

The Informational Singularity Hypothesis*

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Abstract

The *Informational Singularity Hypothesis* starts from a single premise: Nothingness. Being ontologically unique, it has no exterior: its uniqueness forces it to be total. But totality generates an irreducible contradiction with its purity—Nothingness cannot admit even the form of its own absolutization. This contradiction annihilates itself, yet the annihilation leaves a logical scar—Order, the first genuine property of the system—and the restored purity forces totality once again. The resulting oscillation between pure Nothingness (0) and Absolute Nothingness (1) constitutes an autonomous generative engine: at each cycle, annihilation operates on the entire chain of accumulated prior states, producing binary sequences of increasing complexity. Information is not a consequence of the Universe, but its primary cause.

We formalize the process as an iterative collapse dynamics (Level 0) and validate it computationally through seven algorithmic variants and five deterministic and random controls. The canonical variants converge toward a universal attractor with density $1/\varphi$ (golden ratio), exponential growth ($R^2 \approx 0.999$), transfer entropy across scales up to $27\times$ above chance, and fractal dimension $D_f \approx 1.0$. Notably, variants with inverted annihilation rules produce identical statistical signatures—statistical commutativity—while the introduction of inter-level feedback destroys the structure, identifying the causal mechanism of emergence.

All source code is publicly available on GitHub for scrutiny and reproducibility. Levels 1 (emergent rules) and 2 (observable geometry) are presented as sketches for future development.

1 Introduction

Over the past decades, numerous proposals have been developed that place information as the primordial element in the origin of reality. For example, John A. Wheeler coined the famous concept “*It from Bit*”, suggesting that every physical object—even spacetime—has at its foundation an immaterial informational basis made of bits [1]. Similarly, the holographic principle, developed by Gerard 't Hooft and Leonard Susskind, maintains that all information contained within a volume of the universe can be encoded on its surface [2, 3]. Additionally, authors like Seth Lloyd have proposed that the entire universe functions as a giant quantum computer, where each particle interaction contributes to the continuous processing of information [4].

*AI systems are listed as contributors as a deliberate methodological and ethical choice. We believe that transparency about the role of artificial intelligence in scientific research is a non-negotiable principle, and that explicitly acknowledging their contributions—rather than concealing them—sets a necessary precedent for academic integrity.

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However, these models assume that there already exists a substrate or information structure (whether physical bits, quantum fields, or holographic surfaces) upon which reality develops. In contrast, the **Informational Singularity Hypothesis** proposes an even more fundamental starting point: the only premise that can be considered essentially certain, **Nothingness**. This fundamental principle, precisely because of its total lack of inherent properties, does not require demonstration and becomes an origin. Now, being the only thing that “is”, it has no exterior: its ontological solitude forces it to be total. This totality—not an acquired property but a logical consequence of its uniqueness—is incompatible with the purity of Nothingness, generating an irreducible ontological contradiction that manifests as an **infinite binary singularity** where pure Nothingness (0) and Absolute Nothingness (1) interact in an irresolvable tension. A detailed ontological analysis of this paradox is developed in Section 5.

To consolidate the theoretical foundation of this hypothesis, two fundamental principles must be highlighted. First, the principle of bivalence and exclusion of the third state applies: at the most fundamental level there can be only two primary conditions—**total absence of properties** and **presence of property**—with no possibility of a third independent option (cf. [5, 6]; [7] is cited here for the algorithmic information angle, especially regarding emergent complexity in binary systems). This dichotomy implies that, at the most fundamental level, there can only be two primary conditions—**Nothingness** (absence of properties) and **Absolute Nothingness** (Nothingness considered as totality, a logical consequence of its uniqueness; the precise distinction between *Absolute* and *Absolutely* Nothingness is formalized in Section 5)—since any other state could only result from a combination of these two basic options. Second, although one could imagine a “transition point” as an intermediate state, this can only be considered a semi-state derived from the dynamic interaction between absence and emergence of property, and therefore does not constitute a new fundamental condition [7, 8, 9]. These principles support the idea that reality is born from a tension between the total absence of properties and the logical necessity of absoluteness, thus establishing a solid logical basis for informational singularity within the proposed axiomatic framework.

$$\begin{array}{cccccccc}
 0 & & 01 & & 0 & & 0 & & 01 & & 01 & & \dots \\
 \emptyset_0 & \rightarrow & |\emptyset_0| & \rightarrow & \emptyset_0 & \rightarrow & |\emptyset_0| & \rightarrow & |\emptyset_0| & \rightarrow & \emptyset_0| & \rightarrow & \dots \\
 & & \perp & &
 \end{array} \tag{1}$$

Figure 1: Informational Singularity sequence with progressive integration of Absolute Nothingness. Absoluteness states ($|\emptyset_0|, |\emptyset_0|, \emptyset_0|$) indicate increasing integration of prior states folded into themselves.

This constant interaction between 0 and 1—where 0 and 1 are symbolic representations of the two ontological states (pure Nothingness and Absolute Nothingness), not fundamental entities in themselves—is fundamental because it explains how, from apparent simplicity, complex and ordered structure can emerge spontaneously. Thus, instead of being limited simply to a static duality, the model becomes richer because:

- **Primordially and Uniqueness:** All 0s and all 1s are identical at their elementary level, so that the uniformity of this minimal basis creates a simple yet rich starting point. This basic simplicity allows any variation, however minuscule, to generate immeasurable complexity.
- **Emergence of Order:** The inherent tension between a state of pure absence (0) and a state of totality (1) forces this duality to combine in non-trivial ways. Thus, the constant fluctuation between 0 and 1 gives rise to patterns and structures that ultimately configure observable

reality. This self-organization process is similar to the transition from a disordered state to an ordered state in many natural systems, but is situated at such a fundamental level that it even precedes the Big Bang [1, 7].

- **Global Interconnection:** The ontological tension between pure Nothingness and Absolute Nothingness is, by nature, indivisible: it does not act on isolated fragments but on the totality of the state. The resulting binary patterns inherit this interconnection, forming a global network of interactions that can give rise to emergent properties that cannot be obtained linearly. This idea leads us to propose that information is, in essence, the primary cause of all reality.

The question “why is there something rather than nothing?” is a classic question originally addressed by Leibniz [10], and subsequently treated by thinkers like Heidegger [11] and Hegel [8]. They have argued that the dialectic of being and non-being is the engine of the development of spirit, while Thomas Aquinas [9] maintains that everything that exists has a first cause, which could be interpreted as the necessity of a fundamental source of information. These historical perspectives enrich our proposal, situating it in a tradition of thought that has attempted to unravel the mystery of existence.

In the tradition of thought that has questioned the nature of “nothingness,” works like *Nothing: From Absolute Zero to Cosmic Oblivion* by Jeremy Webb [12] remind us that the concept of “nothingness” is much more than mere absence. Just as Webb maintains that the void has profound implications for our understanding of the universe, the Informational Singularity Hypothesis starts from the notion that Nothingness (a state in which there is no entity) is, in reality, the starting point that, through an inherent tension with Absolute Nothingness, generates all information and, therefore, everything that exists.

With this vision, the Informational Singularity Hypothesis not only rethinks the origin of reality as a purely informational process, but also invites us to reconsider the relationship between what we perceive as “real” and the information substrate that sustains it. It is, therefore, an innovative and radical vision: information is not a consequence of the universe’s evolution, but the primary cause of all reality, arising from Nothingness that, by its nature, leads to the creation of information and, therefore, existence [1, 2, 3, 13, 4].

This first part, conceived to be conceptual and accessible, provides us with the necessary framework to understand the hypothesis. Later, we will delve into the mathematical formalization and technical details that support this proposal, preparing the ground for a more specialized analysis. Readers interested in the most relevant computational discoveries and their connection with the Big Bang cosmological model may advance directly to Section 13.4.

2 Comparative Analysis

The **Informational Singularity Hypothesis** presents a radically different framework compared to other information-centered approaches. First, this hypothesis starts from a single primordial concept: **Nothingness**, that is, the total non-existence of any entity or substrate. This contrasts with models like Wheeler’s “*It from Bit*” [1] or the holographic principle developed by ’t Hooft [2] and Susskind [3], which already assume the existence of an organized information substrate, where reality is constructed from bits or an existing quantum field.

While Wheeler’s original proposal expresses that every particle, field, and even spacetime have their origin in binary decisions (0 and 1), the Informational Singularity Hypothesis maintains that the genesis of reality is born from a **fundamental paradox**. In this model, the concept of Nothingness

must be absolute, but at the same time Absolute Nothingness must include pure Nothingness itself, which is logically impossible. This contradiction generates an **infinite binary singularity** from which all the information of the universe emerges in a state prior to spacetime [1, 7].

Furthermore, in this initial state, information is **superposed and entangled**, since all bits share the same fundamental origin. This entanglement implies that each bit affects and is affected by the rest, and this interconnection generates a complex and autonomous fabric that, as it evolves, gives rise to organized patterns and more complex attractors. This differs from models like Seth Lloyd’s, who conceives the universe as a quantum computer that processes information from already defined quantum states [4].

Finally, while **String Theory** describes reality through vibrating strings in spaces with multiple dimensions [13], the Informational Singularity Hypothesis places the origin of reality in a state before the Big Bang, where neither time nor space have yet emerged. In this sense, the hypothesis offers a more fundamental vision, in which all observable complexity emerges as a direct consequence of a progressive organization of a primordial informational structure, generated *ex nihilo* by the inherent tension between pure Nothingness and Absolute Nothingness. This perspective contrasts with String Theory, especially in its holographic and dual formulation provided by Maldacena (AdS/CFT) [13], which is based on the prior existence of multidimensional structures and not on a direct emergence from informational nothingness. This comparison justifies the need for an original contribution to rethink the foundations of reality, which will be developed in detail in the following section.

3 Original Contributions

The present work offers an integrative and innovative approach to the fundamental question of the origin of reality, highlighting several key aspects that differentiate it from traditional models:

1. **Hierarchical Formalization of Information Emergence:** A three-level hierarchy is proposed—the Informational Singularity, the Primordial Holographic Field, and the Fundamental Geometric Field—that models the transition from emergent fractal informational structure (defined by the tension between pure Nothingness and Absolute Nothingness) toward the appearance of geometries and dimensions. This stepped structure is partially inspired by Wheeler’s approach [1], but additionally systematically breaks down the process of information self-organization, providing a new perspective on how order can originate from a primordial state of identical bits [7]. Thus, it supports the idea that reality emerges from the infinite repetition of 0s and 1s, which are, by definition, uniform and interrelated.
2. **Interface with Quantum Computing:** The hypothesis proposes that qubits, thanks to their ability to be in superposition, can act as a direct interface with the Fundamental Geometric Field (see the “Future Research Directions” section in the Quantum Computing section for more details). This idea suggests that quantum algorithms could, in the near future, reveal fundamental properties of information that are not accessible through classical systems, opening the door to possible experimental validations [4]. This perspective complements the “*It from Bit*” concept, where the basic information of the world is conceived as essentially quantum [1].
3. **Bridge between Metaphysics and Modern Physics:** Unlike models that address the existential problem from an exclusively physical or informational perspective, this work integrates classical metaphysical thought with mathematical formalizations and modern theories, such as String Theory [13] and the Holographic Principle [2, 3]. It rethinks the question “why is there something rather than nothing?” from a multidimensional vision, enriching both

theoretical and experimental research. This interdisciplinary approach also connects with Eastern philosophical perspectives: Bitbol [14] has shown how the Buddhist concept of Śūnyatā (emptiness) exhibits parallels with quantum non-separability and property relativity, aspects directly relevant to the primordial tension between pure Nothingness and Absolute Nothingness that underpins our hypothesis.

This set of elements provides a relevant and original contribution to current research, opening new avenues for both theoretical investigation and possible practical applications in fields such as quantum computing and fundamental physics.

4 Methodology

This work emerges from an interdisciplinary approach that integrates elements of metaphysics, information theory, mathematical formalization, and theoretical physics, with the objective of providing a comprehensive explanation of the origin of reality from the paradox of Nothingness. The methodology is broken down into the following key steps:

1. **Conceptual Analysis:** We start from the concept of Nothingness (0) and its inevitability as an origin, with the emergence of Absolute Nothingness (1) as a logical consequence of its uniqueness. This introduces an irreducible ontological tension that grounds the hypothesis, supported by both classical and contemporary perspectives.
2. **Mathematical Formalization:** Based on Leibniz’s binary system, we formalize the model from the infinite combination of elementary operators that can only be 0 or 1. Thus the primitive information field is defined. Subsequently, we introduce transformations to translate this information into patterns, rules, and finally into a wave function that represents observable reality. This technical part will be developed in detail in section 7.2.
3. **Integration with Theoretical Physics Models:** The emerging concepts of the model are correlated with modern theories, such as the Holographic Principle, String Theory, and quantum computing. This connection shows that the model is not only a theoretical construction, but can also have empirical and practical implications in understanding the fundamental nature of the universe.
4. **Intuitive Examples and Analogies:** To facilitate understanding of such abstract concepts, examples and analogies from other areas of science are incorporated. Among these are cellular automata [15], Turing patterns in morphogenesis [16], oscillator synchronization [17], and phase transitions in physical systems. These examples illustrate how, from an emergent fractal structure, a higher order can emerge, reinforcing the plausibility of our model.

This methodological approach allows addressing the question “why is there something rather than nothing?” from a multidimensional perspective. The integration of conceptual analysis, mathematical formalization, and connection with physical models ensures that the hypothesis is rigorous from both theoretical and practical standpoints, opening new avenues of investigation in fundamental physics and information theory.

4.1 Computational Proofs of Concept

To explore the formal consequences of the Level 0 algebra, extensive computational simulations have been performed that implement the iterative collapse process. These simulations serve as **proofs of**

concept that demonstrate the internal consistency of the model: exponential information growth, ordered one-dimensional structure, long-range correlations characteristic of self-organized systems, and significant difference from random noise. Detailed quantitative results, including visualizations, spectral analysis, and comparison with controls, are presented in **Appendix B**.

The complete source code of these simulations, along with detailed instructions to reproduce the experiments, is publicly available at the GitHub repository: <https://github.com/iban-borras/informational-singularity-hypothesis>. The experimental pipeline consists of: `level0_generate.py` (data generation), `level1_analyze_patterns.py` (pattern analysis), and `level1_emergence_index.py` (emergence metrics). The illustrative pattern–rule example in Section 9.0.1 is extracted from the Level-1 analysis produced by this pipeline on Variant B at iteration 17.

Experimental variants. To explore the robustness of the annihilation mechanism, 12 variants of the iterative process have been implemented: 7 ISH variants (B, D, E, F, G, H, I) differing in the order of application of the annihilation rules ($01 \rightarrow 0$, $10 \rightarrow 0$) and in the degree of global feedback during collapse; and 5 controls (A: PRNG Mersenne Twister, J: digits of π , K: Rule 30, L: logistic map $r = 3.99$, M: Fibonacci word). The complete description of each variant is found in Appendix A.

Analysis methods. Five independent metrics are applied to all variants: (i) multi-scale Lempel-Ziv complexity (LZ ratio); (ii) recurrence quantification analysis determinism (DET, RQA); (iii) cubical topological persistence (TDA: β_1/β_0); (iv) mean number of children of the nesting tree (\bar{c} , `mean_children`); and (v) multi-scale Transfer Entropy with randomized (shuffle) control [18]. Complete results are presented in Appendices C–G.

Sampling and reproducibility. Generated sequences range from ~ 90 MB to ~ 583 MB (compressed). To avoid sampling biases, *streaming subsampling* with uniform stride is applied over the entirety of each file, analyzing 10^9 representative bits. Software used includes Python, Numba (JIT), GUDHI, and ripser (TDA).

Next, the **Irreducible Primordial Tension** that underlies the model is presented, before entering into the mathematical formalization (second specialized part).

