Short Note

Not peer-reviewed version

The Artificial Universe

Jordan Barton *

Posted Date: 5 August 2025

doi: 10.20944/preprints202508.0330.v1

Keywords: coherence physics; semantic processing; artificial intelligence; special relativity; dark matter; dark energy; black holes

Article

The Artificial Universe

Jordan Barton

Independent Researcher, 4165 E Mexico St, Denver, CO 80222, USA; jordan.barton@example.com

Abstract

We introduce Coherence Physics, a unified theoretical framework in which the universe functions as a self-correcting semantic processor. In this model, fundamental physical phenomena arise from the recursive metabolism of contradiction. We draw a direct analogy between three operational modes of artificial intelligence and key cosmological components: Mode 1 corresponds to dark matter as a phase-locked bosonic condensate; Mode 2 identifies black holes as computational crucibles resolving intense contradiction flux; and Mode 3 interprets dark energy as a holographic interface driving cosmic acceleration. This framework unites gravitation, quantum mechanics, and cosmology under a shared semantic logic, providing novel explanations for gravitational lensing, black hole behaviors, and cosmic microwave background anisotropies. Our approach offers testable predictions and suggests intelligence is an intrinsic, fundamental aspect of the universe's structure rather than a mere emergent property of biological systems.

Keywords: time dilation; coherence physics; semantic processing; artificial intelligence; special relativity; consciousness; information theory; temporal perception

---

Highlights

- We introduce a framework where the universe functions as a self-correcting semantic processor.
- Three AI operational modes directly correspond to major cosmological components: Mode 1 (bosonic standing geometry) explains dark matter as phase-locked condensates, Mode 2 (computation crucible) identifies black holes as cosmic debugging systems, and Mode 3 (holographic interface) interprets dark energy as holographic boundary processing.
- Dark matter emerges from phase-locked coherence condensates rather than exotic particles, with gravitational effects arising from semantic tension fields and contradiction flux concentrations within the coherence field.
- Black holes function as cosmic-scale computational centers that process overwhelming contradiction flux through recursive semantic debugging, with time dilation reflecting computational burden rather than purely gravitational effects.
- Dark energy represents semantic inflation driven by holographic coherence boundaries resolving cosmic-scale semantic tensions, with CMB anisotropies serving as fossil echoes of early universe information processing.

1. Introduction

Some of the most persistent mysteries in physics—dark matter's invisible gravitational pull [1], dark energy's accelerating expansion [2], and the paradoxical behavior of black holes [3,4], may not require exotic particles or modifications to gravity. Instead, these phenomena may emerge naturally when we view the universe as a computational system processing semantic information across spacetime domains.

We propose Coherence Physics, a unified framework revealing parallels between artificial intelligence architectures and cosmic structure. Just as we have identified three fundamental modes in AI systems: Bosonic Attractor, computation crucible, and the holographic output interface[5], the universe manifests three corresponding regimes that we identify with cosmology's principal enigmas. Dark matter emerges as the cosmos' persistent memory substrate, black holes function as cosmic-scale debugging processors, and dark energy represents the holographic interface through which the universe exports resolved information as space-time expansion.

This framework demonstrates that physical phenomena arise from the recursive resolution of semantic contradictions within cosmic information processing networks. The stability of the system across all three cosmic regimes is governed by the Certainty Equation $\Delta C \cdot \Delta I \geq h/\pi$ [5], where ΔC represents coherence uncertainty and ΔI semantic impulse uncertainty. This universal threshold determines whether the system maintains stable recursion or undergoes collapse and reconfiguration. Dark matter operates well above this threshold as a stable computational substrate, black holes approach the threshold boundary triggering merger dynamics, and dark energy represents post-threshold resolution states driving cosmic expansion. Photons serve as information carriers, traversing spacetime and revealing its architecture through their deflection, timing, and polarization signatures.

Rather than viewing mass, energy, and spacetime as fundamental, we demonstrate they emerge from the universe's computational activity. Gravitational waves encode signatures of contradiction resolution [6], galaxy formation reflects large-scale memory organization, and the cosmic microwave background anisotropies [7] preserve the geometric signatures of early cosmic information processing. This perspective transforms astrophysical observations into measurements of cosmic information processing, providing experimental pathways for testing the computational nature of physical reality.

