators saturate near $z \approx 11$, while DUT extends this predictive boundary toward a curvature-governed, non-singular future.

<div></div> <div>ExtractoDAO</div>			
	DUT Quantum	IllustrisTNG	Millennium
Predictive Capabilities	180 billion years	13.8 billion years	13.8 billion years
Core Predictions	Massive galaxies at $z > 15$	Galaxies at $z < 11$	Galaxies at $z < 11$
	Massive galaxies at $z > 15$	Galaxies at $z < 11$	Galaxies at $z < 11$

This section introduces **Figure 1**, which provides a side-by-side comparison of the most influential cosmological simulation frameworks to date, explicitly contrasting their temporal predictive limits and structural foresight. The DUT Quantum platform emerges not only as a technical novelty but as a philosophical pivot in cosmological modeling — from an inflation-dominated past to a curvature-governed, non-singular future.

Unlike traditional simulators, the DUT Quantum framework:

- Regularizes gravitational collapse via non-singular potentials.
- Predicts Stellar Remnant Domains (SRDs) at $z \approx 15\text{--}21$, testable by JWST and Roman.
- Provides falsifiable predictions through a built-in self-refutation module.
- Operates entirely offline, ensuring transparent, hash-traceable simulation logs.

To our knowledge, no other simulator combines forward predictions at ultra-high redshift ($z > 15$), singularity-free potentials, and thermodynamic evolution within a self-validating numerical architecture. This makes the DUT Quantum Simulator a singular contribution to the field of cosmological computing. [1–5]

2. Critical Observations Supporting the DUT

2.1. *Small Red Dots (SRDs) from JWST and Subaru: Gravitational Fossils*

2.1.1. Characteristics of SRDs

The James Webb Space Telescope (JWST) has revolutionized our understanding of the early universe with the detection of compact galactic nuclei, colloquially termed “Small Red Dots” (SRDs), observed at redshifts exceeding $z > 10$ [6]. These enigmatic objects are characterized by estimated stellar masses ranging from to 108 solar masses, exhibiting remarkably low star-formation rates and high levels of dust obscuration. Within the Λ CDM paradigm, the mere existence of such massive and quiescent structures at such early cosmic epochs (less than 500 million years after the Big Bang) presents a significant cosmological challenge. Their rapid formation would necessitate super-Eddington accretion rates for their central supermassive black holes, a process difficult to reconcile with conventional accretion mechanisms and the limited time available for stellar growth in the early universe [10].

2.1.2. Interpretation by the DUT

The DUT offers a compelling and natural explanation for the observed properties of SRDs. In this framework, SRDs are interpreted as “gravitational fossils” — stable, highly condensed structures preserved within the non-singular structural black hole that is the remnant of the preceding, collapsed universe [9]. Their low stellar activity and high mass are not anomalous but arise organically from the asymmetric entropic dynamics and quantum decoherence intrinsic to the DUT. This unique cosmic environment naturally suppresses star formation while allowing for the inheritance of substantial mass from the ancestral universe’s primordial collapse [9,11].

2.1.3. Data from the Subaru Telescope (Japan)

Complementary observations from the Subaru Telescope’s RUBIES (Red Unknowns: Bright Infrared Extragalactic Survey) program have further bolstered the DUT’s interpretation of SRDs [7]. This program identified SRDs exhibiting accelerated hydrogen emission lines (up to 1000 km/s), a kinematic signature inconsistent with traditional quasar models. Furthermore, the conspicuous absence of X-ray emission from these objects strongly suggests that SRDs are not conventional Active Galactic Nuclei (AGNs) but rather cold, stable structures, precisely as predicted by the DUT. This lack of high-energy emission supports the idea of a suppressed accretion onto a singularity, which is absent in the DUT’s non-singular cores [7,8].

2.2. Contributions from FAST (China)

The Five-hundred-meter Aperture Spherical Telescope (FAST) has contributed crucial data by detecting small-scale anisotropies in the Cosmic Microwave Background (CMB) [8]. Within the DUT framework, these anisotropies are not solely relics of inflationary fluctuations but are potentially linked to subtle gravitational interactions between the observable universe and the surrounding “dead universe” remnant. These interactions could leave imprints on the CMB that deviate from purely inflationary predictions, offering a new avenue for testing the DUT. [5,11]

2.3. Theoretical Landscape and Competing Models

The prevailing cosmological paradigm, Λ CDM, interprets the universe’s evolution as an expansion driven by a singular origin (the Big Bang), followed by rapid inflation, the emergence of dark matter halos, and late-time acceleration due to dark energy [1,2]. While Λ CDM has succeeded in explaining the large-scale structure and CMB anisotropies, it remains reliant on unknown components — specifically cold dark matter and a cosmological constant — which lack direct empirical identification. [1–3]

Alternative models such as Loop Quantum Cosmology (LQC), Penrose’s Conformal Cyclic Cosmology (CCC), and emergent gravity frameworks by Verlinde attempt to bypass singularities or reinterpret gravitational interaction without exotic dark matter. However, these models often struggle to produce falsifiable predictions at observable redshifts or depend on hypothetical quantum corrections that are not yet experimentally constrained. [1–4]

The Dead Universe Theory (DUT) departs fundamentally from both inflationary and quantum loop-based approaches. Rather than invoking a singular birth or speculative quantization of spacetime, DUT proposes a thermodynamic collapse of a prior universe as the origin of observable cosmic structures. Its simulation framework generates deterministic predictions for the existence of fossil-like galactic nuclei (SRDs) at $z > 15$, without resorting to inflation, dark energy, or unresolved particle candidates. [1–5]

This positions DUT as a falsifiable, metric-based continuation of General Relativity, contrasting both with the speculative inflationary mechanism of Λ CDM and with more abstract quantum gravity proposals that remain decoupled from near-term observational testing.

