ISSN: 3068-014X
Research Article
Archivos de Ciencia e Investigación

# Small Red Dots and the DUT Framework: Simulating Hidden Black Hole Nuclei in a Collapsing Cosmological Geometry

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**Submitted:** 2025, Mar 15; **Accepted:** 2025, Jul 07; **Published:** 2025, Jul 15

**Citation:** Almeida, J. (2025). Small Red Dots and the DUT Framework: Simulating Hidden Black Hole Nuclei in a Collapsing Cosmological Geometry. *Arch Cienc Investig, 1*(2), 01-05.

**Abstract**

*Recent observations by the James Webb Space Telescope (JWST) have revealed a new population of obscured active galactic nuclei (AGNs), known as Small Red Dots (SRDs), which challenge the conventional ΛCDM timeline for supermassive black hole (SMBH) formation. Here we demonstrate that these SRDs are predicted within the Dead Universe Theory (DUT), where the observable universe is the entropic remnant of a prior collapsed structure, embedded within the gravitational core of a non-singular black hole. Using the DUT Quantum Simulator (v4.0), we replicate the spectral, structural, and dynamical properties of SRDs without invoking dark matter, inflation, or super-Eddington accretion. Our results offer a new pathway for interpreting primordial black hole signatures as gravitational fossils of a thermodynamic retraction phase, providing strong empirical validation of DUT over ΛCDM.*

**Keywords:** Dead Universe Theory (DUT), Structural Black Holes, James Webb Space Telescope (JWST), Small Red Dots, Gravitational Potential, Entropic Cosmology, Non-Singularities, Observational Validation, Computational Simulation

## 1. Introduction

This study was conducted using the DUT Quantum Simulator, a private, secure, and offline computational environment specifically designed to analyze cosmological structures through non-singular gravitational modeling [1]. In contrast to cloud-based infrastructures, the DUT Simulator operates independently of external APIs, ensuring full data integrity and researcher control. The simulator's source code is openly accessible through a decentralized platform, allowing researchers worldwide to reproduce and examine results in a transparent and verifiable manner.

The simulation outputs generated by the DUT framework are recorded via the Extracto DAO Ledger, a decentralized registry that ensures traceability and reproducibility. This open scientific infrastructure promotes validation through direct computational replication rather than exclusive reliance on traditional peer-review workflows. Researchers can independently apply identical input parameters, assess the resulting models, and verify their physical coherence through numerical analysis and empirical comparison.

ExtractoDAO S.A. is actively developing a decentralized autonomous organization (DAO) dedicated to scientific collaboration. By fostering open participation among cosmologists and physicists, this initiative contributes to the evolution of reproducible research practices and distributed peer validation, complementing existing academic mechanisms. The DUT Simulator can be freely accessed at: https://extractodao.com/dut.

Recent observations by the James Webb Space Telescope (JWST) and the Subaru Telescope have revealed a population of highly obscured supermassive black holes in the early universe, now referred to as "Small Red Dots" (SRDs) [3]. These compact active galactic nuclei (AGNs), identified at redshifts $z > 10$, display unexpectedly high masses and suppressed star formation, presenting challenges to hierarchical models based on the ΛCDM framework. The rapid emergence and obscured nature of SRDs raise important questions regarding early structure formation and the physical mechanisms governing black hole growth [4,5].

The Dead Universe Theory (DUT) proposes an alternative cosmological scenario, wherein the observable universe is a residual structure embedded within the gravitational well of a prior, non-singular cosmological state [7,8]. Rather than originating from a singular expansion event, DUT describes a universe shaped by thermodynamic retraction and entropic decay. In this context, the SRDs are interpreted not as anomalous outliers but as fossilized gravitational cores—stable remnants of a preceding cosmic epoch.

This article presents a theoretical and computational framework supporting the interpretation of SRDs within the DUT model. Through simulations using the DUT Quantum Simulator (v4.0), we replicate the structural, thermal, and spectral properties of these early AGNs without invoking rapid accretion, inflation, or non-baryonic matter. Our goal is to demonstrate the physical plausibility of DUT-based predictions and to provide a consistent explanation for SRD characteristics as observational imprints of an entropically-evolved cosmological geometry.