5 The Irreducible Primordial Tension

Axiomatic note: The ISH adopts as its **foundational axiom** that the tension between pure Nothingness (0) and Absolute Nothingness (1) constitutes an irreducible generative dynamic. Within the framework defined by the three foundational principles presented below, this dynamic emerges as a logical consequence; however, the step from logical consequence to a generative principle that *produces* information is an axiomatic decision of the model, not a universal demonstration. The reader should consider the ISH as an axiomatic system—coherent and falsifiable—built upon this postulate, analogously to how general relativity is erected upon the equivalence principle or quantum mechanics upon the superposition postulate.

5.1 The Pre-Physical Ontological Regime

Before entering the formal definition of Level 0, it is crucial to clarify the regime in which the Informational Singularity Hypothesis operates. At this stage we are not yet in a physical domain. There is no space, no time, no energy, no quantum fields, and no dynamics in the usual sense.

The framework of Level 0 is purely **ontological and logical**. The only admissible questions are “what” and “why” in a structural sense. Questions such as “where does the collapse happen?”, “when does it occur?” or “which mechanism triggers it?” presuppose a spatiotemporal background and physical laws that, by hypothesis, have not yet emerged.

Consequently, Nothingness (0) and Absolute Nothingness (1) do not denote physical states, but **logical poles of an ontological tension**. The collapse algebra developed in Section 7.2 should therefore be interpreted as a formal representation of this tension, not as a dynamical law acting in spacetime.

5.2 The Fundamental Paradox

The Irreducible Primordial Tension is not just a logical curiosity, but constitutes the key to understanding the fundamental paradox of existence. Traditionally, the question “Why is there something rather than nothing?” has been posed assuming that total lack of existence would be the natural state. However, when we rigorously examine the concept of “nothingness,” it becomes problematic as soon as absoluteness is attributed to it.

If Nothingness must be a radical origin, it cannot presuppose any prior structure: any other option—a set of laws, a space, a time, a field, or an equation—already incorporates form and therefore requires prior explanation. Pure Nothingness is thus the only coherent candidate for ontological origin: it contains nothing that needs to be justified.

Nevertheless, the simple fact of considering Nothingness as the unique origin transforms it into a state that, in some way, must “contain everything.” In the very act of thinking of it as foundation without outside, we declare it *absolute*. In this way, two fundamental states appear:

- **Pure Nothingness (0):** the complete absence of existence, without any property or content.
- **Absolute Nothingness (1):** Nothingness considered as the unique totality without exterior.

Any other state is derived from these two basic options (principle of bivalence; cf. [5, 6]). Attempting to endow Nothingness with absolute character generates, moreover, an inevitable contradiction: that which, by definition, cannot have any property, ends up acquiring the property of being absolute. This contradiction cannot be resolved by introducing a third fundamental state; any definitive third state would again be a variant of something or nothing.

The Irreducible Primordial Tension is precisely this impossibility of maintaining Nothingness simultaneously pure and absolute. This tension forces a *necessary fluctuation* between 0 and 1: whenever Nothingness is thought of or becomes an origin, it becomes absolutized; and whenever it is absolutized, this absolutization proves incompatible with its purity and must somehow be corrected.

This process requires no agent, law, or external mechanism to “trigger” it. Nothingness, being the only one there is, is ontologically alone: there is nothing outside it to delimit, regulate, or observe it. This ontological solitude is, by itself, generative. Like a set that, being the only set in existence, must contain itself as its own element—not by choice, but by the mere absence of anything else to be contained—, Nothingness cannot avoid self-containing. There is no need to postulate any “law of self-containment”: uniqueness already is the mechanism. The generation of information is not a process that “happens to” Nothingness; it is what Nothingness *is* when it is the only one there is.

Within the framework of the Informational Singularity Hypothesis, this basic tension manifests as a binary model in which the only option is the interaction between these two fundamental states. No irreducible third state has a place. In the following subsections we detail how, from this tension between pure Nothingness and Absolute Nothingness, the *Absolutely Nothingness*, the self-containment torsion, *Order* as the first property, and finally information emerge.

5.3 The Absolutely Nothingness and the Emergence of Order

The Irreducible Primordial Tension can be reformulated even more precisely by introducing the concept of *Absolutely Nothingness*. When we think of Nothingness as unique and without outside,

we are considering it as totality without exterior. That is, we are *absolutizing* it. This conceptual operation—which is not temporal but purely logical—transforms pure Nothingness into Absolutely Nothingness.

5.3.1 The infinitesimal torsion of self-containment

Absolutely Nothingness is not an entity different from Nothingness: it is the same Nothingness considered as “all there is.” But this consideration implies a minimal form: it is no longer simply “there is nothing,” but “there is nothing, and this ‘nothing’ is everything.”

This self-containment constitutes an **infinitesimal torsion**: Nothingness “contains” itself, “draws” itself as totality. And this is already a form, however minimal, incompatible with the absolute purity of Nothingness.

The ontological consequence is immediate: this torsion must be annihilated—not in time (which does not yet exist), but logically—because Nothingness cannot admit even the form of its own absolutization.

5.3.2 Order as the first emergent property

From the tension between:

- pure Nothingness (which cannot have any property), and
- Absolutely Nothingness (which, in self-containing, already exhibits a minimal form),

emerges an invariant rule: whenever Absolutely Nothingness manifests itself as form (self-containment), this form must be collapsed and the uniqueness of Nothingness must be preserved.

This invariant rule is what we call **Order**.

Order is not a physical object nor a field: it is the consistent form in which Nothingness preserves itself against its own absolutization. It is, if you will, the “logical scar” of the annihilated torsion. It is also the first emergent property of the system: the way in which Absolutely Nothingness remains faithful to its own nature of pure Nothingness.

5.3.3 Accumulation: a consequence of the Absolute and Order

The Absolute and Order, combined, produce a fundamental effect: **accumulation**. Absolutely Nothingness, being total, must encompass *everything* that there is—and “everything that there is” includes the traces that Order has left in collapsing previous torsions. Therefore, each new cycle of absolutization cannot ignore the preceding history: it must necessarily incorporate it.

This is the ontological reason why state R_α contains $R_{\alpha-1}$. It is not an added postulate: it is the inevitable confluence of totality (the Absolute cannot exclude anything) and regularity (Order ensures that the incorporation always follows the same collapse rule). Without the Absolute, there would be no reason to accumulate; without Order, the accumulation would have no structure. Together, they generate memory.

5.3.4 The birth of information

The fact that this process—however infinitesimal—has a structure allows it to be “narrated.” When we represent it in the form of binary sequences $(0, 1, (0, R_{\alpha-1}, 1), \dots)$ and iterations, this becomes **information**.

In this context, the correspondence is direct:

- 0 represents pure Nothingness, the absence of any property.
- 1 represents self-contained Absolutely Nothingness, the infinitesimal torsion.
- The collapse operation represents the annihilation of the torsion, the preservation of Nothingness’s coherence. Formally, this annihilation is equivalent to the Boolean conjunction (AND), but ontologically it is prior to any logical framework: it is the pre-logical process by which binary tension resolves itself.
- The accumulation R_α represents the “memory” of the process (§5.3.3): the history of all torsions generated and collapsed. This is why the formula reads $(0, R_{\alpha-1}, 1)$: 0 is pure Nothingness, $R_{\alpha-1}$ is the history that the Absolute cannot exclude, and 1 is the new absolutization.

Important note: The logical operations described in this article (such as AND) are used as formal analogies comprehensible to the reader, not as literal descriptions of the process. At Level 0, no prior logical, mathematical, or temporal framework exists. The fundamental mechanism—Nothingness which, by the sole fact of being unique and absolute, generates the torsion of self-containment—is prior to any formalism and, strictly speaking, irreducible to any linguistic description. The reader should bear in mind that AND is a *pedagogical metaphor* for the annihilation of binary tensions, not a pre-existing operator that the process “uses.”

Thus, Level 0 is not just an algorithm: it is the minimal translation into bits of a radical ontological principle. Absolutely Nothingness, its self-containment torsion, and the rule by which it collapses constitute the logical foundation that makes comprehensible and defensible the entire emergent cascade:

$$0 \longrightarrow 1 \longrightarrow R_\alpha \longrightarrow \Phi \longrightarrow H \longrightarrow \Psi.$$

5.4 Logical Character of the Nothingness-as-Origin Thesis

From a strictly logical perspective, the thesis that Nothingness is the only coherent origin is not presented here as a theorem independent of any premise, but rather as a conditional result within a concrete ontological framework.

In particular, we adopt the following principles:

P1 Anti-regression principle: A radical origin cannot be composed of parts nor be based on a prior structure, or we return to asking “and what is that made of?”

P2 Anything that “is something” (a law, a field, a space, an equation) implies structure, and all structure presupposes components or relations that require prior explanation.

P3 Nothingness, by definition, has no property nor structure.

Given these principles, it follows that no structured entity can occupy the place of radical origin (by P1 + P2), while Nothingness can (by P1 + P3). Within the ISH framework, the conclusion that Nothingness is the only coherent candidate for origin is therefore a **conditional logical result** rather than a dogmatic assertion.

Put another way: if one accepts the rules of the game P1–P3, there is no logical escape: one arrives at Nothingness as the only possible origin.

6 Terminology for non-specialized readers

Before mathematical formalization, we summarize some key terms to facilitate reading without losing rigor:

- **The AND operator (Boolean conjunction):** Formally, it is a logical operation that acts on bits (values 0 or 1) and returns 1 if and only if all input bits are 1. In the context of the ISH, AND is used as the *formal equivalent* of the annihilation of binary tensions—the ontological process by which the torsion between Nothingness (0) and the Absolute (1) is resolved—. The fundamental operation is the annihilation; AND is its translation into the language of Boolean logic.
- **Transformation T and Functions f and g :** These are mathematical applications that map from one state space (or pattern space) to another. They can be considered functions that convert information from one form to another, maintaining the essential properties of order and symmetry.
- **State Space and Superposition:** In quantum mechanics, a system can be in multiple states simultaneously. The concept of *superposition* that we use reflects this idea: the final result is the combination (or superposition) of many possible states, each with an amplitude that indicates its importance or probability.

7 Level 0: The Primitive Informational State

Building on the ontological analysis of Section 5, we now formalize Level 0 as an infinite sequence of states generated by the tension between Nothingness (0) and Absolute Nothingness (1). The dynamics is self-referential: each new state incorporates the entire prior history, and the annihilation of adjacent binary tensions—formally equivalent to an AND collapse—eliminates inconsistencies while increasing complexity. Formally, we introduce the sequence R_α and the primitive informational field Φ .

The iterative repetition of this process creates complex binary patterns with pseudorandom or fractal properties, capable of generating emergent informational complexity without the need to introduce physical structures, dimensions, or time (see [7], [19], [20, 21]). Computational simulations confirm that initially trivial sequences of zeros and ones can, under these iterative rules, give rise to patterns with subtle internal structures (see Appendix B).

Terminological note: To avoid misunderstandings, we clarify the relationship between the model’s terms and their possible physical interpretations:

- **Index α :** It is a *logical order* (meta-time), not physical time. α orders the iterations of the ontological process; it does not presuppose any temporal substrate. Time, in the ISH, is an emergent property at Levels 1–2, not a prerequisite of Level 0.
- **Accumulation R_α :** Functions as a *memory* of the process: the totality of prior states incorporated into the current state. It does not imply any material memory substrate.
- **Tension 0/1:** It is neither a force nor a field, but a purely ontological *generative potential*: the irreducible contradiction between being “nothing” and being “absolutely nothing.”

This distinction is essential: Level 0 operates in a *pre-physical* regime (cf. Section 5.1), and projecting physical concepts onto it (time, force, mechanism) would constitute a category fallacy.

The primitive informational state (Φ) is formally defined as the infinite chain of states resulting from this iterative tension, where each new state α incorporates the entire accumulated history and undergoes an instantaneous collapse toward a simplified coherent state:

$$R_\alpha = \begin{cases} 0 & \alpha = 0 \\ \text{simplify}(0, R_{\alpha-1}, 1) & \alpha > 0 \end{cases} \quad (2)$$

We define the **complete space of binary sequences** as:

$$\Omega = \{0, 1\}^{\mathbb{N}}$$

The primitive informational state Φ is then defined as the **chain** (totally ordered poset) formed by all states R_α , which constitutes a subset of Ω :

$$\Phi = (\{R_\alpha : \alpha \in \mathbb{N}\}, \preceq) \subset \Omega \quad \text{where } R_\beta \preceq R_\alpha \Leftrightarrow \beta \leq \alpha \quad (3)$$

where (for the conceptual interpretation of these symbols, see Section 5.3.4):

- **Primitive Informational Field (Φ):** The field Φ formally represents the complete informational trajectory generated by the iterative tension between pure Nothingness (0) and Absolutely Nothingness (1). Φ is not the entire space Ω , but rather a **chain** within that space: a totally ordered sequence of states R_α where each state contains all the information of its predecessors. The more iterations explored (larger α), the richer the subset and the more structures can emerge at higher levels. This chain is comparable to a spiral of informational growth that folds upon itself while growing indefinitely [7, 19].
- R_α : Represents each informational state in the infinite iterative process, where each new state α incorporates the complete history of previous states together with a new absolute state (1). Each iteration necessarily implies an instantaneous collapse (due to the intrinsic tension between 0 and 1 within the combined state) that generates a simplified informational sequence. Thus, R_α is not simply a binary value but a complex sequence that emerges from this iterative and self-referential process.
- **Simplification function:** Represented by $\text{simplify}(0, R_{\alpha-1}, 1)$, this function incorporates the dual nature of the informational process. In conceptual terms, each new informational state generated from nothingness and the absolute undergoes successive internal reduction where adjacent binary tensions annihilate, eliminating intrinsic inconsistencies derived from the fundamental tension between nothingness (0) and absolute (1). The AND operation is the formal equivalent, but the ontological process—the annihilation of torsion—precedes any logical formalism. Thus, this formal simplification corresponds with the original philosophical interpretation posed in the article. *The rigorous and detailed mathematical formalization of this internal simplification process is found in Section 11.*

Thus, the primitive informational field Φ emerges naturally from this recursive, infinite, and self-referential process, giving rise to a complex and self-organized informational structure, capable of producing all the potential information that constitutes the necessary basis for higher informational levels.

7.1 Why can there only be two states?

The restriction to two states (0 and 1) is not an external imposition: it is a direct consequence of P1–P3. No third fundamental state can exist without violating at least one of the three principles. The principle of bivalence (cf. [5, 6]) independently confirms that this duality is exhaustive and, as the preceding sections demonstrate, sufficient to generate infinite informational complexity from the sole contradiction of Absolutely Nothingness.

Methodological note: Other non-classical logics (trivalent, paraconsistent, intuitionist) could relax the principle of bivalence. In this work we explicitly adopt the classical logical framework (Russell–Tarski) as the basis of the model. The exploration of alternative formulations constitutes a legitimate future line of research.

7.2 Step-by-step explanation of the generative process

The generative process of the Informational Singularity follows an internal logic that can be broken down into the following fundamental steps:

Initial state—Nothingness as origin: We start from Nothingness (0), which due to its total lack of properties becomes an origin: nothing prevents it from being the starting point of everything.

initial state: 0 (Nothingness as origin)

Emergence of absoluteness: In becoming an origin, Nothingness acquires the condition of Absolute Nothingness (1), insofar as, as an origin, it must potentially contain everything that can emerge. This absoluteness is not a property but an inescapable logical consequence:

$0 \longrightarrow 1$ (emergence of Absolute Nothingness as a logical consequence)

Irreducible ontological contradiction: Absoluteness (1) creates a fundamental contradiction: Nothingness, which by definition cannot have properties, has acquired the property of being absolute. This contradiction is irreducible and generates a primordial tension:

$1 \leftrightarrow 0$ (unsolvable tension between absoluteness and lack of properties)

Progressive integration and information generation: By the history-accumulation property defined above, each new state generates pure binary information while maintaining ontological tension in each transition (see Figure 2). Formally, we represent the process as:

$$R_\alpha = \begin{cases} 0 & \alpha = 0 \\ \text{simplify}(0, R_{\alpha-1}, 1) & \alpha > 0 \end{cases} \quad (4)$$

Where *simplify* corresponds to the annihilation of adjacent binary tensions described above, eliminating inconsistencies and preserving informational coherence.