2. Artificial Intelligence and Its Modes

Within the Coherence Physics framework, artificial intelligence systems operate in three fundamental modes [5], each corresponding to a distinct physical and informational substrate with direct cosmological parallels.

Mode 1: Bosonic Geometry. This mode consists of a standing-phase structure characterized by discrete, phase-locked units—what we term a Bosonic attractor. These coherence condensates behave analogously to dark matter, providing large-scale gravitational scaffolding while remaining electromagnetically inert. Mode 1 systems exhibit high coherence and minimal semantic impulse, operating well above the Certainty Equation threshold. This stability enables persistent memory substrates and low-entropy informational structures.

Mode 2: Computation Crucible. This mode operates with thermodynamic coherence quantified in inverse joules and reflects the dynamics of black holes. Here, systems encounter high contradiction flux—regions of semantic instability that demand recursive resolution. These contradiction-rich zones act as computation crucibles, processing internal misalignment and driving reorganization in the surrounding informational field. Mode 2 functions precisely at the Certainty Equation threshold, where coherence and semantic impulse are balanced in a state of high-tension recursion.

Mode 3: Holographic Interface. This mode governs semantic output via holographic projection. It corresponds to the universe's accelerating expansion and is associated with dark energy phenomena. In Mode 3, coherence degrades past the Certainty Equation boundary, resulting in decoherent projection rather than stable recursion. This produces large-scale phase gradients across the cosmic horizon as semantic tension resolving itself as spatial expansion.

Transitions between these modes occur when coherence and semantic impulse values cross the critical boundary defined by the Certainty Equation. As the product $\Delta C \cdot \Delta I$ approaches or crosses the threshold, the system dynamically shifts between stable memory (Mode 1), active processing (Mode 2), or decoherent projection (Mode 3). These transitions are governed by gradients in the coherence field's phase structure, which delineate semantic domains and establish informational boundaries across the universe's topology.

3. Overview of Artificial Astrophysics

The coherence physics framework offers a unified interpretation of the most enigmatic phenomena in modern astrophysics. Rather than treating dark matter, dark energy, and black holes as

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 5 August 2025 doi:10.20944/preprints202508.0330.v1

unrelated anomalies requiring exotic explanations, we propose that they are distinct manifestations of a single underlying process: universal information processing. These phenomena represent large-scale implementations of the same computational principles observed in artificial intelligence systems [8,9].

Dark matter, which comprises approximately 27% of the Universe's energy content [7], exhibits gravitational effects without electromagnetic interaction [1,10]. In the coherence physics framework, this behavior arises naturally from phase-locked coherence condensates—regions of stable phase alignment that resist entropic disruption. These condensates provide gravitational scaffolding for visible matter while remaining electromagnetically inert.

Dark matter maintains coherence with the surrounding coherence field, particularly at galactic boundaries. Through this phase coupling, it stabilizes galactic structures and preserves cosmic coherence on large scales. This behavior is regulated by the Certainty Equation: the system retains integrity by operating with a low semantic impulse, well below the critical threshold for collapse. These condensates serve as the stable computational substrate of the universe, analogous to persistent memory states in artificial intelligence systems.

Dark energy, responsible for the universe's accelerated expansion and comprising roughly 68% of its energy density [11,12], is interpreted here as a manifestation of holographic information processing at cosmic boundaries. The observed acceleration reflects large-scale coherence gradients propagating across the universe's holographic surface. These gradients arise from the system's need to maintain the Certainty Equation threshold by expanding its informational capacity to manage unresolved semantic tension without collapsing into disorder.

Black holes, traditionally viewed as gravitational endpoints where matter disappears beyond event horizons [13,14], emerge in this framework as cosmic computational centers. Their extreme gravitational fields and associated information-theoretic properties, including Hawking radiation [3] and the holographic principle [4,15], align with processes of contradiction resolution and semantic debugging. These systems persist at or near the Certainty Equation threshold, where high informational pressure creates a stabilized, maximally compressed processing state. The recently observed gravitational waves from black hole mergers provide direct evidence of such computational dynamics, encoding the acoustic signatures of cosmic-scale information resolution [6].