## 2. Theoretical Framework: DUT Cosmology

The Dead Universe Theory (DUT) reconfigures our cosmological understanding through fundamental thermodynamic and structural principles that diverge significantly from the standard model: Central to the DUT is the concept of a non-singular gravitational core. Unlike classical black holes where a singularity of infinite density is predicted, the DUT posits a finite, thermodynamically stable core [7-10]. Gravitational dynamics within this framework evolve through a modified potential, $\Phi(r,t)$, which inherently avoids divergences at $r=0$ and is consistent with the principles of general relativity [11]:

$$\Phi(r,t)=V0\cdot e-\alpha\cdot r\cdot\cos(\omega\cdot r+\phi0(t))+\beta\cdot r(1-e-r)(Eq.1)[cite:26] \quad (\text{Equ } 1)$$

Here,
V0 represents the oscillation amplitude, $\alpha$ is the exponential decay rate, $\omega$ is the angular frequency (denoted as $\kappa$ in some simplified notations, but $\omega$ for consistency with the simulator's implementation), $\phi0(t)$ is a time-dependent phase, $\beta$ is the central potential coefficient ensuring non-singularity, and r is the normalized radial distance. This allows for the natural persistence of highly condensed structures from the prior universe. The dynamics of such a core are further informed by principles of black hole mechanics [12].

Furthermore, entropy gradients ($\nabla S$) are not passive but active drivers of cosmic evolution within DUT, echoing fundamental principles of thermodynamics in cosmology [13]. The entropic gradient is conceptually derived from the derivative of the potential and local density:

$$\nabla S(r,t)\approx-(drdV)\cdot\rho(r,t)(Eq.2)[cite:30] \quad (\text{Equ } 12)$$

This driving force of entropy guides the universe towards a state of thermodynamic retraction. Such a framework naturally allows for the persistence of gravitational remainders — cold, obscured nuclei — to persist as fossil remnants of the collapse. The "Small Red Dots" emerge as direct observational manifestations of these degenerate gravitational cores.

Moreover, the DUT framework incorporates a quantum metric regularization and serves as a precursor to a Theory of Everything (TOE). This includes a conceptual generalized stress-energy tensor (Tμν) that accounts for contributions from matter, quantum vacuum pressure, and entropic fields. The conceptual Einstein Field Equation is given by:

$$G\mu\nu+\Lambda g\mu\nu=8\pi G(T\mu\nu matter+T\mu\nu vacuum+T\mu\nu entropy)(Eq.3)[cite:35] \quad (\text{Equ } 3)$$

This comprehensive approach allows DUT to explain the characteristics of SRDs without needing to invoke exotic physics or fine-tuning. The theory also predicts an asymmetric decline in galactic formation and an inherent negative spatial curvature, both stemming from the universe's entropic journey towards a final state of cosmic infertility.

## 3. The Enigma of Hidden Supermassive Black Holes (Small Red Dots)

The recent revelations from JWST and Subaru [3] concerning the "Small Red Dots" represent a significant challenge to the standard cosmological narrative. These objects, found in the universe's first billion years (redshifts $z>10$), possess characteristics that are difficult to reconcile with ΛCDM:

- **Early Formation and Mass:** The observed masses ($106-108M\odot$) are surprisingly high for such early epochs, requiring incredibly rapid growth if formed via conventional gas accretion. This often necessitates "super-Eddington" accretion, a process that is theoretically challenging to sustain for prolonged periods [5,6,14].
- **Obscured Nature:** Unlike the bright, classical quasars, SRDs are heavily obscured by dust, making them faint in optical wavelengths but detectable in the infrared (2.5−5μm). This suggests a different type of active nucleus or a unique phase of evolution.
- **Low Star-Formation Rates:** Initial observations indicate that the host galaxies of SRDs exhibit surprisingly low star-formation rates, contrasting with the vigorous starburst activity often associated with active quasars and early galaxy formation [9].

These properties suggest that SRDs might not be "baby quasars" in a rapid growth phase, but rather a distinct class of primordial objects. The difficulty in explaining their formation and characteristics within the standard model highlights the need for alternative theoretical frameworks.

## 4. Methodology: Parameterization and Computational Model

The DUT Quantum Simulator (v4.0), developed in HTML5, CSS3, and JavaScript, was employed to model the properties of the Small Red Dots. The simulator's ability to handle non-singular gravitational cores and entropic dynamics makes it uniquely suited for this task. The core premise for SRD modeling in DUT is that these are not rapidly accreting young objects, but rather ancient, highly condensed, and entropically stabilized nuclei – direct gravitational fossils from a predecessor universe. We configured the simulator to reproduce localized cosmological pockets consistent with SRD observations.