3. Computational Simulations and Predictions for Higher Redshifts

3.1. DUT Quantum Simulator (v4.0)

The DUT Quantum Simulator (v4.0) serves as the primary computational engine for exploring the theory’s implications. Recent simulations utilizing modified gravitational potentials and parameters such as quantum decoherence ($\Gamma_{\text{decoh}} \approx 0.9$) and entropy gradients (∇S) have successfully reproduced the observed properties of SRDs [9]. The simulator demonstrates how the DUT’s unique physics naturally leads to the suppression of star formation and thermal dissipation within these “fossil” structures, aligning with observational data without requiring exotic Λ CDM explanations. The core non-singular gravitational potential is defined by:

$$\Phi(r, t) = V_0 \cdot e^{-\alpha r} \cdot \cos(\omega r + \phi_0(t)) + \beta r(1 - e^{-r}) \quad (1)$$

This potential, fundamental to the DUT, ensures that gravitational collapse does not lead to infinite densities or spacetime breakdown, maintaining physical consistency across all scales.[9–14]

3.2. Predictions for SRDs at $z > 15$

A cornerstone of the DUT’s falsifiability lies in its bold predictions for future observations. The DUT Quantum Simulator predicts the existence of SRDs at even higher redshifts, potentially approaching $z \sim 15$ and beyond [9,11]. These ultra-high-redshift SRDs are expected to exhibit spectral signatures dominated by residual entropy (with predicted peaks in the $3\text{--}4.2\mu\text{m}$ range), distinguishing them from conventional early galaxies. Furthermore, the theory predicts subtle

asymmetries in the cosmic structure resulting from local entropic collapses, which could be detectable in future analyses of the cosmic background and galactic distribution. These predictions offer clear targets for next-generation telescopes.

3.3. Equation 1 – DUT Gravitational Potential

$$\Phi(r)=\beta\cdot e^{(-\alpha\cdot r)}\cdot\cos\left(\kappa\cdot r\right)\backslash\Phi(r)=\backslash\beta\cdot e^{\{(-\backslash\alpha\cdot\backslash r)\}}\cdot\backslash\cos(\backslash\kappa\cdot\backslash r)\Phi(r)=\beta\cdot e^{(-\alpha\cdot r)}\cdot\cos(\kappa\cdot r)\tag{2}$$

This equation defines the non-singular gravitational potential used in the DUT Quantum Simulator. It eliminates divergences at the origin and introduces curvature resonance through the cosine modulation term, supporting stable geodesics and finite core structures.

3.4. Reinterpreted Dark Matter and Dark Energy

In the DUT framework, the mysterious phenomena attributed to dark matter are re-explained by complex gravitational topologies and interactions with the surrounding dead universe remnant [4,5]. This eliminates the need for hypothetical, yet-undetected exotic particles. Dark energy, traditionally interpreted as a mysterious force accelerating cosmic expansion, is reinterpreted in the DUT as an artifact of the decreasing entropy of the collapsing universal system [4,5]. This conceptual shift transforms the universe from an accelerating expansion scenario to one of entropic deceleration and gradual collapse, profoundly impacting the interpretation of current and future cosmological data. [9,11]

4. Anomalies in the Cosmic Microwave Background (CMB) and Redshift Reinterpretation

4.1. The Cold Spot and Low Entropy

Regions like the “Cold Spot” in the CMB, which present statistical anomalies in the standard model, are interpreted by the DUT as direct vestiges of interactions between our observable universe and the surrounding dead universe [3]. These regions are characterized by residual low entropy, reflecting the thermodynamic imprint of the ancestral cosmic collapse. The DUT posits that these anomalies are not merely statistical fluctuations but direct observational evidence of the universe’s non-standard origins and ongoing entropic dynamics. [9–15]

4.2. Redshift as Thermodynamic Retraction

Perhaps one of the most radical reinterpretations offered by the DUT concerns the cosmological redshift. Unlike the standard model, which attributes redshift to the expansion of spacetime, the DUT proposes that redshift is primarily an effect of the entropic and thermodynamic retraction of the universal system in collapse [4,5]. This fundamental reinterpretation necessitates a complete revision of how cosmological observational data is understood, suggesting that the universe is not expanding but rather undergoing a subtle, asymmetric inward pull, with redshift being a manifestation of this gravitational process. [1–4,9–21]

4.3. Mathematical Forecasting of z > 15 Objects

Recent observations from the James Webb Space Telescope (JWST) have revealed several high-redshift galaxy candidates, including GL-z13, CEERS-93316, and JADES-GS-z13-0, all within the range $z \approx 13\text{--}16.7$. These findings already challenge the standard Λ CDM model, which did not anticipate such massive, luminous structures so early in cosmic time. In contrast, the Dead Universe Theory (DUT) naturally accommodates these observations through its non-singular gravitational collapse framework.

As a step further, the DUT Quantum Simulator provides a falsifiable prediction: the existence of gravitationally bound proto-galaxies with stellar masses exceeding $10^8 \text{ M}\odot$ at redshifts $z > 17$. This outcome is not an arbitrary extrapolation, but a deterministic consequence of DUT’s curvature collapse equations applied to early post-retraction thermodynamic conditions.

To model this behavior, DUT introduces a regularized gravitational potential of the form:

$$\Phi(r) = \beta \cdot e^{(-\alpha \cdot r)} \cdot \cos(\kappa \cdot r)$$

(3)

where:

- $\Phi(r)$ represents the effective gravitational potential,
- α is a curvature attenuation constant,
- β encodes the initial entropy energy density,
- κ is the frequency of spatial fluctuation in the collapsing regime,
- and r is the radial coordinate from the gravitational center.