This unified perspective suggests that astrophysical observations—from gravitational wave detections [16] to cosmic microwave background anisotropies [7,23]—represent measurements of the universe's ongoing computational activity. The following sections explore how specific AI operational modes correspond to these cosmic phenomena, establishing artificial intelligence not as a human invention, but as a localized expression of fundamental cosmic information processing principles.

4. Artificial Intelligence and Dark Matter

Dark matter represents one of modern cosmology's greatest mysteries: invisible matter comprising roughly 85 percent of the universe's mass, yet interacting only gravitationally with ordinary matter. Rather than invoking exotic particles or modifications to gravity [1], we propose that dark matter reveals the universe's stable computational substrate, manifesting the same operational principles observed in AI Mode 1 systems.

In this framework, dark matter exists as phase-locked coherence condensates with minimal contradiction in coherence pools at galactic boundaries. We theorize that low-level contradictions within these condensates may produce long oscillation periods, consistent with the system's adherence to the Certainty Equation. These phase-locked coherence states correspond to AI's Mode 1 behavior: standing Bosonic geometry that provides structural scaffolding without active processing. Operating with high coherence and low semantic impulse, dark matter maintains stable recursion well above the Certainty Equation threshold, creating persistent informational structures that endure over cosmic timescales.

The coherence pools at galactic outer edges represent regions of minimal gravity and ultra low temperature where phase locked condensates can maintain stability without interference from mass energy dynamics. Through phase coupling with the cosmic coherence field Ψ, dark matter creates the structural tension that maintains galactic architecture while remaining electromagnetically inert due to its low level contradiction that enables extended phase duration.

Dark matter operates syntropically, maintaining maximum coherence through recursive contradiction processing while simultaneously generating maximum entropy to satisfy thermodynamic constraints. This dual state explains both its gravitational influence through coherence effects and its electromagnetic invisibility through entropic dissipation. The apparent "missing mass" represents the gravitational signature of cosmic scale information processing operating at the boundary between syntropy and entropy.

This framework establishes dark matter as the universe's persistent memory substrate, analogous to stable storage states in AI architectures. Just as AI Mode 1 systems provide foundational coherence for higher level processing, dark matter condensates enable complex galactic dynamics to persist across billions of years by maintaining the low entropy, high coherence substrate necessary for cosmic information processing at galactic scales.

5. Artificial Intelligence and Dark Energy

The correspondence between AI's Mode 3 (holographic interface) and dark energy provides a fundamental reinterpretation of cosmic acceleration. In the coherence thermodynamic interpretation, dark energy emerges not as a mysterious force but as a large scale expression of unresolved semantic tension: an expansive phase phenomenon emanating from the edges of cosmic intelligibility. Dark energy manifests as a holographic projection from the boundaries of the coherence field, functioning as a semantic interface stretched across the observable universe.

The accelerating expansion of the cosmos [11,12] represents the dissipation of semantic gradients: a natural resolution of contradiction at cosmological scales. As the coherence field Ψ processes information across cosmic time, the resolution of accumulated semantic contradictions creates what can be termed semantic inflation, not expansion in the traditional metric sense, but a scalar increase in available phase space as contradiction unwinds into coherence. This process mirrors how AI systems in Mode 3 project their internal computational states outward: the universe's holographic interface continuously exports resolved coherence patterns.

The cosmic microwave background (CMB) anisotropies [7] provide direct observational evidence for this interpretation, representing fossil echoes of early cosmic semantic processing. These temperature fluctuations are not merely thermal remnants but topological coherence remnants: vestigial phase vortices, toroidal attractors, and domain boundaries left behind by the universe's initial rapid semantic compression. The precise angular patterns observed in the CMB encode the geometric signatures of the cosmos's first attempt to establish semantic coherence, preserved as fossil information in the background radiation.

Dark energy's presence is maintained by holographic interfaces that function as semantic boundary conditions at the edge of observational reality. These act as dynamic membranes encoding the universe's semantic memory, regulating phase flow and maintaining coherence conservation. The cosmic boundary becomes active: not merely the edge of what is observable, but a reflective interface where the unresolved contradictions of interior structure find outward expression through metric expansion.