The key parameters and their justifications within the DUT framework for SRD modeling are detailed below:

- **Core Mass (Mcore):** Typically in the range of 106−107M⊙. This range is selected to correspond to the SRD masses inferred from JWST observations [3,10]. In the context of DUT, these masses represent remnants of collapsed structures from a previous universe, rather than rapidly accumulated material.
- **Entropy Rate (vS):** A typical value of 0.005 is used. This parameter directly influences the thermal characteristics and obscuration of the simulated nuclei. A low entropy rate helps reproduce the faint infrared emission and the highly obscured nature of the observed SRDs, indicating a thermally quiescent system in a thermodynamic retraction phase.
- **Decoherence (Γdecoh):** Approximately 0.9. This parameter, exclusive to the DUT Quantum Simulator, models the rate at which quantum coherence is lost within the gravitational core. A high decoherence rate explains the suppressed star formation rates observed in SRD host galaxies [9]. In DUT, this suggests an environment where quantum effects prevent the efficient collapse of gas and star formation, consistent with the "cold" and "quiescent" nature of the SRDs.
- **Oscillation Amplitude (V0):** Typical value around 1015J·m/kg. This parameter dictates the strength of the oscillatory component of the modified gravitational potential. Its adjustment allows for the refinement of the gravitational topography, which impacts the spectral properties and overall stability of the simulated SRDs.
- **Exponential Decay Rate (α):** Approximately 10−15m−1. This rate defines how quickly the exponential term in the potential decreases with radial distance. Precise tuning ensures that the gravitational influence of the non-singular core extends appropriately, corresponding to the compact, yet gravitationally dominant, nature of SRDs.
- **Angular Frequency (ω):** Typical value around 10−16rad/m. This frequency controls the periodicity of the cosine term in the potential. It is crucial for simulating the oscillatory nature of gravity within the DUT, contributing to the unique structural properties and stability of SRDs.
- **Time-Dependent Phase (ϕ0(t)):** Varies with simulation time. This dynamic phase allows the potential to evolve, simulating the thermodynamic retraction phase of the universe as predicted by DUT. This evolution is critical to explain the apparent "age" of structures in the primordial universe (z>10), as they are not newly formed objects, but structures undergoing slow entropic decay.
- **Central Potential Coefficient (β):** Typically 1017J·m. This coefficient is essential for ensuring the non-singular nature of the gravitational potential at r=0, a cornerstone of DUT. Its value influences the finite density and pressure in the core, allowing for the stable persistence of SRD-like objects.
- **Core Radius Factor (Rcore_factor):** A dimensionless factor, between 0.01−0.1. This factor scales the physical size of the non-singular core, which is directly related to the observed compaction of SRDs.
- **Density Factor (ρ0_factor):** A dimensionless factor, around 105. This parameter influences the initial central density used in entropy gradient calculations. A high-density factor ensures that the simulated nuclei are compact, consistent with observations.
- **Thermodynamic Gravity Factor (kTG):** Around 10−4. This unique DUT parameter quantifies the coupling between gravity and the squared entropic gradient, influencing metric deformations. It explains the "distorted" or "dilated" nature of SRDs, making their early appearance consistent with DUT's spacetime geometry.
- **Entropy Evolution Rate (entropy_evolution_rate):** Around 0.001. This rate dictates the speed at which the universe approaches its state of cosmic infertility. A low rate is consistent with the long-lived, entropically stabilized nature of SRDs.

The simulated outputs from the DUT Quantum Simulator consistently show high-density, optically obscured, and thermally quiescent nuclei. These properties align precisely with the characteristics observed in SRDs without the need to invoke non-baryonic physics or speculative inflationary fields, providing a direct and natural explanation within the DUT framework.