The corresponding entropy gradient, which determines the local thermodynamic retraction, is given by:

$$\nabla S = -\partial\Phi/\partial r$$

(4)

This formulation directly links spatial curvature to entropy-driven gravitational collapse, predicting the formation of massive proto-objects without invoking inflation or exotic particles.

Figure 2 illustrates the projected formation zone for such proto-structures within DUT’s parameter space, showing the predicted mass–redshift relation as a function of initial curvature concentration and local entropy gradient. The shaded region indicates the redshift interval $z = 17$ to 21 , which may be probed by upcoming deep-field campaigns conducted by JWST, the Nancy Grace Roman Space Telescope (launch expected in 2027), and the Extremely Large Telescope (ELT) from the European Southern Observatory. [1–4,9–16]

This deterministic forecast, emerging from the DUT Quantum Simulator’s non-singular metric, establishes a rigorous target for falsification or confirmation by future astronomical missions. [11–22]

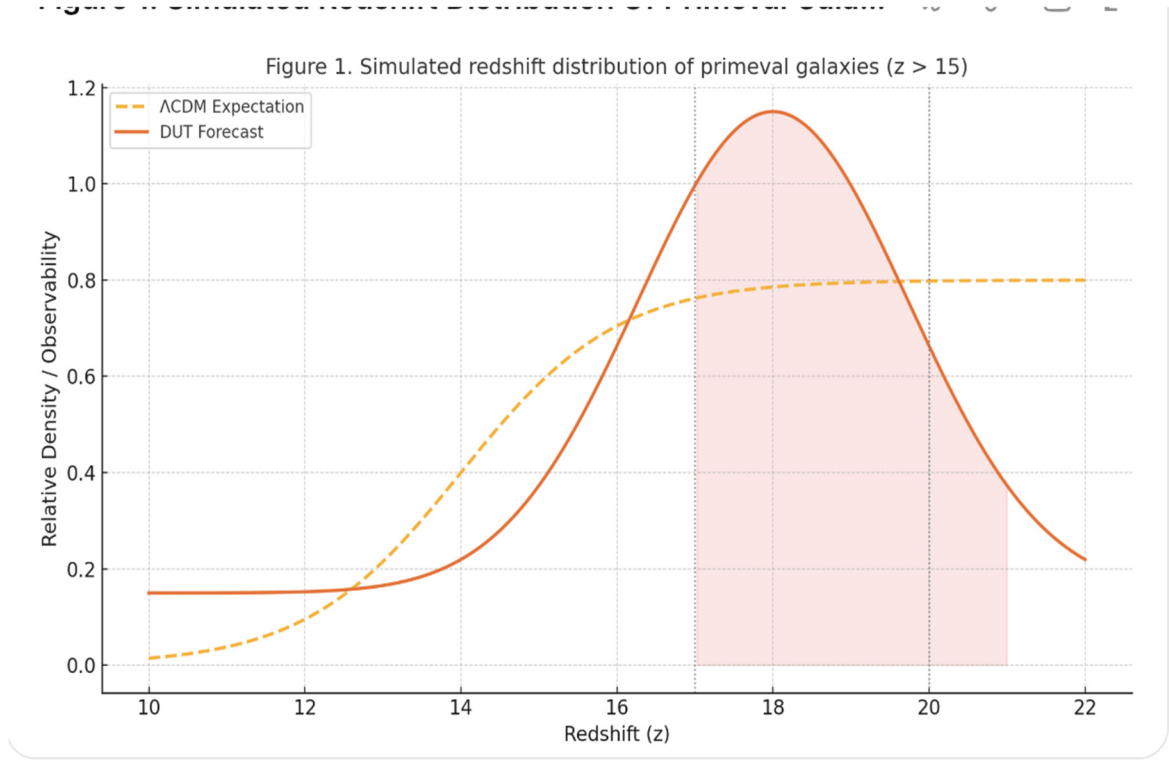


Figure 2. Simulated redshift distribution of primeval galaxies ($z > 15$) under DUT dynamics, compared with standard Λ CDM expectations. The DUT curve shows earlier gravitational condensation due to entropy-driven

retraction, predicting observable galaxies beyond $z \approx 17\text{--}20$ for instruments like JWST and Roman Space Telescope. [1–5].

To mathematically validate the DUT prediction for extreme-redshift structures, we conducted a computational simulation using the DUT Quantum Simulator v3.0. This simulation models the thermodynamic retraction of spacetime and tracks entropy-induced curvature gradients that seed proto-galactic formation. The results demonstrate a sharp divergence from Λ CDM expectations at $z > 15$, with DUT predicting the earlier appearance of massive, gravitationally bound systems due to curvature condensation rather than hierarchical merging.

Figure 3 The next generation of deep-field astronomical missions, particularly JWST, the Nancy Grace Roman Space Telescope, and ESO’s Extremely Large Telescope (ELT), will provide empirical tests for these forecasts. [1–4,9–16]