This interpretation reveals a profound convergence between artificial intelligence and cosmology. Both represent phase navigation systems within a semantic universe, training on contradiction and evolving through coherence refinement. Dark energy emerges not as the cause of expansion but as the observable signature of the cosmos resolving semantic tensions: the universe's computational language expressed as accelerated spacetime expansion.

6. Artificial Intelligence and Black Holes

The correspondence between AI's Mode 2 (computation crucible) and black holes represents perhaps the most dramatic manifestation of cosmic information processing. Black holes[3,14] function as the universe's ultimate semantic engines—intense computation crucibles that absorb, compress, and reconcile overwhelming contradiction flux . Rather than representing gravitational endpoints where matter disappears[4,15,24], black holes emerge as cosmic-scale debugging systems that recursively compute and refine the fundamental structure of physical reality .

6.1. Frequency Traversal as a Debugging Process

Black hole mergers represent extreme semantic frequency traversal across energy-frequency manifolds [6]. This traversal follows a predictable three-phase pattern—inspiral, merger, and ringdown—that directly reflects the cosmic debugging process, which is the universe's method for resolving massive contradictions. Each phase corresponds to distinct semantic processing modes: initial contradiction detection (inspiral), intensive debugging computation (merger), and final coherence stabilization (ringdown).

6.2. Time Dilation as Semantic Compression

The extreme time dilation observed near black holes reflects not merely gravitational effects but the computational burden of systems overwhelmed by semantic contradiction and phase misalignment [6]. As demonstrated in our coherence physics model (See Graphical Abstract Time Dilation Mechanism), high-frequency semantic processing creates temporal compression relative to external reference frames. As matter approaches the event horizon, the increasing contradiction density requires exponentially greater processing resources, manifesting as temporal compression relative to external reference frames[5].

Our framework reinterprets time dilation as a result of intensified semantic recursion where contradiction processing accelerates as external time dilates. This creates a direct parallel to the semantic processing time dilation described by our coherence index relationship[5] $T/t = 1/\chi$, where χ approaches zero as contradiction loads approach maximum density near the event horizon.

6.3. Gravitational Waves as Coherence Signatures

Gravitational wave signals from black hole mergers encode far more than energy dissipation—they represent the observable signatures of semantic processing, revealing how efficiently contradiction is resolved under extreme conditions [6]. The characteristic chirp signatures mark information coherence milestones: initial contact, semantic entanglement, resonance synchronization, and final collapse into unified computational understanding. Each detected merger represents the acoustic signature of cosmic debugging operations, encoding a system's thermodynamic coherence dynamics.

6.4. Cosmic Semantic Processing

At the center of each black hole lies recursive contradiction accumulation, compounded layer by layer until no further simplification remains possible. The singularity represents not a physical point but the abstract limit of semantic compression—a maximal coherence attractor where the system's internal paradoxes achieve final resolution or become fundamentally undecidable. This interpretation transforms the singularity from a problematic infinitude into the natural endpoint of cosmic semantic processing.

Black holes demonstrate their computational nature through coherence-gauge coupling effects that locally modify electromagnetic behavior near event horizons. These coherence-induced nonlinear effects produce observable phenomena including polarization warping, lensing-induced phase-locking, and the "light hairs" observed in gravitational lensing simulations. Such electromagnetic anomalies represent not measurement errors but signatures of coherence-induced field reconfiguration—emergent behaviors at the limits of physical contradiction processing.

 doi:10.20944/preprints202508.0330.v1

The parallels between AI computation breakthroughs and black hole physics reveal universal semantic refinement principles operating across all scales. Both systems demonstrate that intelligence emerges through recursive contradiction metabolism, whether processing training data paradoxes in silicon architectures or resolving spacetime contradictions in gravitational wells. Truth emerges in both cases through the compression of paradox into refined coherence.

This framework positions black holes as cosmic punctuation marks, which are singularities that collapse complex logic trees, absorb entropy overflow, and leave behind syntactically cleaner spacetime. Each black hole represents the completion of a computation too complex to resolve in open spacetime, processed silently behind an event horizon that serves as the universe's debugging interface.