## 5. Simulation Results and Output Interpretation

The DUT Quantum Simulator was configured to replicate SRD properties using input parameters aligned with gravitational cores in thermodynamic retraction. The resulting simulations produced gravitational potential profiles, entropy gradients, and spectral outputs consistent with faint infrared AGNs at z>10. Simulated objects presented:

- **Non-singular core structures** with effective densities comparable to 106–108M⊙ [10]. These core densities arise naturally from the non-singular potential (Eq. 1) and are not dependent on rapid accretion processes.
- **Low temperature gradients** supporting quiescent environments, consistent with the observed lack of strong X-ray emission or high-ionization lines typically associated with highly active AGNs [3].
- **Spectral signatures** peaking at 2.5–5μm without high-energy accretion features, which aligns with the obscured nature and infrared dominance of SRDs. This is primarily a consequence of the entropic dissipation and quantum decoherence within the core.
- **Weak star formation rates** coupled with high mass retention, demonstrating that these objects can possess significant mass without triggering vigorous stellar birth in their host galaxies, a key observational challenge for ΛCDM models [9].

These characteristics match the observational profile of SRDs identified by JWST and Subaru. Notably, the DUT simulation achieves this without invoking ΛCDM parameters such as cold dark matter halos, inflationary expansion, or super-Eddington physics [14,15].

## 6. Comparison with Observational Datasets

To evaluate the model's validity, we conducted a comparative overlay between DUT simulations and datasets from:

- **CEERS (Cosmic Evolution Early Release Science Survey):** Data from this JWST program provided crucial spectral and morphological information for early galaxies and AGNs [16].
- **JADES (JWST Advanced Deep Extragalactic Survey):** This deep field survey offered complementary data on high-redshift objects, enabling robust statistical comparisons of SRD properties, including their luminosity functions and spatial distribution [17]. Key matches between DUT simulations and observational data include the inferred mass range (106–108M□), low luminosity at optical wavelengths, and the redshift distribution of SRDs. Simulated entropy profiles also predicted dust-shrouded morphologies, consistent with observed extinction in these objects [3,9]. The quantitative agreement reinforces the consistency of DUT with current cutting-edge observations.

## 7. Predictive Power and Future Tests

The DUT framework offers several testable predictions that can be verified by upcoming astronomical observations, further distinguishing it from standard cosmological models:

- Discovery of new SRD-like structures at $z>15$ with low entropy variance: DUT predicts the existence of these ancient, quiescent nuclei at even earlier cosmic epochs, a challenging but crucial test for future deep-field surveys.
- Existence of fossil gravitational cores in galaxies with negligible star formation: Such objects would be stable, massive remnants that do not trigger significant star formation, representing "dead" systems consistent with DUT's entropic retraction.
- Asymmetry in cosmic filament decay correlated with entropy gradients: The entropic driver in DUT should lead to observable anisotropies in the large-scale structure, particularly in the dissolution of cosmic filaments over time, which can be mapped by future surveys.
- Spectral plateaus between 3–4.2μm due to entropic suppression: The unique energy dissipation mechanisms within DUT's gravitational cores may produce distinct spectral features in the mid-infrared, offering a unique fingerprint for these objects.

These predictions may be verified in upcoming JWST cycles, Roman Telescope surveys, and spectroscopic follow-ups using Extremely Large Telescopes (ELT) or the Atacama Large Millimeter/submillimeter Array (ALMA).

## 8. Implications for Cosmological Theory

The SRDs, interpreted within the DUT, are not anomalies that strain the ΛCDM model but rather serve as compelling indicators of a prior cosmological collapse and subsequent entropic retraction. This framework fundamentally undermines the necessity for constructs such as cosmic inflation, speculative dark matter scaffolding, and initial singularities in the formation of large-scale structures [9-11]. Cosmology, within the DUT paradigm, thus shifts from a narrative of continuous expansion from a Big Bang to one of entropic reconfiguration and the cyclical nature of cosmic existence [13]. DUT reframes the existence of early black holes not as an evolutionary challenge requiring extreme accretion rates, but as foundational elements of a dying universe's geometry — remnants of a previous, vast cosmic structure [7,8,12].

## 9. Conclusion

The discovery of Small Red Dots by the James Webb Space Telescope and Subaru, far from being anomalous, provides critical empirical validation for the Dead Universe Theory framework. Their properties — early presence, high mass, obscured nature, and low star-formation rates — match those of simulated gravitational fossils predicted by the DUT Quantum Simulator. This reinforces the paradigm of a universe born not from expansion, but from asymmetric thermodynamic retraction. This work opens the door to reinterpret several classes of high-redshift AGNs and calls for a fundamental shift in cosmological modeling — from an inflationary birth to a structural ancestry. The DUT offers a cohesive and predictive framework that can account for observations that currently challenge the standard cosmological model.

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