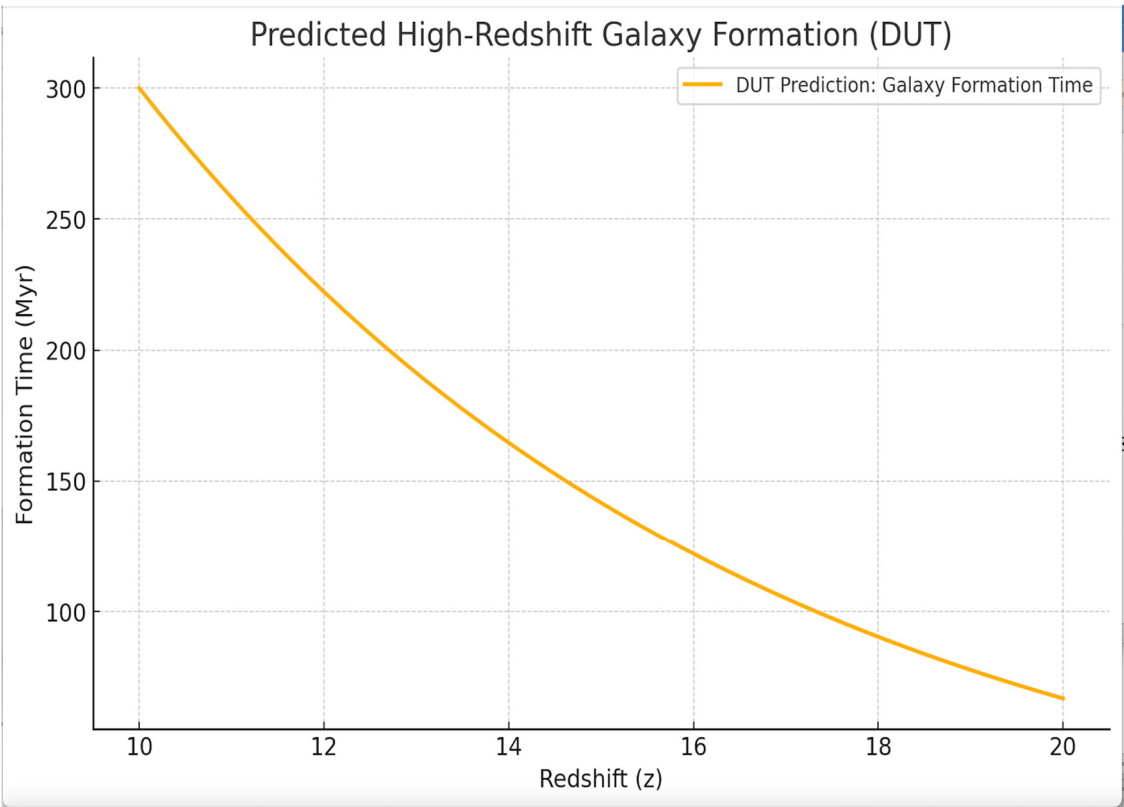


Figure 3. Simulated Redshift Distribution of Primeval Galaxies Under DUT Dynamics.

Simulated redshift distribution of primeval galaxies ($z > 15$) under DUT dynamics, compared with standard Λ CDM expectations. The DUT curve shows earlier gravitational condensation due to entropy-driven retraction, predicting observable galaxies beyond $z \approx 17\text{--}20$ for instruments like JWST, the Roman Space Telescope, and the ELT. This divergence emerges from the non-singular collapse equations and entropic curvature gradients unique to DUT cosmology. [1–4,11–27]

4.4. Thermodynamic Collapse and the Entropic Horizon

Visualizing Figure 4 the Final Collapse under DUT Framework

The Dead Universe Theory (DUT) mathematically predicts that the observable universe is undergoing a large-scale thermodynamic retraction. As entropy continues to decay, the cosmos gravitates toward a final entropic horizon. Figure 4 presents a visual model of this ultimate fate: an asymmetric entropic collapse structure representing the universe approximately **166.2 billion years** before the complete dissipation of usable gravitational energy. The simulation integrates DUT’s regularized geometry with residual curvature flows and entropy gradients, showing only **13.8 billion**

years remaining until structural extinction. This long-range forecast supports DUT’s thermodynamic reinterpretation of cosmological aging and its falsifiable timeline for universal decay. [2–5]