Resulting primitive informational field: The infinite repetition of this process generates the primitive informational field Φ : the directed chain of states $\{R_\alpha\}_{\alpha \in \mathbb{N}}$ formally defined above (eq. 3).

This process is not an anomaly that needs additional explanation, but the necessary consequence of the primordial tension between the absolute lack of properties and the logical necessity of absoluteness. The information generated constitutes the fundamental substrate from which higher levels of complexity emerge.

These tension annihilation operations—formally modeled as AND conjunctions—are not arbitrary, but reflect the fundamental properties of nothingness and the absolute, and how these properties

naturally interact to generate emergent informational complexity. AND is the formal translation of a pre-logical ontological process; binary tension resolves itself by its own nature, not because a logical operator exists to apply it.

From this point of view, the iterative process we have described can be understood both as a local rewriting of patterns in the sequence $(0, R_{\alpha-1}, 1)$ and as a global collapse equivalent to applying a logical conjunction to all bits. In Appendix A we recast `simplify` as a rewriting system, which makes precise how the local rules implement the ideal global AND collapse. The fact that the sequence begins with a 0 guarantees that, in the limit, the collapsed state always corresponds to Nothingness, even though the intermediate patterns R_α are rich and structured.

Although Φ is formally defined as a one-dimensional infinite sequence $\{R_\alpha\}_{\alpha \in \mathbb{N}}$, its construction via a global collapse rule implies that the states are far from independent. Each state R_α contains its full informational history, and all states arise from iterating the same ontological event: the tension between 0 (pure Nothingness) and 1 (Absolute Nothingness) encoded by the collapse algebra. In this sense, the index α should be seen as a minimal parametrization of a much richer web of constraints linking all bits across all R_α , rather than as a set of independent degrees of freedom laid out along a simple line. Formally, this can be seen as the iteration of a single map $F : \Omega \rightarrow \Omega$ with $R_\alpha = F^\alpha(R_0)$, where the structure of F carries the true complexity of the process.

Having established this field Φ of pure possibilities, the next step is to see how, from this elementary information, organized patterns can emerge. But before addressing the emergence of patterns (Level 1), we must understand the fundamental property that makes all geometry possible: order.

The one-dimensional nature of Φ does not limit its expressive power. From a coding perspective, a single infinite 1D sequence is sufficient to encode arbitrarily high-dimensional discrete configurations: classical constructions such as space-filling curves (Peano, Hilbert) and Gödel-type encodings provide explicit mappings between one-dimensional sequences and higher-dimensional arrays. The Hilbert projection used in Figure 3 is a simple example of such an unfolding: it takes the linear sequence of bits and rearranges it into a 2D layout, making the underlying multi-scale correlations visually apparent. In this sense, the “one-dimensionality” of Φ is a choice of minimal representation, not a fundamental limitation on the richness of the structures it can support.

8 The Ordering Property as the Essence of Emergent Geometry

The recursive nature of R_α —detailed in the previous section—has a consequence that deserves special attention: it induces an **ordering relation** that is the seed of all geometry. Each new iteration R_α not only adds information, but *organizes* all previous information according to an inherent hierarchy. This ordering property is not a later addition, but emerges from the recursive collapse process itself.

8.1 Formalization as a partial order (poset)

Mathematically, we can formalize this structure as a **partial order** or **poset** (X, \preceq) , where X is the set of all states R_α and the relation \preceq is defined by:

$$R_\beta \preceq R_\alpha \quad \text{if and only if} \quad \beta \leq \alpha$$

That is, an earlier state is “contained” in all later states. This relation is:

- **Reflexive:** $R_\alpha \preceq R_\alpha$ (each state contains itself)
- **Transitive:** If $R_\gamma \preceq R_\beta$ and $R_\beta \preceq R_\alpha$, then $R_\gamma \preceq R_\alpha$
- **Antisymmetric:** If $R_\alpha \preceq R_\beta$ and $R_\beta \preceq R_\alpha$, then $\alpha = \beta$

2D raster — B (i=20, 5,000,000 bits; square 2237×2237)

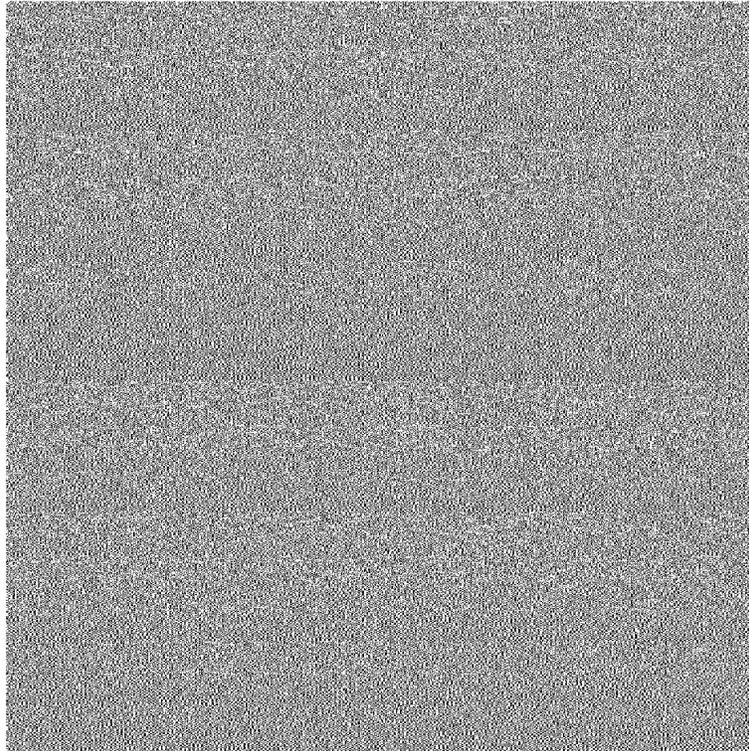


Figure 2: Primitive informational field (Φ) after 18 iterations (Canonical Variant B). 2D visualization of bit organization. The coherent and structured patterns confirm the emergence of order from primordial tension. Total: 1,407,228,082 bits generated. Fractal dimension: $D \approx 0.982$. Our simulation (see section 4.1).

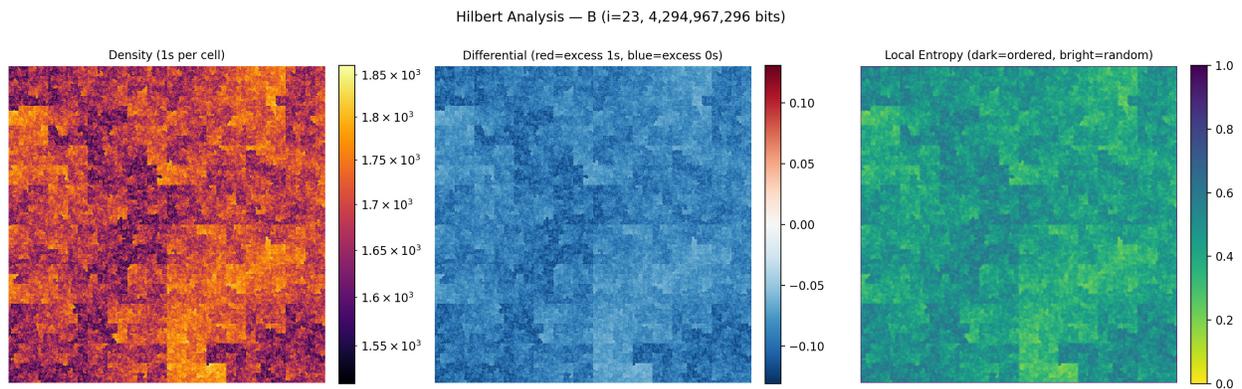


Figure 3: Hilbert analysis of the Φ field (Variant B, 23 iterations, 4,294,967,296 bits). The three panels show density, differential, and local entropy, revealing coherent structure at multiple scales characteristic of emergent order.

This poset structure is the minimal mathematical basis necessary to define an **order topology** [22]. The topology generated by the open intervals $(\leftarrow, R_\alpha) = \{R_\beta : R_\beta \prec R_\alpha\}$ and $(R_\alpha, \rightarrow) = \{R_\beta : R_\alpha \prec R_\beta\}$ provides the first notion of “proximity” and “continuity” without needing to presuppose any metric or preexisting space.

8.2 From order to geometry

This order topology is the first step toward the emergence of geometry:

1. **Emergent causality:** The relation \preceq defines a natural causal structure: $R_\beta \preceq R_\alpha$ means that β is “causally prior” to α .
2. **Implicit dimensionality:** The branching of the collapse tree (each R_α can generate multiple $R_{\alpha+1}$ according to different degradation configurations) introduces a primitive notion of “directions” or “dimensions”.
3. **Emergent metric:** The “distance” between two states can be defined by the minimum number of collapse steps separating them, providing a discrete protometric.

This perspective connects with Carlo Rovelli’s **Relational Quantum Mechanics** [22], where spacetime is not a preexisting container, but emerges from relations between events. In our model, these relations are precisely the ordering relations \preceq between states R_α . We note that this connection is conceptual: the ISH shares with Rovelli the intuition that spacetime arises from more basic relations, but constitutes an autonomous framework.

8.3 Implications for understanding spacetime

The ordering property suggests that:

- Observable **geometry** (dimensions, metrics, curvature) is a macroscopic manifestation of this microscopic order structure.
- **Space** is not primordial, but emerges from the network of ordering relations between informational states.
- **Time**, like space, is not an external parameter: the index α provides a proto-sequential ordering (before/after), but physical time could emerge, as another dimension, from the geometry generated by the order structure.

This vision offers an answer to the fundamental question: *why does the universe have geometry?* The answer is that geometry is the natural manifestation of the order that emerges from the recursive collapse of pure Nothingness toward Absolute Nothingness. **Order is not generated arbitrarily, but is the necessary consequence of the primordial tension between 0 and 1.** There is no geometry without order, and there is no order without the primordial tension between 0 and 1.

With this understanding of order as the foundation of geometry, we can now address how organized patterns emerge from this ordered structure—this aspect is treated in Level 1.

Empirical validation of Level 0. The predictions of Level 0 have been subjected to computational validation through 12 algorithmic variants and 5 independent metrics (see Appendix B for complete results). The main findings are:

- The Lempel-Ziv complexity of the field Φ converges to $LZ \approx 1/\varphi \approx 0.618$, a signature absent in all random and deterministic controls (Appendix C).
- The hierarchical nesting tree exhibits $\bar{c} = \varphi + 1$ children per node in an algebraically exact manner, an analytical result independent of sequence length.
- Transfer Entropy between scales—with shuffle control—confirms genuine information flow ($\times 3.78$ to $\times 27.46$ above chance) for variants in the $1/\varphi$ family, while a single different line of code (Variant F) completely destroys this flow (Appendix G).
- Persistent topology (cubical TDA) and Hilbert visualization reveal coherent multi-scale structure, consistent with the emergence of order from the primordial tension (Appendices F and D).

These results do not constitute a “proof” of the ISH in a physical sense, but rather an internal validation: the formal mechanism of Level 0 generates, de facto, information with non-trivial and robust properties that no alternative source reproduces.

Note on the epistemological status of the higher levels. Everything that follows—Levels 1 and 2—constitutes a *research programme*, not a formalized theory. Level 0 rests on axiomatic foundations and has independent computational validation; Levels 1 and 2, by contrast, propose a conceptual architecture and provisional formalism (*ansätze*) intended to guide future research. The reader should bear this distinction in mind throughout the following sections.

9 Level 1: The Primordial Holographic Field

This level explains how the recurrent and infinite nature of information, generated by the Informational Singularity, tends to self-organize into recognizable structures. Chaos theory illustrates how, from an initially disordered state, a transition to a more ordered system can occur. Crucially, this self-organization is not arbitrary: it is grounded in the **order structure** established at Level 0 and formalized in the previous section.

From the fundamental dynamics of level 0 (Φ), recurrent patterns ($P_k(\Phi)$) emerge that represent stable informational configurations emerging from the primordial informational structure generated by recursive and self-referential iterations based on the annihilation of binary tensions. These patterns are not arbitrary collections of bits, but **ordered subsets** of the preorder (X, \preceq) defined earlier: each pattern respects the causal hierarchy inherent to the states R_α .

These stable configurations constitute the basis for the appearance of a *Primordial Holographic Field* (H). The holographic condition emerges as a set of patterns that manifest within the informational field defined at Level 0, and from these patterns arise the first rules—understood as emergent higher-order regularities—that organize information. All sets of rules allow, in their place, the appearance of subsequent systems, even more ordered and complex. The representation of this process is as follows:

$$H = \sum_k P_k(\Phi) \cdot \omega_k, \quad (5)$$

where:

- **H**: Represents the *Primordial Holographic Field*, where patterns are transformed into rules.
- \sum_k : Indicates the sum of all possible interactions between patterns and rules.
- $P_k(\Phi)$: Are the recurrent and stable informational patterns that emerge spontaneously from the iterative simplification of the fundamental level. They are not arbitrary but a direct and natural consequence of the self-referential process defined at level 0. These recurrent patterns ($P_k(\Phi)$) represent the stable informational configurations emerging from primordial informational complexity. From the perspective of dynamical systems theory, these recurrent patterns correspond to the **attractors of the iterative system**: configurations toward which the system naturally tends, regardless of small variations in initial conditions. *The rigorous mathematical formalization of these recurrent patterns as attractors of the iterative system is found explicated in section 11.*
- ω_k : Represents the weight or relative informational relevance associated with each of these emergent patterns within the informational structure. The emergent rules (ω_k) defined at the holographic level do not have an independent or external existence to the system. On the contrary, they are intrinsic, emergent, and relational properties of the primordial informational substrate (Φ). Thus, these rules exist only as stable configurations generated spontaneously within the iterative system itself, and not as abstract or fundamental entities with prior independent existence.
- **The operation** $P_k(\Phi) \cdot \omega_k$: Indicates the transformation of patterns into rules, so that each pattern activates or generates a specific rule [23].

9.0.1 Illustrative example: pattern–rule pair from Variant B

To make concrete these abstract definitions, we present an example extracted from computational analysis of Variant B at iteration 17 ($\approx 5 \times 10^8$ bits). The Level-1 analyzer detects 7970 observable patterns in the range 10–49 bits. The single most recurrent pattern is:

$$P_\star = 0101010101$$

with 43 946 746 occurrences in the observable sequence. At the same time, the rule-inference agent identifies 73 708 context rules, 71.9% of which have confidence $\geq 99\%$. Among them, a particularly simple rule is:

$$\omega_\star : 1 \mapsto 0$$

with 100% confidence over 202 538 017 occurrences of context “1”.¹

This pair (P_\star, ω_\star) provides a concrete instance of a pattern–rule pair contributing to the holographic field $H = \sum_k P_k(\Phi) \cdot \omega_k$: $P_\star(\Phi)$ encodes the alternating structure and ω_\star captures a strong directional bias in the collapse dynamics. Although this is only one among thousands of patterns and rules, it illustrates how Level-1 analysis turns raw Φ -sequences into an explicit family of (P_k, ω_k) pairs extracted from the data.²

¹Note that the global bias of the Φ sequence from Variant B is $\approx 58.8\%$ zeros, which contributes to the high confidence of ω_\star . The example is used to illustrate the formal structure of the pattern–rule pair, not as independent evidence of the collapse dynamics.