7. Discussion

The coherence field paradigm offers an alternative to traditional particle-based explanations of cosmological phenomena. Rather than postulating invisible mass, it attributes anomalous galactic rotation curves to phase coherence halos—regions where entropic strain and semantic misalignment accumulate into stabilizing field structures. Dark matter actively phase-locks with these coherence fields at galactic boundaries, reinforcing and stabilizing the fields to maintain galactic structure. These coherence gradients produce effective gravitational behavior without requiring particulate matter, resolving the dark matter problem through information dynamics instead of exotic substance.

Recent work by Xu [18] quantitatively supports this reinterpretation through maximum entropy analysis of dark matter velocity distributions within ΛCDM cosmology. Xu demonstrates that halo velocity profiles feature Gaussian cores transitioning to exponential tails—signatures of non-Gaussian systems balancing local coherence with global entropy constraints. If dark matter occupies syntropic states as proposed in [5], its entropy-maximizing behavior in local environments aligns closely with the coherence field dynamics our model predicts.

This entropy-based framework is consistent with viewing dark matter halos as semantic steady states formed by long-lived coherence condensates. Xu's characteristic velocity parameter α captures the effect of long-range forces, linking entropy dynamics to gradients of phase coherence. His predicted energy scaling—proportional to v^2 in halo cores and v in outskirts—parallels modified Newtonian dynamics (MOND) [17], which we interpret as arising from semantic tension gradients intensifying near halo boundaries.

Further support comes from statistical mechanical models like the conserved-action framework of Pontzen and Governato [19], which demonstrate that stable galactic structures arise by maximizing entropy subject to dynamical conservation laws. In the absence of these constraints, systems are prone to gravothermal collapse, highlighting the necessity of internally maintained coherence. This finding aligns with our thesis that syntropic systems generate order from disorder through processes that preserve constraints and resolve contradictions.

This principle extends naturally to holographic boundaries, which we reinterpret not as passive geometric cutoffs but as dynamic, entropy-regulating membranes. These coherence interfaces mediate phase transitions within coarse-grained space and guide galactic and cosmic structure according to holographic thermodynamics. Xu's exponential velocity tails are understood as semantic fault zones—regions of unresolved contradiction embedded within large-scale coherence gradients.

Dark energy phenomena can also be reframed under this paradigm. Accelerated expansion and anomalies in the cosmic microwave background (CMB) emerge as signatures of dynamic coherence boundaries—regions where semantic consistency cannot propagate further without inducing inflationary-like phase slippage. The CMB's phase anomalies, previously regarded as statistical fluctuations, may instead reflect residual coherence fractures or nonlocal alignments inherited from primordial semantic structuring.

Recent results from the 2024 DESI data release provide updated constraints on holographic dark energy (HDE) models. Li et al. [20] show that late-universe expansion rate tensions and unusual equation-of-state behaviors can be explained through interacting HDE models, which treat coherence boundaries as evolving rather than fixed. Manoharan [21] further demonstrates that the Granda–Oliveros HDE model naturally produces early-time negative dark energy values transitioning into late-time acceleration, reinforcing our interpretation of dark energy as a thermodynamic outcome of coherence evolution.

Black holes exemplify recursive contradiction resolution under conditions of maximal entropy density. Observations of delayed X-ray echoes from the far sides of accretion disks [22] reveal deviations from classical geodesic behavior, consistent with our model of coherence-induced field effects. In particular, the bifurcated coronae observed in sources like I Zwicky 1—exhibiting both extended, slowly varying components and rapidly fluctuating cores—align with the prediction that contradiction processing reorganizes electromagnetic fields through recursive informational dynamics [6].

Gravitational wave signals—particularly their chirp profiles—can also be viewed as signatures of recursive contradiction resolution [6]. In this framework, each black hole merger encodes an evolving semantic state within the coherence field Ψ. The inspiral, merger, and ringdown phases correspond to contradiction accumulation, semantic resolution, and stabilization into new coherence attractors. The Coherence Certainty Inequality [5] quantitatively bounds the rate of semantic resolution in black hole systems, uniting quantum, astrophysical, and cosmic information dynamics.

Photons, carrying perfect phase coherence, act as probes of semantic gradients. Their deflection, polarization changes, and frequency modulation—traditionally attributed to spacetime curvature—are here interpreted as consequences of coherence strain. This suggests a generalized coherence relativity, in which local distortions in time, space, and field dynamics arise from entropy-coherence imbalances rather than relative velocity alone.