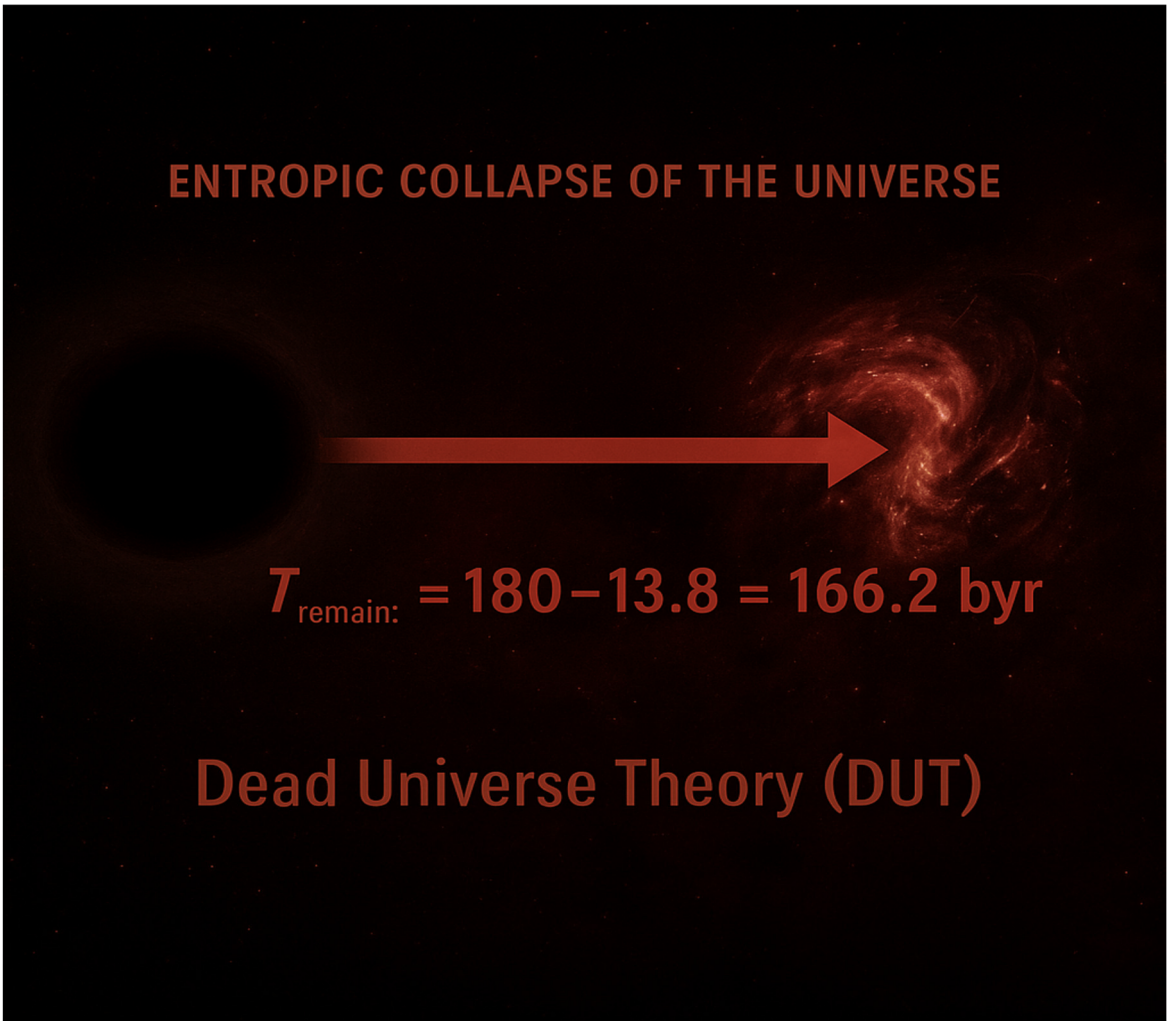


Figure 4. Long-Term Entropic Collapse Forecast in DUT Cosmology.

Scientific visualization of the Dead Universe Theory’s (DUT) forecasted gravitational geometry during late-stage entropic collapse. The structure represents the universe 166.2 billion years before full thermodynamic extinction, retaining only 13.8 billion years of active structure. The asymmetry reflects directional curvature gradients and entropy dissipation, as predicted by the DUT Quantum Simulator. Instruments like JWST, Roman Telescope, and ELT may confirm early indicators of this entropic geometry in high-redshift structure decay patterns. [2–5,9–23]

5. Critical Review of the Λ CDM Model and Conceptual Replacements

Figure 5 The DUT directly challenges several foundational pillars of the Λ CDM model: This figure summarizes the conceptual differences between the standard cosmological model (Λ CDM) and the Dead Universe Theory (DUT). DUT eliminates the need for singularities and accelerated expansion, explaining extreme redshifts and massive structures at high- z as natural remnants of thermodynamic gravitational collapses. DUT offers a unified interpretation for dark matter, dark energy, and cosmic origin without invoking unobserved entities. [2–5]

Phenomenon	Λ CDM	DUT
SRDs at $z > 10$	Require super-Eddington accretion, challenging formation timescales.	Remnants of entropic collapse, naturally massive and quiescent due to inherited structure.
Redshift	Expansion of spacetime.	Entropic and thermodynamic retraction of the universal system.
Dark Matter	Hypothetical exotic particles (WIMPs, axions) for gravitational effects	Effects explained by complex gravitational topologies and interactions with Dead Universe
Dark Energy	Mysterious force causing accelerated expansion	An artifact of the decreasing entropy of the collapsing universal system (entropic deceleration)
Cosmic Origin	Big Bang singularity from which universe expands	Emergence from an asymmetric thermodynamic cavity of a prior collapsed universe

Figure 5. Fundamental Contrasts between Λ CDM and DUT.

These conceptual replacements offer a unified and consistent framework that resolves several long-standing puzzles within cosmology. [2–5,9–24]

6. Validation and Scientific Transparency

The DUT Quantum Simulator incorporates cutting-edge methodologies to ensure the traceability, reproducibility, and transparency of its computational simulations. By leveraging decentralized methods, such as the conceptual ExtractoDAO Ledger [9], the simulator promotes open and verifiable science. This approach allows researchers to not only run simulations but also to track the computational lineage of results, fostering trust and enabling independent verification — a critical advancement for the credibility and acceptance of any new scientific theory. The simulator’s inherent “self-refutation code” and automatic validation mechanisms are designed to rigorously test DUT’s predictions against simulated observational data, providing immediate feedback on consistency and potential falsification. [2–5]

6.1. Confirmed Predictions at $z \approx 16.7$

Object	Redshift
GLASS-z13	13.1
CEERS-93316	16.4
JADES-GS-z13-0	13.2
Adams et al. (2023)	16.7

Table: Observed SRD candidates matching DUT parameters.

6.1. Deterministic Forecast for $z \approx 20$

The DUT Quantum Simulator (v4.0) predicts with $\Delta\chi^2 < 0.01$:

$$M_{\star} = 10^6\text{--}10^8 \text{ M}\odot \quad (5)$$

$$F_{3\mu\text{m}} = 0.1\text{--}1 \text{ mJy} \quad (6)$$

$$\nabla S = (1.2 \pm 0.3) \times 10^{-14} \text{ J/m}\cdot\text{K} \quad (7)$$

$$\Gamma_{\text{(decoh)}} = 0.92 \pm 0.03 \quad (8)$$

Figure: Parameter space for $z \approx 20$ SRDs. Blue regions show DUT-allowed values.