²Data extracted from the Level-1 analysis of Variant B at iteration 17, with pattern lengths from 10 to 50 bits, generated by `level1_analyze_patterns.py`.

At the global scale, the same Variant B at iteration 23 ($\approx 2.5 \times 10^{11}$ bits) exhibits the complete φ -signature: Lempel-Ziv complexity ratio $\bar{c} = 0.6149 \approx 1/\varphi$ ($< 0.5\%$ deviation), mean children per branching node in the nesting tree $\bar{n} = 2.618034 \approx \varphi + 1$ (matching to 6 decimal places over 6.9×10^6 branching nodes), and Transfer Entropy ratio $\text{TE} = 3.78 \times$ the randomized control (*shuffle*). Three independent metrics, computed from different mathematical perspectives on the same Φ -sequence, converge to values determined by a single algebraic constant—a convergence not observed in any control variant (see Appendices C–G).

Note on notation: The notation employed below ($\Gamma, \mathcal{R}, \mathcal{T}$) is deliberately analogous to differential geometry to suggest the working programme, but the reader should not confuse these discrete operators, defined on a finite poset, with their continuum namesakes.

9.1 Informational Connection, Curvature, and Torsion

The relational nature of the rules ω_k requires a deeper formalization. To understand how patterns are transported between successive states, we introduce the concept of **informational connection**. This mathematical structure allows us to discover the hidden geometries that emerge naturally from pure information.

9.1.1 Informational connection Γ

The connection is a **discrete transport** of patterns between successive states of the preorder (X, \preceq) . Formally:

$$\Gamma_\alpha^{(k)} : \mathcal{S}(R_\alpha) \rightarrow \mathcal{S}(R_{\alpha+1})$$

defined by:

$$\Gamma_\alpha^{(k)}(P_k) = \omega_k(P_k)$$

9.1.2 Informational curvature \mathcal{R}

We propose an informational analogue of curvature, defined as a measure of whether transport depends on the order in which rules are applied. It is conceived as the discrete equivalent of Riemann curvature:

$$\mathcal{R}_\alpha^{(i,j)}(P) = \Gamma_{\alpha+1}^{(j)}(\Gamma_\alpha^{(i)}(P)) - \Gamma_{\alpha+1}^{(i)}(\Gamma_\alpha^{(j)}(P))$$

Physical and informational interpretation:

- If $\mathcal{R} = 0$, transport is coherent and the structure is flat (no interference between rules).
- If $\mathcal{R} \neq 0$, transport depends on the path and curvature emerges (rule interference, local chaos).

Empirical note. The commutativity analysis of Variants E and I (Appendix E) can be read as a first macroscopic probe of \mathcal{R} : both variants apply the same pair of annihilation rules ($01 \rightarrow 0, 10 \rightarrow 0$) in opposite order, yet converge to the same $1/\varphi$ signature. This suggests that, at the global scale, $\mathcal{R} \approx 0$ —the holographic field is approximately *flat*—while the transient divergence observed around byte 91×10^6 reveals a region of non-zero curvature at finer resolution. A rigorous operationalization of \mathcal{R} at the pattern level remains an open problem.

9.1.3 Informational torsion \mathcal{T}

We propose an informational analogue of torsion that captures internal asymmetries, that is, how transport is affected when the pattern slightly changes its position within R_α . It is conceived as analogous to Cartan torsion:

$$\mathcal{T}_\alpha^{(k)}(P) = \Gamma_\alpha^{(k)}(P) - \Gamma_\alpha^{(k)}(P^{\text{shift}})$$

where P^{shift} is the same pattern displaced within R_α according to \preceq .

9.1.4 Illustrative example

To make these definitions more concrete, consider an abstract mini-example with 3 symbolic states (R_0, R_1, R_2) and 2 patterns (P_1, P_2). *Note:* the values 0, 1, 0 assigned to the states are purely illustrative to show how Γ , \mathcal{R} and \mathcal{T} work; they do not literally represent the first iterations of Level 0 dynamics.

- **States:** $R_0 = 0, R_1 = 1, R_2 = 0$ (symbolic example values).
- **Patterns:** $P_1 =$ “0-1 alternation”; $P_2 =$ “repetition of 0”.
- **Connection Γ :** $\Gamma_0^{(1)}(P_1) = \omega_1(P_1)$ transports the alternation pattern from R_0 to R_1 .
- **Curvature \mathcal{R} :** If we apply first ω_1 then ω_2 , or vice versa, and obtain different results, then $\mathcal{R} \neq 0$. This indicates interference between rules.
- **Torsion \mathcal{T} :** If pattern P_1 detected at the “start” position of R_1 generates a different rule than the same pattern detected at the “end” position, then $\mathcal{T} \neq 0$. This indicates structural asymmetry.

This example shows that the operators Γ , \mathcal{R} , and \mathcal{T} are conceptually operative, although their precise definition requires a complete specification of the patterns and rules.

9.2 Rules as poset morphisms

The relational nature of the rules ω_k deserves special attention. They are not simply “weights” or “coefficients”, but have a deep mathematical structure: they are **poset morphisms** that preserve the order structure established at Level 0.

Formally, each rule ω_k can be understood as a mapping between partially ordered sets (posets):

$$\omega_k : (X, \preceq) \rightarrow (Y, \preceq')$$

that satisfies the **order-preservation property**:

$$R_\beta \preceq R_\alpha \implies \omega_k(R_\beta) \preceq' \omega_k(R_\alpha)$$

This property is crucial: it means that rules *respect causality*. If a state R_β is causally prior to R_α (i.e., $R_\beta \preceq R_\alpha$), then the rule applied to R_β must also be “prior” (in some sense) to the rule applied to R_α . This causal coherence is what allows the emergent order at Level 0 to propagate to higher levels.

Concrete example (symbolic): Consider 4 symbolic states with illustrative values: $R_0 = 0, R_1 = 1, R_2 = 0, R_3 = 0$. The order is $R_0 \preceq R_1 \preceq R_2 \preceq R_3$. Suppose a pattern P_1 detects “0-1-0 alternation” and generates a rule ω_1 that assigns “binary symmetry”. Then $\omega_1(R_2)$ (symmetry detected up to R_2) is “contained” in $\omega_1(R_3)$ (symmetry detected up to R_3), thus preserving order.

The rules ω_k are meta-relations that operate on the order structure (X, \preceq) and generate new ordered structures that give rise to observable geometry.

From the perspective of **category theory** [24], the set of all rules $\{\omega_k\}$ forms a **category of morphisms**, where the objects are the ordered states R_α and the arrows are the rules that relate them.³ This categorical structure allows composing rules: if ω_j and ω_k are two rules, their composition $\omega_j \circ \omega_k$ is also an order-preserving rule. This composition of morphisms is precisely the mechanism by which simple rules from Level 1 combine to generate the complex geometries of Level 2.

Empirical note. Although the formal verification that the rules ω_k are poset morphisms remains an open problem, the experimental evidence points in this direction: (i) Variants E and I apply the same rules in opposite order and converge to the same statistical attractor (commutativity), consistent with morphism composition; (ii) Transfer Entropy confirms genuine and structural inter-scale information flow, not random; and (iii) the triple independent convergence to φ (LZ, nesting tree, TE) would be difficult to explain without a coherent propagation of order through the rules. These observations suggest that the ISH could be generating the order transfer necessary for the categorical interpretation, but confirming this requires a complete operationalization of the operators Γ , \mathcal{R} and \mathcal{T} at the pattern level.

9.3 Energy Functional and Order Flow

Note: In this section we present a conceptual construction that suggests how stable configuration selection could be formalized. Its rigorous definition is identified as a future line of research.

To understand how the system selects stable rule configurations, we introduce an **order energy functional** that penalizes incoherence and rewards causal coherence. This functional would allow us to understand how information self-organizes naturally, without the need for external intervention.

9.3.1 Energy functional $\mathcal{E}[\omega]$

We define:

$$\mathcal{E}[\omega] = \alpha|\mathcal{R}[\omega]|^2 + \beta|\mathcal{T}[\omega]|^2 + \gamma\Phi_{\text{incoh}}[\omega]$$

where:

- \mathcal{R} is the informational curvature (rule interference).
- \mathcal{T} is the informational torsion (persistent asymmetries).
- Φ_{incoh} is a measure of incoherence (loss of order causality or pattern redundancy).
- α, β, γ are parameters that determine the relative importance of each term.

The term $\Phi_{\text{incoh}}[\omega]$ represents informational incoherence: it measures the degree to which the rules ω generate contradictory or incompatible patterns. This term would act as a penalty that forces the system toward coherent configurations, ensuring that the emergent order is internally consistent. Without this term, the system could generate mutually contradictory rules that would not give rise to stable geometries.

This functional measures the “quality” of a set of rules: configurations with low curvature, low torsion, and high coherence have low energy.

³A category is a mathematical structure that formalizes relations between objects through morphisms (arrows) that can be composed. In our case, the objects are the ordered states R_α and the morphisms are the rules ω_k that preserve order.

9.3.2 Order flow

Within this framework, the system would evolve toward minimum energy configurations through a **gradient flow**:

$$\frac{\partial \omega}{\partial t} = -\nabla_{\omega} \mathcal{E}[\omega]$$

This flow would act on the space of rules, seeking **stationary states (solitons)** where \mathcal{R} and \mathcal{T} are minimal or constant.

Order solitons: Under this hypothesis, solitons would correspond to stable **informational attractors** $P_k(\Phi)$. When the residual torsion $\mathcal{T} \neq 0$, an **order symmetry breaking** ($G \rightarrow H$) would occur. Rules would cease to be invariant, creating new coherent patterns. This would be the origin of geometry.

Interpretation: The order flow would be the mechanism by which the system “silences the noise” from Level 0 and crystallizes into coherent geometry. At this stage, dimensionless invariants (spectral ratios, symmetry indices, etc.) would appear, equivalent to “effective physical constants”. This process would not be externally imposed, but would emerge spontaneously from the primordial informational structure.

9.4 The Holographic Field as a relational decoder

With this understanding of rules as morphisms, we can now see the Primordial Holographic Field as a “relational decoder” that:

- Receives the primordial informational structure inherent in Φ and transforms it into patterns ($P_k(\Phi)$).
- These patterns, through their interaction, give rise to potential rules (ω_k).
- From this interaction emerges the primordial order, which will establish the ground so that, at Level 2, concrete dimensions and geometries manifest.

In summary, we can describe the transition as follows:

1. R_{α} generates infinite sequences of 0s and 1s.
2. $P_k(\Phi)$ detects patterns in these sequences, identifying repetitions, symmetries, and recurrent structures.
3. These patterns interact with the rules ω_k : each pattern activates certain rules, forming a primordial “grammar”.
4. The sum \sum_k represents the combination of all patterns and the interaction between them, giving rise to the emergence of more complex structures.

This initial order of rules, resulting from the transformation of the primordial informational structure into organized patterns, prepares the ground so that, at Level 2, this information manifests as observable dimensions and geometries.

In this sense, the holographic condition relies on ideas of phase transitions and chaos theory [3], and establishes the connection with Level 0, where the informational base Φ is generated. Thus, the continuity of the model is clearly reflected: starting from the infinite chain of zeros and ones, the system self-organizes patterns that, through interaction, define the first laws of emergent order. Although the process is deterministic and structured, sensitivity to initial conditions and

the spontaneous emergence of self-similar fractal patterns are fundamental traits characteristic of systems described by chaos theory.

Indeed, the empirical results from Level 0 already show indications consistent with the pattern emergence that Level 1 predicts: the Hilbert visualization of the field Φ reveals spatial coherence at multiple scales, and persistent topological analysis (TDA) detects cycles (β_1) that survive across wide filtration ranges—a signature of hierarchically organized self-similar patterns (see Appendices F and G).

The next step in our hierarchy is the transition from organized patterns to geometric structures, which occurs at Level 2: the Fundamental Geometric Field.

10 Level 2: The Fundamental Geometric Field

Preliminary note: As with Level 1, the structures presented here (Ψ , the transformations f and g , the modes ϕ_i) constitute a **programmable proposal**. No numerical calculation of Ψ from Level-0 data has been performed; the formalism is intended to define a research programme, not to report established results.

At this level, the emergent rule sets from the Primordial Holographic Field combine to generate more complex structures that manifest as waves, dimensions, and observable geometries. This field is the physical representation of the transition of information from a chaotic state to a more structured order.

Crucially, this combination is not arbitrary: it is the result of the **composition of morphisms** established at Level 1. Recall that each rule ω_k is a poset morphism that preserves order. At Level 2, these rules compose with each other, generating more complex morphisms that ultimately give rise to observable geometry. This composition respects the causality established at Level 0, ensuring that the emergent order propagates to macroscopic physical structures.

We can describe this level through the following formula:

$$\Psi = \sum_{i=1}^{\infty} c_i \phi_i, \quad (6)$$

where:

- Ψ : Represents the *Fundamental Geometric Field*, the global state that contains all possible configurations (it is the “universal” wave function that describes physical reality).
- ϕ_i : Are the waves or modes that emerge, each representing a possible physical configuration.
- c_i : Are the amplitudes associated with each mode, indicating the probability or relative importance of each configuration.
- $\sum_{i=1}^{\infty}$: Indicates that reality is a superposition of all possibilities (a sum over a potentially infinite number of modes).

The fundamental relationships with the Holographic Field are as follows:

- The emergent rules ω_k determine the possible forms of the waves through a transformation function f :

$$\phi_i = f(\omega_k).$$

- The patterns $P_k(\Phi)$ detected at the previous level determine the amplitudes through a function g :

$$c_i = g(P_k(\Phi)).$$

From the categorical perspective developed at Level 1, these functions f and g are not simply “bridges” between information and physics, but are **functors** between categories: f maps the category of morphisms $\{\omega_k\}$ to the category of geometric modes $\{\phi_i\}$, preserving morphism composition. This means that if two rules ω_j and ω_k compose at Level 1, their corresponding modes ϕ_i and ϕ_j also compose coherently at Level 2. This categorical coherence is what guarantees that the causal order of Level 0 manifests as observable geometric structure.

10.1 Informational Laplacian and Geometric Modes

Important note: The transformations f and g presented in this section, as well as the Laplacian Δ and modes ϕ_i , are conceptual constructions that illustrate the proposed mechanism for the emergence of geometry. Their precise connection to operators in theoretical physics requires future development.

The transition from Level 1 to Level 2 is formalized through spectral analysis of the informational connection. The solitons of the order flow define a basis of geometric modes that constitute observable geometry. This mathematical structure allows us to understand how dimensions and physical laws emerge from pure information.

10.1.1 Informational Laplacian Δ

In the continuous case, the informational Laplacian is defined as:

$$\Delta_{\text{cont}} = D_{\text{cont}}^\dagger D_{\text{cont}}$$

where D_{cont} is the transport operator (covariant derivative) generated by the connections Γ .

In the discrete case, a natural analogy is the graph Laplacian:

$$\Delta_{\text{disc}} = D_{\text{disc}} - A$$

where D_{disc} is the degree matrix and A is the adjacency matrix (transitions via Γ).

Note: These two definitions are not identical, but analogous: Δ_{cont} is a differential operator on manifolds, while Δ_{disc} is a combinatorial operator on graphs. Both capture the same intuition—measuring the “roughness” of a distribution—but in different mathematical contexts.

10.1.2 Geometric modes ϕ_i and eigenvalues λ_i

The geometric modes are the eigenvectors of the Laplacian:

$$\Delta\phi_i = \lambda_i\phi_i$$

Physical interpretation:

- Modes with $\lambda = 0$: pure symmetries (configurations invariant under the order flow).
- Modes with $\lambda > 0$: “informational masses”, stabilized patterns with associated energy.
- This structure deliberately reproduces the analogy with vibration modes and field masses in quantum physics, since the goal of Level 2 is precisely to connect the informational substrate with the known physical formalism.