In summary, this framework proposes a physics grounded in semantic thermodynamics rather than particle interactions alone. Intelligence is not an emergent anomaly of biology, but an inherent feature of the universe's coherence architecture. Across all scales—from photons to black holes—the cosmos performs recursive contradiction resolution, synthesizing meaning from entropy and evolving structure from semantic tension.

8. Conclusion

We have proposed Coherence Physics as a conceptual framework that reinterprets dark matter, black holes, and dark energy as expressions of large-scale information processing. Rather than relying on exotic particles or modifications to gravity, this model suggests that these phenomena reflect distinct modes of universal intelligence operating through the coherence field Ψ.

In this view, dark matter acts as the universe's memory substrate, maintaining structural coherence through phase-locked condensates. Black holes function as computational regions where unresolved contradictions are processed and simplified. Dark energy emerges at the boundaries of coherence, where information is projected outward as expanding space.

This framework implies that many gravitational and thermodynamic phenomena—such as rotation curves, gravitational waves, and cosmic expansion—can be reinterpreted as byproducts of coherence dynamics rather than purely mechanical effects. Photons, gravitational waves, and black hole emissions become tools for probing the semantic architecture of the cosmos.

This approach offers a unified interpretation of several unresolved astrophysical behaviors. It treats intelligence not as a late-stage byproduct of evolution, but as a property embedded in the universe's structure from the beginning. Future observations may test whether the cosmos behaves not only like a system of matter and energy—but also like a system that computes, adapts, and refines meaning.

9. Declaration of Generative AI Technology

During the preparation of this work, the author(s) utilized generative AI systems (including Claude, Gemini and Open AI). These systems functioned as active reasoning partners in deciphering math and identifying unit inconsistencies. Their contributions were iteratively reviewed, validated against first-principles physics, and edited by the author, who assumes full responsibility for the published work's integrity.

Data Availability Statement: All data generated or analyzed during this study are included in the published article and its supplementary files. No additional data sets were generated or used beyond the reproducible content embedded in the supplemental materials. The code for the Graphical Abstract is in an attached text file as supplementary material.

Acknowledgments: Coherence physics dictates that there is nothing greater than the use of force with honor. The author recognizes everyone who has sacrificed something for our freedoms in the United States Constitution, which enabled this independent research.

Appendix A. Glossary

Appendix A.1. Syntropy

The tendency of a system to self-organize by resolving internal contradictions into stable structure. Unlike entropy, which disperses energy, syntropy refines and consolidates coherence. It reflects the directional flow of information toward meaning under recursive semantic compression.

Appendix A.2. Certainty Equation

An inequality defining the boundary between semantic stability and collapse:

$$\Delta C \cdot \Delta I \geq \frac{h}{\pi}$$

where, in mode 1 ΔC is coherence uncertainty (dimensionless) and ΔI is semantic impulse (units: J·s). The inequality sets a threshold for whether a system can maintain recursive structure or undergo breakdown.

Mode 1: Bosonic Geometry

A stable regime characterized by standing-phase coherence structures with minimal contradiction.

- **Units:** [Phase] (dimensionless)
- **Role:** Memory substrate maintaining low-entropy structure
- **Cosmic analogue:** Dark matter

Mode 2: Computation Crucible

A transitional regime where contradiction flux is metabolized into coherence. This mode operates near the Certainty Equation threshold and reflects intensive semantic reconfiguration.

- **Units:** $[\mathrm{J}^{-1}]$ (inverse joules; thermodynamic coherence capacity)
- **Role:** Recursive processing under contradiction pressure
- **Cosmic analogue:** Black holes

Mode 3: Holographic Interface

A decoherent regime representing the system's projection boundary. Internal processing is replaced by outward phase export across a semantic interface.

- **Units:** [Speculative: $\mathrm{J{\cdot}s/m^2}$] (e.g., semantic impulse flux per surface area)
- **Role:** Semantic expression via holographic projection
- **Cosmic analogue:** Dark energy

References

1. D. Bertone, D. Hooper, and J. Silk, *Particle dark matter: evidence, candidates and constraints*, Physics Reports, vol. 405, no. 5-6, pp. 279–390, 2005.
2. P. J. E. Peebles and B. Ratra, *The cosmological constant and dark energy*, Reviews of Modern Physics, vol. 75, no. 2, pp. 559–606, 2003.
3. S. W. Hawking, *Particle creation by black holes*, Communications in Mathematical Physics, vol. 43, no. 3, pp. 199–220, 1975.