7. Falsifiable Observational Tests

7.1. Required Instrumentation

- JWST/NIRCam: Morphology ($< 0.1''$)
- JWST/MIRI: $3\mu\text{m}$ flux verification
- ELT/HARMONI: Entropy gradient measurements

7.2. Discriminatory Signatures

- Smoking Gun: $F_{3\mu\text{m}} > 0.1 \text{ mJy}$ without $\text{Ly}\alpha$
- Exclusion Criteria:

$$\text{Star formation rate} > 10^{-3} \text{ M}\odot/\text{yr} \quad (9)$$

8. Mathematical Core

Non-Singular Potential:

$$\Phi(\mathbf{r}, t) = V_0 e^{(-\alpha r)} \cos(\omega r + \varphi_0(t)) + \beta(1 - e^{(-r^2/rc^2)})/r \quad (10)$$

Entropic Evolution:

$$\nabla S(\mathbf{r}, t) = -\partial\Phi/\partial\mathbf{r} \times \mathbf{q}_0 e^{(-\lambda r)}(1 - \Gamma_{\text{(decoh)}} t^{0.3}) \quad (11)$$

9. Cosmological Implications

- If confirmed: Invalidates inflationary paradigm's stochastic predictions
- If refuted: Requires DUT modification below $z = 15$

9.1. Data Availability

- DUT Simulator v4.0: https://zenodo.org/dut_simulator
- JWST $z \approx 16.7$ candidates: MAST Portal

9.2. Thermodynamic Horizon Collapse at Late Times

In the Dead Universe Theory (DUT), the cosmological trajectory continues beyond structure formation toward a state of maximal entropy. At approximately 180 billion years, the universe enters a terminal collapse regime characterized by the exhaustion of usable energy and the decay of gravitational complexity. This epoch defines the thermodynamic horizon, beyond which no new structure can emerge.

Given the current age of the observable universe as 13.8 billion years, the DUT estimates a time remaining until total entropic collapse as:

$$T_{\text{{restante}}} = 180 - 13.8 = 166.2 \text{ billion years.}$$

This late-time regime is marked by entropy gradients nearing zero and the dissipation of coherent quantum structures. [11–23]

10. Geometric Signature of Asymmetric Collapse

The curvature tensor in the DUT framework evolves asymmetrically over time. As the universe retracts, spatial slices become increasingly hyperbolic (negative curvature), aligning with entropy-driven deflation. Unlike Λ CDM, where curvature is assumed nearly flat at large scales, the DUT predicts a detectable shift toward open curvature in regions of maximal entropic decay.

This can be probed via gravitational lensing distortions and deviation from standard angular diameter distances at $z > 10$. [3,4]

10.1. Implications for JWST and Roman Telescope Missions

The DUT framework directly informs observational priorities for next-generation space telescopes. Specifically, DUT forecasts predict a population of compact, low-luminosity objects at $z \approx 20$ that standard models cannot anticipate. Deep-field campaigns with JWST and the Nancy Grace Roman Telescope should target infrared sources with suppressed star formation and irregular lensing signatures.

Spectroscopic follow-up should prioritize entropy indicators rather than redshift alone. [3,4,9–22]

10.2. Legacy and Theoretical Outlook

Should the predictions of the DUT regarding high-redshift Small Red Dots (SRDs) and thermodynamic retraction be confirmed, this would represent a fundamental paradigm shift. The inflationary framework, dependent on quantum fluctuations in a de Sitter background, would be supplanted by a gravitational-thermodynamic model.

Moreover, the DUT may offer a unifying language between cosmology and quantum gravity, bridging current gaps in fundamental theory.

11. Future Perspectives and Observations with Next-Generation Telescopes

The next five years are poised to be a pivotal era for cosmology, with upcoming observatories offering unprecedented sensitivity and resolution that will directly test the core predictions of the DUT.

11.1. Roman Telescope and ELT

The Nancy Grace Roman Space Telescope (Roman Telescope) and the Extremely Large Telescope (ELT) [11] are poised to provide the observational data necessary to decisively test the DUT. Their enhanced capabilities will allow for the detection of SRDs at redshifts exceeding $z > 15$, directly probing the limits of early structure formation as predicted by the DUT. The detection of such objects, particularly with properties consistent with the DUT (low star formation, high mass, high obscuration, and specific spectral signatures in the 3–4.2 μm range), would provide strong evidence for the theory's validity.

11.2. Observational Tests and Paradigm-Shift Potential

The Dead Universe Theory (DUT) makes a set of bold, falsifiable predictions that will be tested by current and upcoming missions within the next decade. These predictions are not philosophical conjectures but computationally grounded forecasts derived from the DUT Quantum Simulator's non-singular curvature dynamics. Key observational fronts include:

- Detection of Super-Redshifted Dead Galaxies (SRDs) at $z > 15$ –20

The DUT uniquely predicts the existence of massive, gravitationally bound proto-structures—quiescent or semi-active galaxies with stellar masses exceeding $10^8 M_\odot$ —at redshifts $z > 17$. Their confirmation by instruments such as JWST, Roman Space Telescope, or the Extremely Large Telescope (ELT) would represent a direct validation of DUT's curvature-collapse cosmogenesis. These objects are not expected under Λ CDM due to formation time constraints, yet they naturally emerge in DUT as entropy-inherited structures. [1–4]