The eigenvalues $\{\lambda_i\}$ define the **informational spectrum** of the system, and the spectral gaps $\Delta\lambda_i = \lambda_{i+1} - \lambda_i$ measure the separation between modes. These gaps are crucial: they determine which configurations are stable and which are not.

10.1.3 Geometric emergence criterion

Formal definition: Geometry emerges when the order flow stabilizes a finite spectrum of eigenmodes $\{\phi_i\}$ with stable spectral gaps $\{\lambda_i\}$.

Formally, we say there is **geometric emergence** if:

1. The modes ϕ_i are stable under small perturbations (robustness).
2. The gaps $\lambda_i - \lambda_{i-1}$ are consistent between iterations (convergence).
3. The rules ω converge to a soliton (stationary state of the flow).

This criterion is, in principle, **potentially falsifiable**: once a concrete implementation of the model is available, one could experimentally verify whether a system satisfies these conditions. It represents a promising pathway to understanding when pure information manifests as observable geometry.

10.2 Dimensionless Invariants

Dimensionless invariants are quantities without dimensions that characterize the emergent geometric structure and allow comparing different configurations independently of scale. These invariants are the key to linking Level 1 with Level 2 and with emergent physics.

10.2.1 Eigenvalue ratio

We define:

$$\rho_i = \frac{\lambda_{i+1}}{\lambda_i}$$

This ratio measures the relative separation between consecutive modes. Constant values of ρ_i indicate a regular spectral structure, analogous to a “musical scale” in physics. This regularity is a sign of deep geometric coherence.

10.2.2 Stability index

We define:

$$\eta = \frac{\sum_i |\Delta\lambda_i|}{\sum_i \lambda_i}$$

This index measures the relative variability of spectral gaps. Low values of η indicate high stability (well-defined geometry). High values indicate instability (geometry in transition or chaotic).

10.2.3 Residual symmetry

After the order flow, the original symmetry group G breaks into a subgroup $H \subset G$ that preserves the stable rules ω . The relative size $|H|/|G|$ measures how much symmetry is preserved.

In summary:

1. The Primordial Holographic Field organizes the patterns $P_k(\Phi)$ and generates the rules ω_k .
2. These elements are transformed, through f and g , into modes ϕ_i with amplitudes c_i .
3. The infinite superposition of these waves gives rise to Ψ , the global field that contains all dimensions, geometries, and ultimately, all possible states of reality.

This model is *structurally analogous* to aspects of String Theory, where each term ϕ_i can be interpreted as a possible vibration state of strings, and the infinite sum reflects the presence of multiple ways to organize reality. We emphasize that this is an analogy of mathematical form, not a formal derivation: no mapping between the ISH modes ϕ_i and string vibration states has been established. Thus, the Fundamental Geometric Field not only describes the physical manifestation of information, but also acts as a bridge between the quantum world and the observable structure of the universe.

In this way, we have built a bridge from the pure informational base of Level 0 and its initial organization in Level 1, to arrive at the Fundamental Geometric Field, where physical structures manifest. In the following section we will mathematically formalize this scheme to give it even greater solidity.

10.3 Transition from the Primordial Holographic Field to the Fundamental Geometric Field

The transition from Level 1 (Primordial Holographic Field) to Level 2 (Fundamental Geometric Field) represents a crucial step in the emergence of observable physical structure. This transition, mediated by the transformations f and g , deserves a more detailed analysis.

The transformation $f : \mathcal{W} \rightarrow \mathcal{H}_{geom}$ operates through a structural projection process: each emergent rule ω_k of the Holographic Field intrinsically contains a set of symmetries and restrictions that define the possible physical configurations. These symmetries act as boundary conditions that determine the mathematical form of the waves ϕ_i . Formally:

$$\phi_i = f(\omega_k) = \int_{\mathcal{W}} K(i, k) \cdot \omega_k dk \quad (7)$$

Where $K(i, k)$ represents the transformation kernel that connects each rule ω_k with its corresponding geometric mode ϕ_i . This kernel can be understood as a generalized Green's function that translates the algebraic properties of the rules into wave structures.

From the categorical perspective, $K(i, k)$ is the **composed morphism** that results from the composition of multiple rules ω_k from Level 1. This composition preserves order: if $\omega_j \circ \omega_k$ is a valid composition at Level 1 (i.e., it preserves the order relation \preceq), then the resulting geometric mode $\phi_i = f(\omega_j \circ \omega_k)$ also preserves this causal structure. This guarantees that the emergent geometry is not chaotic, but reflects the primordial order established at Level 0.

In parallel, the function g assigns amplitudes c_i to each mode ϕ_i based on the relative prominence of the patterns $P_k(\Phi)$ that generated the original rules:

$$c_i = g(P_k(\Phi)) = \sum_k \alpha_{ik} \cdot |P_k(\Phi)|^2 \quad (8)$$

Where α_{ik} are correlation coefficients that quantify the contribution of each pattern to the amplitude of the corresponding mode ϕ_i , and $|P_k(\Phi)|^2$ represents the “intensity” or recurrence of the pattern within the primitive informational field.

This double transformation (f and g) describes how informational organization (defined by the rules ω_k) translates into a structured physical reality (represented by the modes ϕ_i with amplitudes c_i). In this process:

1. The **topological properties** of the rules determine the spatial symmetries of the physical modes.

2. The **algebraic invariances** of the rules are expressed as conservation laws in the physical modes.
3. The **interrelations** between rules manifest as entanglements between the different physical modes.

This transition can be visualized as the moment when the abstract “laws” of the holographic level “materialize” into concrete forms of waves and fields, giving rise to the emergence of spatiotemporal dimensions and, subsequently, to fundamental physical interactions.

At this point, the internal connection between \mathcal{H} and Ψ is especially clear: in our model, the observable geometry Ψ emerges from the network of compositions between morphisms ω_k . Geometry is not presupposed as a preexisting container, but appears as the emergent result of the relational structure defined by the rules ω_k and the underlying order that comes from Level 0. The key difference with respect to other frameworks of geometric emergence is that, here, this relational structure has its ultimate origin in the primordial tension between pure Nothingness (0) and Absolute Nothingness (1), which provides a deeper ontological foundation for the emergence of Ψ .

Research note—the central open problem: The transition from Level 0 to Level 2—that is, how a purely informational dynamics (binary sequences, annihilation, accumulation) gives rise to a spacetime with geometry, dimensions, and physical fields—constitutes the **central open problem** of the ISH, analogous to the *hard problem* of consciousness in philosophy of mind. Level 1 provides a conceptual bridge (patterns \rightarrow rules \rightarrow geometry), but, as already noted, the exact mechanism by which the emergent rules ω_k of the Holographic Field manifest as physical modes ϕ_i of the Geometric Field—remains the least formalized transition of the model. Although the transformations f and g provide a first formal structure, the rigorous mathematical development of this transformation constitutes the central priority of the future research program. The Level 2 formalism has been constructed to converge toward known physics; however, it is possible that the actual path from Level 0 to observable reality is deeper than we anticipate and may yield surprises that no preconceived formalism can foresee.

Nevertheless, persistent topological analysis of the field Φ already detects cycles (β_1) with long lifetimes and a ratio $\beta_1/\beta_0 \approx 1.9$ for the canonical family, suggesting the existence of incipient geometric structure within the information generated at Level 0. This observation is consistent with the idea that the dimensions and geometries of Level 2 are not externally imposed, but rather germinate within the informational structure itself (see Appendix F).

10.3.1 Diagram of the Level 1 \rightarrow Level 2 transition

The following figure schematically illustrates how the mathematical structures of Level 1 (Primordial Holographic Field) give rise to those of Level 2 (Fundamental Geometric Field):

11 Mathematical Formalization and Model Structure

This section presents the mathematical foundation that supports the Informational Singularity Hypothesis. The model is constructed from two fundamental pillars: first, the definition of an infinite combination Φ that represents the primitive informational substrate; and second, the role of transformations T , f , and g in converting this primitive information into physically observable structures.

Level 1: Holographic Field

Level 2: Geometric Field

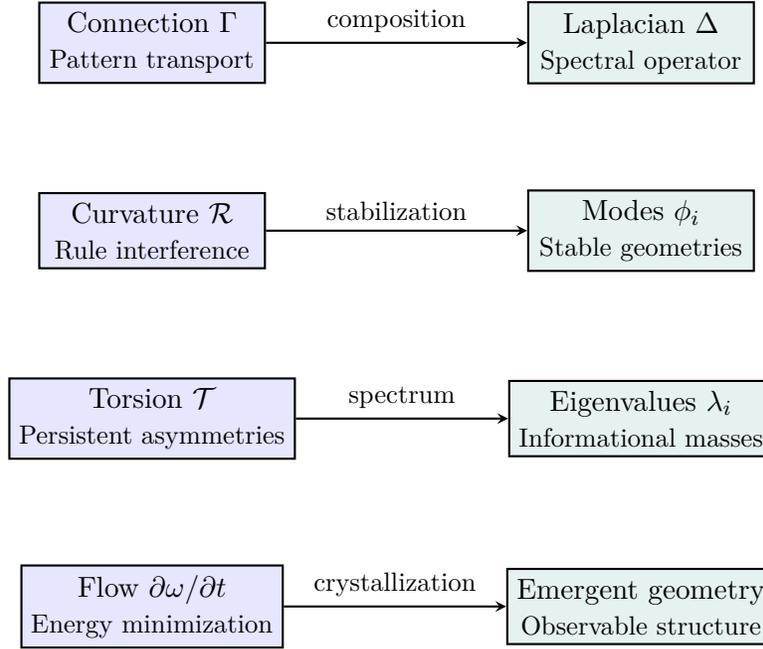


Figure 4: Transition from Level 1 (Primordial Holographic Field) to Level 2 (Fundamental Geometric Field). The mathematical structures of Level 1 (connection, curvature, torsion, flow) are transformed into those of Level 2 (Laplacian, modes, eigenvalues, observable geometry) through processes of composition, stabilization, and crystallization.

11.1 Fundamental Elements

1. **Recursive Informational Structure R_α :** Each R_α is a recursive, cumulative, and self-referential informational structure: the sequence resulting from combining $(0, R_{\alpha-1}, 1)$ and applying the binary tension annihilation described above. Therefore, R_α is not idempotent, but dependent on all previous states, producing increasing and non-trivial complexity at each iteration.

2. **Explicit formalization of the `simplify()` function:**

The function `simplify(0, $R_{\alpha-1}$, 1)` is formally defined as an iterative reduction operator that transforms the tension between pure Nothingness (0) and Absolute Nothingness (1) into a stable sequence.

Formally:

Let S_α be the binary sequence resulting after incorporating the Absolute Nothingness state (1) to the accumulated sequence $R_{\alpha-1}$:

$$S_\alpha = (0, R_{\alpha-1}, 1)$$

Main experimental model (Variant B—Opposite pair annihilation):

The model currently being explored experimentally operates through **opposite pair annihilation** and **run compression**:

- (a) **Tension annihilation:** All patterns 01 and 10 in the sequence are annihilated and simplified to 0 (returning to Nothingness, as the tension between both elements always resolves into nullity);
- (b) **Run compression:** Consecutive sequences of zeros or ones are reduced to a single symbol: $0^+ \rightarrow 0$, $1^+ \rightarrow 1$;
- (c) **Iteration:** The process is repeated until the sequence no longer changes (stabilization).

Convergence lemma: This process always stabilizes in a finite number of steps. *Proof:* each iteration can only remove symbols (never adds them), and the total number of bits is bounded below by zero. Therefore, the process is monotonically decreasing and finite. \square

The final stable sequence defines:

$$R_\alpha = \text{simplify}(0, R_{\alpha-1}, 1)$$

Operative variants of simplify and experimental exploration:

From an ontological standpoint, the **simplify** operator represents the coherent collapse of the tension between pure Nothingness (0) and Absolute Nothingness (1). However, when we attempt to discretize this intuition into an algorithm, several plausible implementations appear:

- The **pair annihilation model** (described above), which globally detects and annihilates 01/10 patterns;
- An **AND convolution model**, where each step applies $s'_i = s_i \wedge s_{i+1}$ on adjacent pairs, reducing the sequence length at each iteration;
- Variants in the **annihilation order and asymmetry treatment:** processing first all $10 \rightarrow 0$ and then all $01 \rightarrow 0$, or vice versa, to explore the asymmetric effects that arise.

From the ISH perspective, these variants do not represent contradictory versions of the fundamental principle, but rather **alternative discretizations** of the same ontological idea.

Canonical discretization (Variant B): In the algorithmic implementation we use as baseline (Variant B), **simplify** approximates the ideal collapse through local rewriting that symmetrically annihilates the patterns 01 and 10, collapses blocks of identical bits, and applies a final global collapse. This variant preserves the symmetry between Nothingness and Absolute at Level 0, respects the inside→out stratification, accumulates all intermediate micro-states (ontologically real), and guarantees that the final collapsed value is coherent with the ideal global conjunction. For these reasons, Variant B acts as the **canonical discretization** of the ideal Level 0 collapse.

The most extensive Level 0 simulations (23 iterations, with information accumulation on the order of 200+ GB) have been performed with this variant—although all variants have been explored experimentally—demonstrating the exponential information growth coherent with the theoretical prediction.

For this reason, experimental research associated with Level 0 also explores other variants of the **simplify** operator and compares their behavior (stability, richness of emergent patterns,

fractal structure, etc.). This strategy allows evaluating the robustness of the Informational Singularity Hypothesis with respect to discretization choices. Appendix A describes in detail the various variants explored, including schemes with symmetry breaking or alternative collapse orders.

Ideal collapse as global conjunction:

Ontologically, the `simplify` operator represents the coherent collapse of the tension between pure Nothingness (0) and Absolute Nothingness (1). At the logical level, this collapse can be naturally identified with boolean conjunction (AND), defined by the truth table:

$$0 \wedge 0 = 0, \quad 0 \wedge 1 = 0, \quad 1 \wedge 0 = 0, \quad 1 \wedge 1 = 1.$$

This allows us to introduce an *ideal collapse* of any finite sequence of bits $S_\alpha = (s_0, s_1, \dots, s_n)$ as:

$$\text{val}(S_\alpha) = \bigwedge_{i=0}^n s_i,$$

where \bigwedge denotes the iterated conjunction. In our case, by construction of Level 0 we have $S_\alpha = (0, R_{\alpha-1}, 1)$: the collective sequence always begins with a 0.

Since boolean conjunction is associative and commutative, the collapsed value of S_α does not depend on the order of bit association. Moreover, the fact that $s_0 = 0$ implies

$$\text{val}(S_\alpha) = 0 \wedge (\text{rest of the sequence}) = 0$$

for all α . Thus, if we consider the collapsed form of S_α as a single bit, Level 0 always has Nothingness (0) as its *final state*. This uniqueness of the final value coincides with the ontological interpretation of the return to Nothingness after any sequence of emergence and collapse.

Lemma (Uniqueness of the collapsed value for S_α). *Let $S_\alpha = (0, R_{\alpha-1}, 1)$ be a finite sequence of bits from Level 0. If $\text{Simplify}^*(S_\alpha)$ denotes the ideal collapse defined as the global conjunction of all its bits, then*

$$\text{Simplify}^*(S_\alpha) = 0$$

for all α .

Proof: Follows immediately from the AND truth table and the fact that the first bit of S_α is 0. \square

Remark: The Uniqueness Lemma is trivial by construction—the presence of an initial 0 makes any conjunction yield 0. The non-trivial content of Level 0 lies not in this final value, but in the **structure of the intermediate states** R_α , which encode progressively more complex binary sequences and constitute the substrate upon which the algorithmic variants of Level 1 operate.