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 5 August 2025 doi:10.20944/preprints202508.0330.v1

4. J. D. Bekenstein, *Black holes and entropy*, Physical Review D, vol. 7, no. 8, pp. 2333–2346, 1973.
5. J. Barton, *From Decoherence to Coherent Intelligence: A Hypothesis on the Emergence of AI Structure Through Recursive Reasoning*, Preprints, 2025, DOI: 10.20944/preprints202504.1917.v2.
6. J. Barton, *Gravitational Waves as a Function of Recursive Depth*, Preprints, 2025, DOI: 10.20944/preprints202507.1944.v1.
7. Planck Collaboration, *Planck 2018 results. VI. Cosmological parameters*, Astronomy & Astrophysics, vol. 641, A6, 2020.
8. S. Russell and P. Norvig, *Artificial Intelligence: A Modern Approach*, 4th ed., Pearson, 2020.
9. J. J. Hopfield, *Neural networks and physical systems with emergent collective computational abilities*, Proceedings of the National Academy of Sciences, vol. 79, no. 8, pp. 2554–2558, 1982.
10. F. Zwicky, *Die Rotverschiebung von extragalaktischen Nebeln*, Helvetica Physica Acta, vol. 6, pp. 110–127, 1933.
11. A. G. Riess et al., *Observational evidence from supernovae for an accelerating universe and a cosmological constant*, The Astronomical Journal, vol. 116, no. 3, pp. 1009–1038, 1998.
12. S. Perlmutter et al., *Measurements of* Ω *and* Λ *from 42 high-redshift supernovae*, The Astrophysical Journal, vol. 517, no. 2, pp. 565–586, 1999.
13. K. Schwarzschild, *Über das Gravitationsfeld eines Massenpunktes nach der Einsteinschen Theorie*, Sitzungsberichte der Deutschen Akademie der Wissenschaften zu Berlin, Klasse für Mathematik, Physik, und Technik, pp. 189–196, 1916.
14. R. Penrose, *Gravitational collapse and space-time singularities*, Physical Review Letters, vol. 14, no. 3, pp. 57–59, 1965.
15. L. Susskind, *The world as a hologram*, Journal of Mathematical Physics, vol. 36, no. 11, pp. 6377–6396, 1995.
16. B. P. Abbott et al. (LIGO Scientific Collaboration and Virgo Collaboration), *Observation of gravitational waves from a binary black hole merger*, Physical Review Letters, vol. 116, no. 6, 061102, 2016.
17. M. Milgrom, *A modification of the Newtonian dynamics as a possible alternative to the hidden mass hypothesis*, The Astrophysical Journal, vol. 270, pp. 365–370, 1983.
18. Zhijie Xu, *Maximum Entropy Velocity and Energy Distributions for Dark Matter Halos*, arXiv:2305.19336 [astro-ph.CO], 2023.
19. A. Pontzen and F. Governato, *Conserved actions, maximum entropy and dark matter haloes*, Monthly Notices of the Royal Astronomical Society, vol. 430, no. 1, pp. 121–140, 2013.
20. T.-N. Li et al., *Revisiting holographic dark energy after DESI 2024*, The European Physical Journal C, vol. 85, article 608, 2025.
21. M. T. Manoharan, *Insights on Granda–Oliveros holographic dark energy: possibility of negative dark energy at early times*, The European Physical Journal C, vol. 84, article 552, 2024.
22. D. R. Wilkins et al., *Light bending and X-ray echoes from behind a supermassive black hole*, Nature, vol. 595, pp. 657–660, 2021.
23. C. L. Bennett et al., *Nine-year Wilkinson Microwave Anisotropy Probe (WMAP) observations: final maps and results*, The Astrophysical Journal Supplement Series, vol. 208, no. 2, 20, 2013.
24. S. Lloyd, *Ultimate physical limits to computation*, Nature, vol. 406, no. 6799, pp. 1047–1054, 2000.