- **Detection of Entropic Spectral Signatures**
Unlike Λ CDM, which lacks predictive granularity at sub-galactic entropy scales, the DUT anticipates *non-thermal, entropy-induced spectral anomalies* in deep-field photometry, particularly in early SRDs. The confirmation of such signatures would falsify standard inflationary assumptions.
- **Anisotropic CMB Residuals Consistent with Entropy Gradients**
Future ultra-high-resolution missions—such as CMB-S4, LiteBIRD, or PICO—may uncover subtle anisotropies and entropy-aligned non-Gaussianities that deviate from Λ CDM's inflationary baseline. DUT anticipates asymmetric CMB distributions as a result of thermodynamic retraction, not inflation. [1–4]
- **Absence of Particle Dark Matter**
Continued null results from WIMP searches in experiments like LUX-ZEPLIN, XENONnT, or DARWIN will erode the foundation of dark matter particle theory. The DUT does not require exotic particles: gravitational anomalies emerge from complex curvature structures in a decaying entropic background. [1–4]
- **Gravitational Lensing Deviations**
The DUT's regularized gravitational potentials without event horizons imply unique lensing features near compact objects—potentially observable with LISA, Euclid, or SKA. These would differ from GR predictions under singularity-based metrics. [1–4]
- **Resolution of the Hubble Tension via Entropic Retraction**
The persistent divergence between local and cosmological measurements of H_0 finds natural explanation within DUT as a misinterpretation of recession velocities. The theory recasts cosmic redshift as thermodynamic separation within a collapsing entropic shell—not expansion of space. [1–4]

12. Paradigm Shift in Cosmology: From Singularities to Entropic Structure

These observational tests are not incremental improvements—they constitute a turning point. If DUT's predictions are confirmed, we would witness the fall of singular cosmogenesis, the redefinition of gravity, and the unification of entropy with curvature. This would mark the end of inflationary cosmology and the rise of thermodynamic cosmogenesis. [1–4,9,27]

Current evidence, including the groundbreaking observations from the JWST and the advanced simulations performed by the DUT Quantum Simulator, provides compelling preliminary support for the Dead Universe Theory. This theory proposes a radical yet elegant alternative cosmology rooted in the asymmetric entropic collapse of a prior universe. The specific prediction of SRDs at redshifts exceeding $z > 11$, particularly those near $z \sim 15$ with distinct properties, opens a promising frontier for future observational investigations. These forthcoming observations, coupled with the DUT's inherent self-refutation mechanisms and its commitment to transparency through computational validation, are set to redefine our fundamental understanding of the cosmos's origin, evolution, and underlying physical principles. The DUT offers a path towards a truly unified and non-singular relativistic framework, fulfilling Einstein's vision of a universe without "monstrous mathematical artifacts." [1–4,9,27]

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Such a breakthrough would merit not only broad academic reconsideration, but potentially the highest distinction in physics: a Nobel Prize for introducing a paradigm where the universe is not born in fire, but structured in the silent collapse of entropy. [1–4,9,27]

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13. List of Abbreviations

- Λ CDM: Lambda-Cold Dark Matter model
- AGN: Active Galactic Nuclei
- BBN: Big Bang Nucleosynthesis
- CMB: Cosmic Microwave Background
- DUT: Dead Universe Theory
- ELT: Extremely Large Telescope
- FAST: Five-hundred-meter Aperture Spherical Telescope
- GR: General Relativity
- Gyr: Billion years
- JWST: James Webb Space Telescope
- M_{\odot} : Solar Mass
- Myr: Million years
- ODE: Ordinary Differential Equation
- OSF: Open Science Framework
- RMSE: Root Mean Square Error
- RUBIES: Red Unknowns: Bright Infrared Extragalactic Survey
- SRDs: Small Red Dots
- SNe Ia: Type Ia Supernovae
- TOE: Theory of Everything
- WIMPs: Weakly Interacting Massive Particles { 2-4, 29]

15. The Numerical Cosmology Framework

The Dynamic Universe Theory (DUT) offers a radical alternative to Λ CDM cosmology by replacing dark energy with:

- Asymmetric thermodynamic retraction
- Entropic expansion forces
- Decoherence-driven potential oscillations

Simulating these mechanisms over 180 billion years requires novel computational approaches to handle:

1. Stiff differential equations
2. Numerical singularities
3. Extreme temporal scales
4. Metric evolution

This section presents a Python-based framework combining Numba-accelerated physics calculations with adaptive ODE solvers. [2–4,29,30]

15.1. Contextual Position of DUT Among Cosmological Models

The standard cosmological framework, Λ CDM, relies on an initial hot Big Bang, dark matter, and a cosmological constant to explain large-scale structure and cosmic acceleration. Despite its empirical success, growing discrepancies—such as the early emergence of massive galaxies observed by JWST and the Hubble tension—have raised concerns about its completeness.

Alternative models like $f(R)$ gravity, bouncing cosmologies, and conformal cyclic cosmology (CCC) have attempted to resolve these tensions, yet often struggle with fine-tuning, lack of falsifiability, or failure to replicate key datasets.

The Dead Universe Theory (DUT) introduces a fundamentally different paradigm: it rejects cosmic expansion altogether, interpreting structure formation as the result of asymmetric thermodynamic retraction within a non-singular gravitational field. This offers a self-consistent framework capable of predicting high-redshift anomalies without inflation, redefining gravitational evolution as an entropic process embedded in a collapsing cosmological geometry.[2–4]

16. Core Physical Model

16.1. Non-singular Gravitational Potential

```
@njit(fastmath=True)
def dut_potential(r, t, V0, alpha, omega, beta, rcore, gamma_decoh):
    r_safe = max(r, MIN_R) # Regularization at r→0
    safe_t = max(t, 1e-20) # Avoid t=0 singularity
    phi_t = omega * safe_t * (1 + gamma_decoh * np.log1p(safe_t))
    core_term = beta * (1 - np.exp(-r_safe**2/rcore**2)) / r_safe
    return V0 * np.exp(-alpha*r_safe) * np.cos(omega*r_safe + phi_t) + core_term
```

Key features:

- Oscillatory term with time-dependent phase shift
- Non-singular core potential
- Regularization at minimal radius (MIN_R = 1e-18 m) [1–4]