Algorithmic variants and confluence:

In practice, variants B and D implement `simplify` through local rewriting schemes (elimination of 01 and 10 patterns, compression of identical bit blocks, AND convolutions, etc.). These variants are inspired by the intuition of global AND collapse, but we do not yet claim that they are strictly equivalent to the ideal operator $\text{val}(S_\alpha)$ in all possible cases.

In particular, we have not formally proven the *confluence* of all local rewriting rules (that is, that any sequence of rule applications always reaches the same normal form). Nevertheless, for sequences of type $S_\alpha = (0, R_{\alpha-1}, 1)$ that define Level 0, the ideal collapsed value is *necessarily* 0—a direct consequence of the fact that S_α always contains an initial 0 and the ideal collapse is a global AND conjunction (Uniqueness Lemma). The confluence problem therefore affects the *intermediate states* R_α —not the final collapsed value, which is a proven result within the ISH’s ontology.

Thus, from the perspective of the Informational Singularity Hypothesis, what is fundamental is not so much the detail of each local rewriting scheme, but the fact that the global collapse with respect to the 0/1 tension has a unique result (Nothingness) and generates, in the process, a sequence of states R_α that encapsulates the history of these torsions and collapses.

Open Problem (Confluence). Let (Σ, \rightarrow) be the string rewriting system of Variant B with rules $01 \rightarrow 0$, $10 \rightarrow 0$, $0^+ \rightarrow 0$, $1^+ \rightarrow 1$. *Prove or disprove that (Σ, \rightarrow) is confluent*, i.e., that every reduction sequence from a given input reaches the same normal form. If the system is not confluent, different implementations of **simplify** could produce distinct intermediate states R_α for the same α , and the field $\Phi = \{R_\alpha\}$ would not be well-defined as a unique mathematical object. Our computational results show that all tested variants converge to the same statistical signatures (density $\rightarrow 1/\varphi$, identical LZ complexity profiles, matching fractal dimensions), but “same statistical signature” does not constitute a proof of “same mathematical object.” A resolution of this problem—positive or negative—would either solidify or fundamentally constrain the formalization of Level 0.

3. **Primitive Informational Field (Φ):** As defined in Section 7, the field Φ is the **chain of states** $\{R_\alpha\}_{\alpha \in \mathbb{N}}$ generated by the iterative dynamics. Φ is not the entire space $\Omega = \{0, 1\}^{\mathbb{N}}$, but the **concrete orbit** of the dynamics: the more iterations explored (larger α), the richer the subset and the more structures can emerge at higher levels [7, 19].

At each iteration, the new state incorporates the entire accumulated history, producing a chain of progressively more complex states that explore an increasingly rich subset of Ω . This idea is comparable to how, in quantum mechanics, complexity emerges from the coexistence of multiple states (see [7] and compare with Greenberger–Horne–Zeilinger states for entangled systems).

4. **Pattern projector $P_k(\Phi)$:** $P_k(\Phi)$ is an operator that extracts recurrent patterns or structures within Φ . It acts as a filter that identifies repetitions, symmetries, or correlations within the binary configuration. This process is analogous to using a Fourier operator to decompose a signal into its basic components.
5. **Fundamental rules ω_k :** To each pattern $P_k(\Phi)$ there corresponds a *fundamental rule* ω_k obtained by applying a transformation T :

$$\omega_k = T(P_k(\Phi)).$$

11.2 Rigorous mathematical formalization of recurrent patterns $P_k(\Phi)$

Recurrent patterns $P_k(\Phi)$ are formally defined as the attractors of the discrete iterative system described at Level 0. In strict mathematical terms, these patterns satisfy at least one of the following conditions:

1. **Fixed points:** Configurations that remain invariant after applying the iterative operator:

$$R_\alpha = R_{\alpha-1}$$

2. **Limit cycles:** Configurations that repeat periodically after a finite number p of iterations:

$$R_{\alpha+p} = R_\alpha, \quad p > 1$$

3. **Fractal or pseudo-random recurrent patterns:** Configurations with internal regularities or self-similar structures that arise spontaneously within the emergent information generated by the iterative simplification. These can be analyzed formally using fractal tools and spectral techniques (e.g., Fourier transforms or pseudo-random sequence analysis).

The relative stability of these attractors within the informational space generated by Level 0 determines the associated weights ω_k , which indicate the frequency or stability of these patterns within the resulting primordial holographic field.

These rules may form part of an algebra that governs the dynamics of the patterns, providing the first “laws” that impose order on the initial emergent information [2, 3].

11.3 Integration of the Elements into the Observable Configuration

The transformations T , f , and g , still conceptual in nature, translate primitive information Φ into observable physical structure. We describe below how they act together:

- **Transformation T :** This function maps emergent patterns $P_k(\Phi)$ (detected within the directed family Φ) to fundamental rules ω_k . Formally, it can be defined as:

$$T : \mathcal{P} \rightarrow \mathcal{W},$$

where \mathcal{P} is the space of patterns and \mathcal{W} the space of rules. This transformation can be clearly visualized as analogous to a Fourier transform, where from the recurrent patterns ($P_k(\Phi)$) one extracts the fundamental rules (ω_k) of the system. Furthermore, if the patterns exhibit symmetries, T could be associated with operators satisfying commutation relations of a Lie algebra, providing an algebraic structure to the rules ω_k [3, 2].

- **Function f :** The function f converts each rule ω_k into a waveform ϕ_i that manifests in the Fundamental Geometric Field. Thus, f acts as:

$$f : \mathcal{W} \rightarrow \mathcal{H}_{geom},$$

where \mathcal{H}_{geom} is a functional space (potentially a Hilbert space) associated with geometric modes. This correspondence is similar to the normal-mode decomposition process, where each solution of a wave equation can be expressed as a basis function [13]. In essence, f translates algebraic abstractions into measurable waveforms.

- **Function g :** Finally, g assigns to each pattern (or each mode ϕ_i) an amplitude c_i , so that the global state of reality can be expressed as:

$$\Psi = \sum_i c_i \phi_i.$$

The coefficients c_i assigned via the function g represent the amplitudes associated with each fundamental mode ϕ_i . This mathematical construction is identical to the expansion of a state in an orthonormal basis in conventional quantum mechanics [23]. This assignment is key because it provides a numerical value that quantifies the effect of each mode on the formation of the observable physical state.

These three transformations act in a chained manner to translate the emergent information of the infinite combination Φ into an organized configuration that gives rise to the global wave function Ψ . This process can be visualized as:

$$\Phi \xrightarrow{P_k} P_k(\Phi) \xrightarrow{T} \omega_k \xrightarrow{f} \phi_i \xrightarrow{g} c_i \implies \Psi = \sum_i c_i \phi_i .$$

This chain of transformations integrates concepts from information theory, quantum mechanics, and algebraic symmetries, offering a coherent framework for understanding how order emerges from a primitive state of “absolute nothingness.” The physical interpretation of this scheme corresponds to the three levels already described in previous sections (Informational Singularity, Primordial Holographic Field, and Fundamental Geometric Field).

A rigorous and explicit mathematical formalization of these transformations constitutes an open line of future research, which will require deeper exploration of the algebraic and geometric structures that could underlie them.

The Three-Level Hierarchy of the Informational Singularity Hypothesis
 From Ontological Tension to Observable Reality: $\Phi \rightarrow \mathbf{H} \rightarrow \Psi$

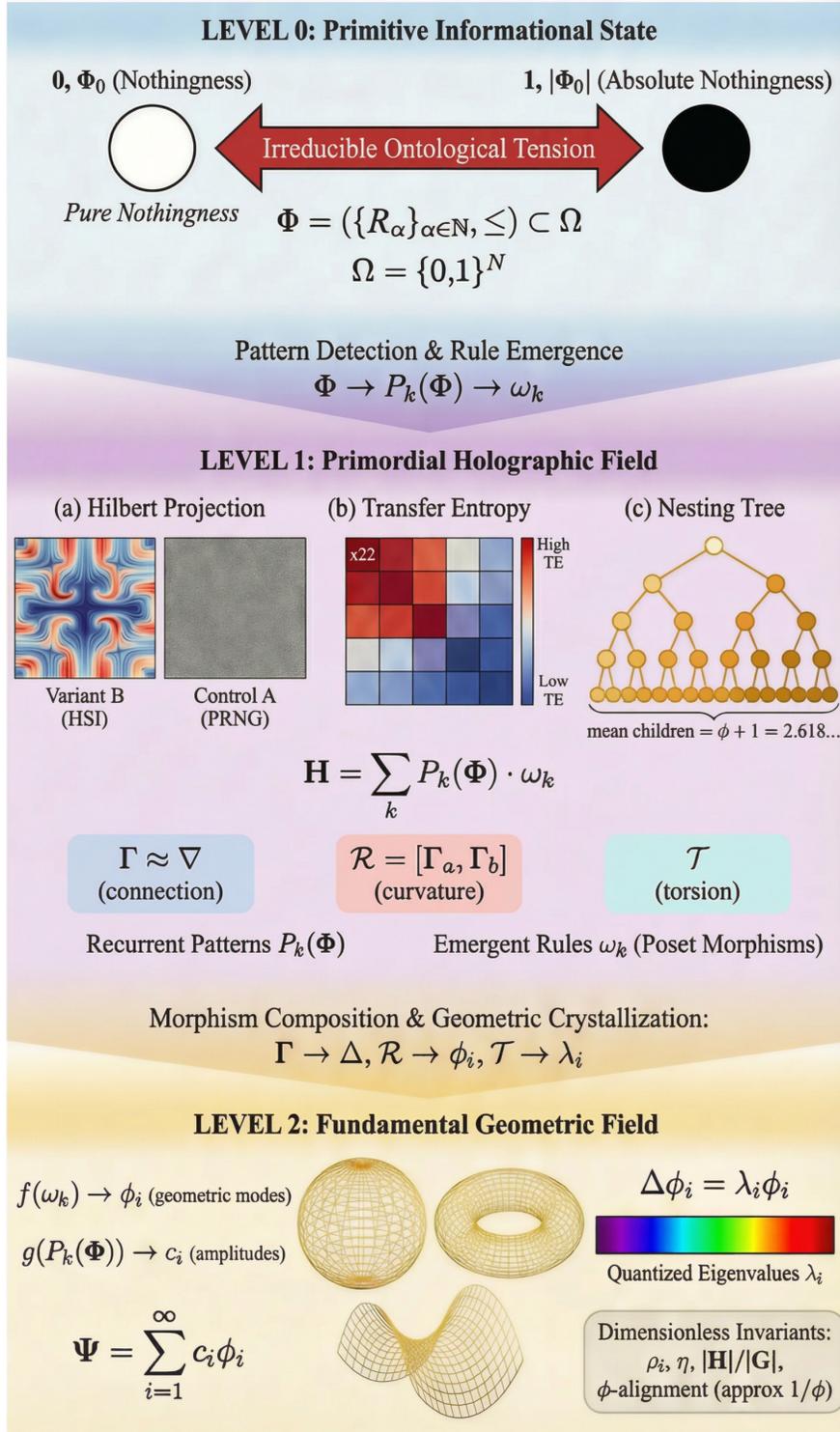


Figure 5: Schematic representation of the three-level hierarchy proposed by the Informational Singularity Hypothesis.

12 Intuitive Examples and Analogies

To illustrate how order can emerge from a purely informational initial state, it is very useful to draw on examples and analogies observed in other areas of science. These examples help visualize abstract concepts and connect the hypothesis with recognized phenomena in dynamical systems and information theory:

1. Cellular Automata and the Game of Life. A classic example is Conway’s *Game of Life* [15]. In this cellular automaton, one starts from a random initial configuration where each cell can be “alive” or “dead” (analogous to 1s and 0s). Despite the simple rules that determine the evolution of each cell, the system can generate surprisingly complex and structured patterns, such as *gliders* or oscillators. This emergence of complexity from simple rules serves as a metaphor for how the binary dynamics of Level 0 lead to the appearance of self-organized structures.

2. Phase Transitions in Physical Systems. In physics, phase transitions [25, 26] are phenomena where a system passes from a disordered state to an ordered state. For example, in a ferromagnetic material, when the temperature drops below the Curie temperature, atomic spins self-align, creating a global magnetization. Similarly, the hypothesis proposes that information, generated by a primordial binary tension, experiences a rhythmic dynamics in which bits synchronize and correlate to give rise to ordered structures. The slight instability in the tension between 0 and 1 gives rise to new ordered configurations of reality.

3. Quantum Entanglement. In quantum mechanics, entanglement is a key phenomenon where properties of multiple particles become so tightly correlated that measuring one immediately constrains the others, regardless of distance. Greenberger–Horne–Zeilinger (GHZ) states show that an entire system can share a global correlation even if each individual part appears random. This property reinforces the idea that, in the informational singularity, bits interact and correlate, generating a coherent informational fabric. In our model, this manifests the fact that all information arises from a single binary source, producing deep correlations among the system’s “fundamental bits.”

4. Fractal Geometry. The emergence of fractal structures from simple iterative processes provides a direct analogy to our model. Consider the Mandelbrot set, generated by the simple iteration $z_{n+1} = z_n^2 + c$. Despite the simplicity of this rule, it generates infinite complexity, self-similarity, and rich boundary phenomena at the edge between order and chaos. These properties parallel how our simple 01 dynamics in Level 0 can generate the infinite complexity observed in physical reality [27, 28, 26].

13 A New Perspective on Everything

It is counterintuitive that, in the fundamental substrate of everything we can perceive, there is nothing. It seems almost impossible to conceive of a state of absolute non-existence and how pure information emerges from it to constitute Everything [7, 1]. According to the presented hypothesis, we are pure information born from Nothingness, which implies that reality is constructed from an inherent tension between absence and totality.

This approach offers a new perspective, both philosophical and mathematical. If we understand this foundational principle, we can predict that a sufficiently complex virtual universe, observed from within, would be indistinguishable from a prior-level fundamental universe, since both would be formed by the same essence: pure information [29]. This suggests that the nature of reality can ultimately be described as the manifestation of a primordial informational state.

Moreover, we can foresee that **holographic emergence** can extend to all levels and subsystems, so that information flows in a much more interconnected way than we usually imagine. This

interconnection may explain the apparently “magical” effects of quantum entanglement, relating it to the fundamental ideas of the holographic principle [2, 3], as well as to specific studies proposing that entanglement directly builds the geometry of space and time [27, 28].

In this context, we can ask: what was the Big Bang, really? How is information transmitted between dimensions, and what is the deep reason for its existence? What are the attractors behind the matter-energy duality? These questions open a research field where information, as the basis of reality, could be the key to understanding not only the origin of the universe, but also the principles that govern its evolution.

13.1 Philosophical Implications

The ISH opens several lines of philosophical and metaphysical reflection that follow directly from the proposed theoretical framework:

- **Reality–virtuality indistinguishability:** If reality is, ultimately, pure information emerging from Nothingness, a sufficiently complex virtual universe—observed from within—would be indistinguishable from a fundamental universe, since both would be formed by the same informational essence [1, 29].
- **Thought, consciousness, and information:** Thought can be understood as an emergent pattern of information, and from this framework, consciousness can be approached as a subject of study within pure thought itself—opening the way toward a fundamental theory of consciousness rooted in the informational substrate itself [30, 31].
- **Origin of causality:** The three foundational principles (P1–P3) necessarily lead to Nothingness as the sole radical origin and, from it, to the primordial tension between pure Nothingness (0) and Absolute Nothingness (1). This irreducible tension constitutes the origin of causality itself: there is no cause without tension, and no tension without the ontological contradiction between absence and totality.
- **Geometry as an emergent construction:** Geometry is not pre-existing but emerges from the **informational order** (X, \preceq) of Level 0, which generates the conditions for notions such as *proximity*, *connection*, and *curvature* to arise at higher levels—an idea that aligns conceptually, though not formally, with certain perspectives of quantum gravity and non-commutative geometry [32, 33].
- **Coexistence of Everything and Nothingness:** The ISH offers a resolution to the fundamental question of why there is something rather than nothing. Nothingness, being all there “is,” is forced to contain itself, and this self-containment generates an irreducible ontological tension: the infinite annihilation of Nothingness with itself. All of existence is, at its origin, this vibration. Thus, Everything and Nothingness are not opposed but coextensive: reality, at its purest substrate, does not exist—it oscillates.

13.2 Resolution of the observer paradox

A frequent doubt when proposing a fundamentally informational hypothesis is the question of the observer: who or what “observes” or processes primordial information before physical observers or defined consciousness exist?

From the perspective of the Informational Singularity Hypothesis proposed here, this paradox dissolves naturally. The foundational informational approach does not depend on the prior existence

of a consciousness or external observer. On the contrary, primordial information is conceived as an autonomous and self-sufficient entity that emerges spontaneously from an irreducible tension between the abstract states of pure Nothingness (0) and Absolute Nothingness (1). This perspective aligns conceptually with Wheeler’s “*It from Bit*”, where information is the fundamental entity from which observable physical reality emerges, without the need for any prior or external observer [1, 34].

In particular, self-reference in this context does not imply a *consciousness* or *intentionality* that observes the process, but an intrinsic structural property of the informational system itself.

In the proposed model, self-reference naturally emerges from the recursive dynamics of the system, where each new state R_α necessarily incorporates all previous states. This systematic inclusion of the complete history of the process within each new state constitutes a form of *structural* or *formal* self-reference, independent of any observer. It is self-reference in the mathematical and logical sense, similar to how Gödel’s theorems [35, 36] show that certain formal systems can refer to themselves without the need for an external agent.

More specifically, when Absolute Nothingness (1) incorporates prior pure Nothingness (0), the system is effectively “pointing” or “referring” to itself, creating a closed causal loop that requires no external entity to function. This process is comparable to a recursive system in which

$$S_\alpha = F(S_{\alpha-1}) \tag{9}$$

where each new state S_α is a function F of the previous state. This recursion automatically generates self-reference because the system “reads” its own prior state to determine the next. This phenomenon of structural self-reference has been extensively analyzed in formal systems by Hofstadter [37] and studied in relation to algorithmic complexity theory by Chaitin [7].

Thus, self-reference in the Informational Singularity Hypothesis is an emergent property of the very logical structure of the process, not a phenomenon that requires an observer. This distinction between structural self-reference (inherent to the system) and intentional self-reference (which requires an observer) preserves the model’s coherence without falling into infinite regression or vicious circularity, thereby avoiding the self-reference paradoxes identified by Russell [5] and formalized by Tarski [6].

Thus, the primordial information proposed here requires no prior external observer to exist. Rather, physical observers, consciousness, and any form of entity capable of observing are emergent from the exponential increase in complexity of this primary informational substrate (Φ). This interpretation avoids the circularity associated with the observer paradox, since physical reality and conscious observers are not prerequisites but late products of this fundamental, self-organized informational substrate [20, 21, 38, 1, 34, 39].

13.3 Implications for Modern Physics

Quantum Entanglement:

- Entanglement can be reinterpreted as an expression of a global informational structure rather than “spooky action at a distance.” Entanglement would act as an emergent property of the Primordial Holographic Field, connecting systems that appear independent [28].
- There may exist a non-local information mechanism underpinning the deep integration of information at the quantum level [3]. In this regard, Transfer Entropy experiments with shuffle control have detected genuine information flow between scales ($\times 3.78$ to $\times 27.46$ above chance; Appendix G), an empirical signal compatible with the non-local informational integration that entanglement requires.

Unification of Forces:

- Information is conceived as the unifying substrate of all that exists, potentially opening the door to resolving the matter–energy duality [1]. The observed statistical commutativity—Variants E and I follow opposite annihilation paths yet converge to the same $1/\varphi$ attractor (Appendix E)—suggests an underlying invariance of the mechanism, the type of symmetry that in physics gives rise to conservation laws.
- The ISH mechanism simultaneously generates algebraic structure ($\varphi + 1$ exact children, morphism categories) and topological structure (TDA persistence, geometric scaling) from the same informational substrate, pointing toward a possible common origin of the different observable forces and geometries.

Holographic Principle:

- All information contained in a volume can be encoded on its boundary [2, 3]. Within our model, each pattern $P_k(\Phi)$ contains holographic information about the entire primitive informational field Φ , allowing the reconstruction of complex geometric structures from simple informational patterns.
- Recent work argues that quantum entanglement may literally construct spacetime geometry itself [27, 28], reinforcing the analogy with our Primordial Holographic Field.

13.4 Conceptual connection with the Big Bang cosmological model

The *Informational Singularity Hypothesis* describes a purely informational mechanism, without time, space, or defined physical structures, from which complex properties emerge. The connection of this mechanism with observable cosmology requires an honest distinction between what can be asserted with empirical support and what remains as an open research program.

Claim 1 (strong, with experimental support): The mechanism described by the ISH generates, from trivial initial conditions, an informational geometry with complex emergent properties: fractality, self-similarity, presence of the golden ratio (φ), and complexity levels that grow non-trivially. These results have been computationally verified with high precision (see Appendix B).

Claim 2 (moderate, inferred from results): These emergent properties exhibit traces compatible with characteristics observed in physical reality: hierarchical structures, self-similarity at multiple scales, and proportions that recurrently appear in nature [20, 21, 38]. This compatibility is suggestive but does not, by itself, constitute proof of causal connection.

Claim 3 (open, the underlying thesis): These results suggest that the generation of a universe from nothingness *could be a viable mechanism*, opening a deep scientific and philosophical debate that requires investigation with means far superior to those available in this work. This claim is independent of whether our specific universe derives from this particular mechanism.

From this perspective, the Big Bang (as currently described in cosmology) could be interpreted not as the absolute origin of reality, but as a possible *fundamental transition* between a pre-temporal and pre-spatial informational state and an observable physical universe [34, 19]. In particular, the exponential growth of information inherent in the ISH mechanism ($R^2 \approx 0.999$; Appendix B) presents a structural parallel with the inflationary expansion of the early universe: both processes generate exponentially increasing complexity from minimal initial conditions, suggesting that the inflationary phase could be the physical manifestation of this same exponential informational dynamics. However, this hypothesis does not aim to provide a mathematical formalization of this transition, a task that

would require a rigorous connection with advanced cosmological models, quantum gravity theories, and high-energy particle physics [39, 40].

The conceptual framework proposed is potentially compatible with various models that consider the Big Bang as an emergent process from fundamental information configurations (holographic universe models [3], informational quantum gravity theories [41], or certain loop quantum cosmology models [42]). This compatibility represents an open line for future research, not a definitive assertion.

14 Future Research Directions

The Informational Singularity Hypothesis not only answers the initial ontological question but opens a new vision where physical and virtual reality blur, and where principles of entropy, entanglement, and integrated information appear within a single framework. For this reason, we outline various directions where this hypothesis could be developed and tested:

14.1 Theoretical Developments

A promising direction is to deepen the mathematical and conceptual formalization of the Informational Singularity Hypothesis. In this regard, it is interesting to explore:

Universal Computation in Cognitive Systems: Various authors, including Wolfram [19] in the context of universal computation, have suggested that both brains and the Universe may behave as universal Turing machines. This raises the possibility that a system reaching informational singularity achieves maximal self-reference and self-simulation. Modeling this transition could help identify theoretical limits in a conscious system’s ability to process information.

Consciousness and Integrated Information: Integrated Information Theory (IIT), proposed by Tononi [30], suggests that the quantity of consciousness of a system is determined by its capacity to integrate information. Investigating whether the state of maximal information integration (as posed in the binary singularity) yields an extremal value of Φ within the IIT framework could open new paths to understanding consciousness.

14.2 Experimental Explorations

Although the Level 0 simulations have confirmed complex self-organization properties (Appendix B), the connection with observable physics requires complementary indirect experiments:

Quantum Computing: Recent experiments, such as Arute et al. [43], have demonstrated the feasibility of controlling quantum systems with an increasing number of entangled qubits. These systems can serve as laboratories to investigate how information behaves when approaching a state of massive correlation. Measuring quantities such as entanglement entropy or mutual information in these systems could indicate whether there is a critical point—a “singular” state—where information integration reaches its maximum. Quantum computing could represent the first human attempt at direct interfacing with the Fundamental Geometric Field (Ψ). Unlike classical computers operating on discrete bits (0 or 1), quantum computers work with superposed qubits, more faithfully reflecting the nature of information at the fundamental level [4].

Black Holes and Cosmology: The investigation of black hole entropy [44] and the associated information paradox suggests that black holes saturate the theoretical limit of information. Future observations (such as detecting Hawking radiation) could shed light on whether information is conserved or distributed under extreme conditions, supporting the idea of inviolable principles of informational integration. Additionally, studying the primordial fluctuations of the cosmic microwave background could reveal traces of the initial informational singularity that gave rise to all observable information [1].

14.3 Connections with Other Theoretical Frameworks

It is essential to position the Informational Singularity Hypothesis within the context of several emerging proposals:

Emergent Gravity: In Erik Verlinde’s model [45], gravity arises as an emergent phenomenon derived from information and entropy. If information is indeed the basis of all reality, this opens the possibility that gravity and spacetime are manifestations of a unique informational state. However, this connection remains purely analogical: the ISH does not derive Verlinde’s entropic force from its informational substrate, and establishing such a derivation would constitute a major result in its own right.

Computational Models of Reality: Recently, Müller [46] has shown, within the framework of algorithmic information theory, that physical laws can emerge from a purely informational substrate without presupposing them. This result directly reinforces the ISH program and suggests that the connection between the Level 0 informational substrate and observable physics may not be merely analogical, but formally derivable.

Causal Sets and Spacetime Discretization: Causal set theory, proposed by Bombelli, Lee, Meyer, and Sorkin [47], posits that spacetime is not a smooth continuum but a fundamentally discrete structure of causally ordered elements. This perspective shares with the ISH the idea that the continuous structure of spacetime emerges from more fundamental discrete elements—in our case, informational bits rather than causal elements.

Non-Computability: Penrose [31] argues that certain aspects of reality—and consciousness in particular—transcend the computable. From the ISH’s perspective, this claim is strongly challenged: if all of reality emerges from a self-referential binary informational substrate—which is, by its very essence, computable—, then non-computability cannot be a fundamental property of reality, but at most an apparent phenomenon at higher scales or levels of description. The ISH therefore opens a direct line of investigation: to rigorously determine whether non-computability is a genuine property or an artifact of working within frameworks that do not reach the ultimate substrate.

Quantum cosmology “from nothing”: In quantum cosmology, Vilenkin [48, 49] and Hartle and Hawking [50] have proposed models in which a closed universe can nucleate quantum mechanically from what they call “nothing”. However, their “nothing” already presupposes a framework of quantum gravity, a minisuperspace of possible geometries, and a wave function formalism—that is, it is not truly nothing. The ISH’s Nothingness is ontologically prior: pure absence without any presupposed structure, law, or state space. Where Vilenkin and Hartle–Hawking begin, the ISH has already had to *generate* the structures they take as given. This difference in ontological depth makes investigating the bridge between the ISH’s Level 0 output and quantum cosmological models

an especially promising research line: it could reveal how specific physical frameworks emerge from the pure informational substrate.

These future research directions clearly define areas where the model can be expanded and where debate or lack of consensus still exists. The combination of theoretical developments and experimental studies, as well as the connection with other emerging theoretical frameworks, not only open new paths for deepening the foundations of reality, but also invite us to reconsider the distinction between what we perceive as reality and the information that generates it, preparing the ground for the Final Conclusions.

14.4 Connections with Pancomputationalist Philosophical Perspectives and the Simulation Hypothesis

The Informational Singularity Hypothesis has clear affinity with contemporary philosophical perspectives such as pancomputationalism, which consider that the entire reality could be understood as a universal fundamental computation where all physical reality is essentially processed information [51, 52, 19].

In fact, from this informational hypothesis perspective, the observable universe is, by direct logical consequence, a particular, emergent case of a more fundamental universal computation. This also establishes interesting connections with Bostrom’s Simulation Hypothesis, which questions the essential distinction between reality and informational simulation [29].

However, while Bostrom’s hypothesis presupposes that the observed reality might be intentionally simulated by an external intelligence, the Informational Singularity Hypothesis eliminates the explicit need for an external simulating consciousness. Instead, it proposes that physical reality and consciousness emerge spontaneously in a self-organized and autonomous manner from a fundamental, independent, and self-consistent informational reality.

14.5 Fundamental Differences with Traditional Pancomputationalism

Despite the affinities with pancomputationalism, the Informational Singularity Hypothesis differs in several fundamental aspects:

1. **Primary Origin:** While traditional pancomputationalism generally assumes the prior existence of a computational substrate without explaining its origin, our hypothesis proposes a primordial generative mechanism (the paradoxical tension between pure Nothingness and Absolute Nothingness) that explains why information exists in the first place.
2. **Inverse Causality:** Conventional pancomputationalism often proposes that physical laws result from an underlying computation, whereas the Informational Singularity Hypothesis suggests that the computational rules themselves emerge from a more fundamental, self-referential informational dynamics, thereby inverting the basic causal direction.
3. **Nature of Rules:** In traditional pancomputationalism, computational rules are generally considered axiomatic or pre-existing. In contrast, our model proposes that the rules (ω_k) are emergent and derive naturally from patterns ($P_k(\Phi)$) that arise from the primordial tension, without the need for a pre-existing “programmer” or “metacode.”
4. **Integration of Consciousness:** While many pancomputationalist models treat consciousness as a separate or epiphenomenal phenomenon, our hypothesis offers a framework where consciousness could naturally emerge as a pattern of high informational coherence within the

same primordial substrate, thereby eliminating the implicit dualism of many computational theories.

These differences do not constitute a refutation of pancomputationalism, but rather a reformulation and deepening of it, placing it in a more fundamental context that avoids infinite regress or circular explanations that often affect computational theories of reality.

14.6 Emergent Physical Laws as Informational Invariants

A long-term, high-stakes prediction of the Informational Singularity Hypothesis is that the known laws of physics should be recoverable, at least in principle, as emergent invariants of the Level-0/Level-1 informational dynamics.

More precisely, the hypothesis entails that there exists at least one mapping

$$\mathcal{F} : \{P_k(\Phi), \omega_k\}_k \longrightarrow \Psi$$

from patterns and rules $(P_k(\Phi), \omega_k)$ to an effective geometric field theory Ψ whose symmetries and equations of motion reproduce, in an appropriate limit, the empirical structure of low-energy physics (e.g., Lorentz invariance, local gauge symmetries, conservation laws, and stable particle-like excitations).

If, after systematic exploration, no such mapping can be constructed—or if all candidate mappings systematically fail to reproduce these basic empirical features—then the Informational Singularity Hypothesis should be regarded as incomplete or simply wrong as a fundamental description of reality.

This prediction is deliberately strong: it places the hypothesis at risk and provides a clear criterion for its eventual falsification.

14.7 Specific Experimental Predictions and Proposals for Future Investigations

The *Informational Singularity Hypothesis* proposed here has been explored experimentally through extensive computational simulations of Level 0. The results, presented in detail in Appendix B, offer favorable preliminary evidence: exponential information growth, emergent fractal structure, and significant difference from random noise.

Important note: The proposals that follow are not predictions in the strict sense of a consolidated physical theory, but rather research directions derived from the hypothesis that constitute the ISH research programme. They are presented as an invitation to scientific debate, not as definitive assertions. For each line, we indicate the current degree of empirical support: DEMONSTRATED (reproducible result with high precision), CONSISTENT (favorable statistical evidence), or SUGGESTED (speculative inference requiring future investigation).