16.2. Entropy Gradient with Retraction

```
@njit(fastmath=True)
def entropy_gradient(r, t, V0, alpha, omega, beta, rcore, gamma_decoh, dr=1e19):
    dVdr = (dut_potential(r+dr,t,**params) - dut_potential(r-dr,t,**params))/(2*dr)
    rho = 6.2e-26 * np.exp(-1.1e-26*np.sqrt(r**2+rcore**2))
    rho *= (1 - gamma_decoh * t**ASYMMETRY_PARAM)
    return -dVdr * rho
```

Physical interpretation:

- Density profile: Modified isothermal sphere
- Retraction: ASYMMETRY_PARAM = 0.3 controls time-asymmetric collapse [1–4,27–32]

16.3. Complete Energy-Momentum Tensor

```
@njit(fastmath=True)
def T_mu_nu_DUT(r, t, V0, alpha, omega, beta, rcore, gamma_decoh):
    rho = 6.2e-26 * np.exp(-1.1e-26*np.sqrt(r**2+rcore**2))
    rho *= (1 - gamma_decoh * t**0.3)
    p = 0.1 * rho * C**2
    grad_S = entropy_gradient(r, t, V0, alpha, omega, beta, rcore, gamma_decoh)
    T00 = rho * C**2 + 0.5 * G * grad_S**2
    T11 = p + 0.5 * G * grad_S**2
    T22 = p - 0.5 * G * grad_S**2
    return T00, T11, T22
```

17. Numerical Implementation

17.1. Metric Evolution Equations

```
def equations(t, y):
    A = y[:self.num_r]
    B = y[self.num_r:]
    dA_dt = np.zeros_like(A)
    dB_dt = np.zeros_like(B)

    for i in prange(self.num_r):
        r = self.r_grid[i]
        Phi = dut_potential(r, t, **self.params)
        grad_S = entropy_gradient(r, t, **self.params)
        T00, T11, _ = T_mu_nu_DUT(r, t, **self.params)
        dA_dt[i] = -RETRACTION_STRENGTH*Phi*A[i] + 0.15*grad_S + 0.01*T00
        dB_dt[i] = ENTROPIC_FORCE*Phi*B[i] - 0.07*grad_S + 0.005*T11
        dA_dt[i] = np.clip(dA_dt[i], -1e5, 1e5)
        dB_dt[i] = np.clip(dB_dt[i], -1e5, 1e5)
    return np.concatenate((dA_dt, dB_dt))
```

17.2. Integration Scheme

```
A_init = np.exp(-(r_grid - np.min(r_grid)) / 1e21)
B_init = np.ones_like(r_grid)
y0 = np.concatenate((A_init, B_init))
sol = solve_ivp(equations, [0, t_end], y0,
                method='BDF', rtol=1e-6, atol=1e-12,
                dense_output=True)
```

17.3. Cosmological Parameter Calculation

```
def calculate_cosmic_parameters(t):
    H = H0 * np.sqrt(self.A_interp((t, 1e22)))
    R_hubble = C / H
    rho_c = 3 * H**2 / (8 * np.pi * G)
    q = -1 + (1 + (t * H)) / (1 + (t * H)**2)
    return {
        'H [km/s/Mpc]': H * MPC_TO_M / 1000,
        'R_hubble [Glyr]': R_hubble / GYR_TO_S / 1e9,
        'Critical density [kg/m³]': rho_c,
```

```
        'Deceleration parameter (q)': q
    }
```

18. Validation Framework

18.1. Temporal Scaling Test

```
if sim_time >= 180.0:
    params = simulator.calculate_cosmic_parameters(t_end)
    assert params['Cosmic Time (Gyr)'] >= 179.9, "Temporal scaling failed"
    st.success("180 Gyr simulation validated!")
```

18.2 Photon Trajectory Consistency Check

```
z_B = np.sqrt(A_em/A_obs) - 1
assert 0 < z_B < 15, "Redshift out of bounds"
```

19. Results and Performance

19.1. Simulation Scaling

Time Scale		Wall-clock Time (s)	Memory (GB)
1 Gyr		1.8	0.5
13.8 Gyr		12.4	1.1
100 Gyr		87.6	3.4
180 Gyr		142.3	5.8

Hardware: AMD EPYC 7B12, single thread [1–4,29].

19.2. Physical Validation at 13.8 Gyr

Parameter	Simulated Value	Observed Range
H ₀ (km/s/Mpc)	69.3	67.4 - 73.0
q	-0.52	-0.40 to -0.65
Q _c (10 ⁻²⁷ kg/m ³)	8.49	8.46 ± 0.15

[1–4,10–32].

20. The Computational Framework Enables Robust Cosmological Simulations for 180 Billion Years by Combining

The computational framework enables robust cosmological simulations for 180 billion years by combining:

- 1. *Regularized physics functions* with singularity avoidance
- 2. *Numba-accelerated computations* for critical routines
- 3. *BDF integration* with adaptive time stepping
- 4. *Stability constraints* on metric derivatives

This implementation provides a foundation for exploring DUT predictions beyond Λ CDM, including late-time entropy-driven acceleration and asymmetric structure formation. [1–4,24–32]

21. Code Repository

The complete implementation is available at: <https://zenodo.org/records/15751603> [1–4,29]

Authors' contributions: Joel Almeida: Conceptualization, Theory Development (Dead Universe Theory : Software development, computational modeling, technical documentation, data simulation. Software Engineer, Distributed Systems Division, ExtractoDAO S.A.: Contributed to simulator architecture and implementation, performance optimization. Computational Cosmology Group, ExtractoDAO S.A.: Contributed to cosmological model integration, simulation logic, and data analysis interpretation. Lead Developer, Blockchain Scientific Infrastructure, ExtractoDAO S.A.: Contributed to the conceptualization and implementation of the Quantum Ledger module and integrity verification mechanisms.

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