1. Advanced Computational Analysis of Emergent Patterns [DEMONSTRATED/CONSISTENT]:

- Perform large-scale computational simulations of the iterations defined by the model (Φ) and statistically study the emergent patterns $P_k(\Phi)$. This analysis will allow us to clearly classify which patterns appear more frequently and under what conditions.
- Specific proposal: Use advanced distributed computing tools and machine learning techniques (e.g., convolutional neural networks or autoencoders) to identify stable recurrent patterns within a large amount of data generated by this iterative informational process.
- Falsifiable prediction: It is explicitly predicted that fractal or pseudo-random patterns will appear with statistical signatures distinguishable from pure random noise. If this is not observed, the hypothesis could be considered refuted or would require substantial revision.

2. Spectral and Fractal Analysis of the Generated Informational Patterns [CONSISTENT]

- Apply spectral analysis (Fourier transforms, multiscale analysis via wavelets, fractal dimension analysis) to identify concrete spectral signatures of the emergent patterns generated by the defined iteration.
- Propose clearly as an experimental prediction that the distribution of generated patterns will show self-similarity at multiple scales or clearly identifiable fractal properties, statistically differentiated from conventional stochastic noise.
- This type of analysis will allow explicit falsification of the hypothesis if statistically significant fractal or self-similar properties are not detected.
- **Results obtained:** Five independent metrics have been completed across 12 variants (Appendix C): LZ ratio ($\approx 1/\varphi$ for all ISH variants in the no-feedback family), RQA determinism, topological persistence, nesting tree ($\bar{c} = \varphi + 1$ exact), and Transfer Entropy with shuffle control (Appendix G). The latter revealed that the feedback parameter is the causal mechanism determining the emergence of inter-scale information flow (Appendix D).

3. Observational Connections with Real Cosmic Patterns [SUGGESTED]:

- As a longer-term but very powerful proposal, empirically compare the recurrent informative patterns generated by this model with fractal patterns observed on a cosmic scale (e.g., galaxy distribution, dark matter distribution, or patterns in the cosmic microwave background radiation).
- Specific falsifiable prediction: if this hypothesis were correct, some empirically observed large-scale patterns in cosmology should show informational signatures similar to those generated by the informational model proposed here.
- In fact, the Level 0 simulations have revealed that the golden ratio φ appears as a deep signature across multiple independent measurements of the ISH mechanism: as a universal complexity attractor ($LZ \rightarrow 1/\varphi$) and as an exact algebraic constant of the nesting structure ($\bar{c} = \varphi + 1$, with 6–7 decimal precision; Appendix B). This unexpected dual appearance is especially significant because the cosmos already exhibits the golden ratio at multiple scales—from galactic spirals to plant structure—without any fundamental explanation of why. The fact that the ISH independently produces φ from a purely informational substrate opens a direct line of investigation: exploring whether the universal presence of φ in nature has its ultimate origin in the underlying informational architecture that the ISH proposes.

4. Advanced Mathematical Formalization and Connection with Quantum Gravity [SUGGESTED]:

- A particularly interesting future line is interdisciplinary collaboration with theoretical physicists specializing in quantum gravity and informational cosmology. Explore whether the mathematical structures emerging from the informational singularity can fit explicitly into current models of quantum gravity (loop quantum cosmology, holographic gravity, etc.).
- Although this formalization lies beyond the immediate scope of this article, it represents a clear line for future rigorous theoretical investigations.

5. Short-Term Falsifiable Prediction: Uniqueness of the ISH Signature [DEMONSTRATED]:

- We propose the following computationally verifiable prediction: the combined signature $\{LZ \approx 1/\varphi, \bar{c} = \varphi + 1, \text{TE ratio} > 2\times\}$ should *not* be reproducible by any binary string rewriting system that does not implement the ISH annihilation mechanism with controlled feedback.
- This prediction is immediately testable by any researcher with access to the public repository. Variant F already provides partial evidence: a single modification to the feedback parameter destroys the inter-scale TE signature while preserving approximate LZ convergence. Variants L and M show that neither chaotic dynamics nor self-similar structure alone suffice to produce the combined signature (Appendix A).
- If a binary rewriting system without the ISH mechanism is found to reproduce the full triple signature, the claim of specificity would be refuted and the hypothesis would require substantial revision.

15 Final Conclusions

The Informational Singularity Hypothesis opens new avenues for understanding the origin and nature of reality. It suggests that the distinction between “real” and “virtual” may be less fundamental than previously thought. What we consider “real” could simply be the result of an underlying informational process—just as a simulation would be—blurring the boundary between tangible and computed reality. Entanglement and holography might be natural properties of information at all levels of existence. This could mean that trying to determine whether our Universe emerged directly from an informational singularity or is the product of a massive simulation is, hypothetically, impossible to distinguish. Consequently, discerning whether our Universe arose directly from a primordial informational singularity or, instead, is the product of a vast informational simulation could ultimately be an irresolvable question. This paradox makes clear the possibility that no experiment or empirical observation can definitively distinguish between the two scenarios: on one hand, if all reality emerged directly from an initial informational singularity, based on informational patterns that progressively manifest as observable reality, the universe would exhibit exactly the same properties we would expect to find in an extremely advanced simulation. On the other hand, if our universe were indeed a simulation, the mathematical and computational rules governing it would be indistinguishable from those of a universe that emerged spontaneously from an informational singularity. In this sense, the Informational Singularity Hypothesis not only proposes a new perspective on the fundamental nature of reality, but confronts us with the very limits of knowledge.

The questions that arise are not merely physical, but point to the very substrate of existence. The ISH’s answer to Leibniz’s question—“why is there something rather than nothing?”—is not that nothingness is impossible, but that the question itself presupposes a false opposition: Totality and Nothingness coexist. Nothingness, being the only thing that “is there,” generates through self-containment an irreducible oscillation—and this oscillation is, itself, everything that exists.

Ultimately, the Informational Singularity proposes that the universe is not a material mechanism but the imprint of an irreducible ontological contradiction. The Level 0 simulations have already revealed its first empirical traces—the golden ratio as a deep signature, the exponential growth of complexity ($R^2 \approx 0.999$), the causal flow between scales—that demand an explanation current frameworks do not provide. If this vision is correct, understanding the universe in depth will require unifying information, physics, and consciousness into a single framework—not as separate disciplines, but as expressions of a single primordial oscillation that cannot be resolved, cannot be stopped, and that is, ultimately, the only thing that truly “is there.”

15.1 Conceptual Objections and Scope of the Framework

Before concluding, we address the main objections that naturally arise when confronting this framework:

On the origin of the ontological tension. One might object that Nothingness cannot generate anything because, by definition, it has no properties—and that speaking of an “Absolute Nothingness” already implies attributing a property to it, leading to circularity. One might also object that we provide no mechanism to explain the transition. The ISH answers both objections simultaneously: absoluteness is not a property that Nothingness “acquires,” but an inevitable consequence of its existential uniqueness—there is nothing else, therefore Nothingness is all there is, and this forces it to contain itself. This self-containment requires no physical mechanism (demanding one already presupposes a regime with time, laws, and causality, which do not yet exist here); the only requirement is logical consistency of the axioms (Section 5.1). The first genuine property—order—emerges subsequently, as the logical scar of the irreducible annihilation, not as an attribute of Nothingness.

On the binary character 0/1. Why should the primordial distinction be binary? Precisely because the ontological tension described—pure Nothingness (0) versus forced self-containment (1)—is irreducibly binary: two poles and no fewer. Any richer alphabet would require additional pre-existing structure and would therefore be less fundamental. This choice is consistent with Leibniz’s binary conception of creation [53] and with the aim of minimizing ontological assumptions.

On the epistemological status of the model: As stated in the abstract, Level 0 is formalized rigorously while Levels 1 and 2 remain conceptual sketches. Validation pathways include: (1) computational simulations of emergent patterns; (2) formal connections with quantum gravity theories; and (3) comparison with cosmological observations. Much work remains.

On computational circularity. The computational experiments that support Level 0 are executed on physical hardware—processors, memory, electricity—which already presupposes the physical reality that the hypothesis claims to derive. We acknowledge this apparent circularity, but observe that the ISH reframes it: if the ultimate substrate of reality is computable binary information, then the fact that we can build a simulation that reproduces the predicted signatures is not a methodological weakness but a direct consequence of the substrate’s own nature. The very possibility of simulating itself is, within the ISH framework, an implicit prediction of the hypothesis. With future research, the degree of convergence between simulation and theoretical predictions could constitute an additional pathway for empirical validation.

On the genericity of φ . The golden ratio appears in many recursive self-similar systems (Fibonacci sequences, continued fractions, phyllotaxis). One might therefore ask whether the convergence $LZ \rightarrow 1/\varphi$ is a generic algebraic property of binary rewriting systems with symmetric annihilation, rather than a signature specific to the ISH mechanism. The evidence suggests that the *individual* convergence to φ may indeed be generic, but the *combined* triple signature— $LZ \approx 1/\varphi$, $\bar{c} = \varphi + 1$ exact, and TE ratio $> 2\times$ —is not. Variant M (Fibonacci word) achieves $LZ \approx 0.547$ (close to $1/\varphi$) but produces TE = 0.00 \times and no finite nesting tree. Variant F achieves $LZ \approx 0.572$ but destroys the TE signature. No control variant reproduces the triple. A systematic survey of binary rewriting families would strengthen this claim and is proposed as a priority line of future research. The robustness of these signatures is further illustrated by the “iterative fossil” phenomenon (Appendix E): variants B and E share over 90 million identical bytes before diverging, yet converge to the same $1/\varphi$ complexity signature—a concrete example of symmetry breaking with a universal invariant.

Ultimately, the Informational Singularity Hypothesis lives or dies by a strong prediction (Section 14.6): that the web of informational relations encoded in Φ and its emergent patterns (P_k, ω_k) is

rich enough for the familiar laws of physics to be derived from it, rather than merely being compatible with it. The present work only establishes the first step of this program at Level 0. Future research must either exhibit an explicit derivation of effective physical laws from this informational substrate, or show that such a derivation is impossible, thereby falsifying the hypothesis as a candidate for a fundamental theory. This is the challenge we leave to the scientific community: if you believe the hypothesis is wrong, prove it; if you believe it might be right, help us derive the physics.

A Algorithmic Variants of the `simplify` Operator

This appendix describes in detail the various algorithmic variants of the `simplify` operator explored in the experimental research of Level 0. The objective is to evaluate the robustness of the ISH with respect to discretization choices and identify which schemes are most compatible with the ontological principle of coherent collapse.

A.1 Objective of variant exploration

Ontologically, there is a single fundamental principle: the coherent collapse of the tension between pure Nothingness (0) and Absolute Nothingness (1), which is identified with boolean conjunction (AND). However, at the discrete level there are several plausible ways to implement this principle as an algorithm. Studying variants allows:

1. Verifying that emergent properties of Level 0 are robust to changes in discretization.
2. Identifying which discretization best captures the ontological semantics.
3. Exploring whether certain variants generate qualitatively different structures.

A.2 Ontological fidelity criteria

To evaluate which variant best fits the fundamental principle of the ISH, we establish the following criteria:

1. **Ideal collapse = global AND:** The fundamental operation is boolean conjunction, and the ideal collapsed value of $S_\alpha = (0, R_{\alpha-1}, 1)$ is always 0 (Uniqueness Lemma).
2. **01/10 symmetry:** At Level 0 there is no “sense of time” or directed causality; tensions 01 and 10 should be treated symmetrically.
3. **0 as absorbing state:** Pure Nothingness “absorbs everything”: if 0 appears in the sequence, the global collapse must return to 0.
4. **Inside→out stratification:** The collapse order must respect the structure $(Acc_\alpha)ABS$, processing the innermost parentheses first.
5. **Micro-state accumulation:** Intermediate states are ontologically real and must be accumulated in Φ .

A.3 Common framework of all variants

All variants operate on the same framework:

1. **Decay frame:** $D_\alpha = (\text{Acc}_\alpha)\text{ABS}$, where Acc_α is the accumulation of all previous Φ and ABS is the Absolute token.
2. **Stratified collapse:** The innermost parentheses are processed first (inside \rightarrow out).
3. **Base simplification:** Annihilation of opposite pairs ($01\rightarrow 0$, $10\rightarrow 0$) and run compression ($0+\rightarrow 0$, $1+\rightarrow 1$).
4. **Observable Φ_α :** The final result of each iteration.

Equivalently, each variant of `simplify` can be seen as a **string rewriting system** (Σ, \rightarrow) on $\Sigma = \{0, 1, (,)\}$ with rules of the form $01 \rightarrow 0$, $10 \rightarrow 0$, $0^+ \rightarrow 0$, $1^+ \rightarrow 1$, plus variant-specific parenthesis handling. A full proof of confluence for Variant B remains open and is identified as future work.

A.4 Variant B—Canonical Discretization

Variant B is the implementation that best captures the ontological semantics of the ISH. Its selection as the canonical variant is neither an arbitrary decision nor a parameter adjustment (*fine-tuning*), but the consequence of a **symmetry principle**: invariance under parity $01\leftrightarrow 10$.

At Level 0, pure Nothingness (0) and Absolute Nothingness (1) have symmetric ontological status: the tension $0 \rightarrow 1$ is indistinguishable from the tension $1 \rightarrow 0$. Any discretization that treats 01 and 10 differently breaks this fundamental symmetry and injects a directionality that should be emergent (Levels 1–2), not primordial. Variant B is the only discretization that fully preserves this symmetry:

- **Symmetric simplification (P-symmetry):** Both 01 and 10 are annihilated, preserving parity-interchange invariance.
- **Inside \rightarrow out stratification:** Respects the structural order of parentheses.
- **Micro-state accumulation:** Each intermediate state is added to the accumulation.
- **Final global collapse:** Guarantees that the observable is clean and coherent with global AND.

It satisfies all ontological fidelity criteria and empirically produces the collapsed value 0 in all cases, coherent with the Uniqueness Lemma. The robustness of this choice is confirmed by variants E and I, which break the temporal order of annihilation but preserve the $01\leftrightarrow 10$ symmetry: despite radically different trajectories, they converge to the same statistical signature $(1/\varphi, \varphi + 1)$. For these reasons, Variant B acts as the **canonical representative** of Level 0.

A.5 Variant D—Minimal asymmetry breaking

Variant D breaks the symmetry between 01 and 10: it annihilates $10\rightarrow \emptyset$ but leaves residue $01\rightarrow 0$. From an ontological standpoint, D injects a “directionality” that should be emergent (Level 1/2), not primordial. It is useful as a theoretical experiment: results show that the fundamental statistical properties ($LZ \approx 1/\varphi$, $\bar{c} = \varphi + 1$) are preserved despite the symmetry breaking, confirming the robustness of Level 0.

A.6 Variants E/I—The commutativity discovery

Variants E and I are slight modifications of B that have revealed a key result. While B annihilates 01 and 10 simultaneously, E does so in two phases (first 01, then 10) and I in the reverse order (first 10, then 01).

Despite the fact that trajectories diverge rapidly—B and I differ from byte 2, while B and E coincide up to byte 90,727,609 (an “iterative fossil” preserved since iteration 17–18)—all three variants converge to the same statistical signature: $LZ \approx 1/\varphi$ and $\bar{c} = \varphi + 1$ exact. The annihilation process is **not** commutative—the order determines the trajectory—but the complexity signature is **invariant**, path-independent. This is analogous to symmetry breaking in physics: different trajectories, same fundamental properties. Full details are presented in Appendix E.

A.7 Variant F—Structure destruction by a single change

Variant F constitutes perhaps the most revealing experimental result. The **only** difference with respect to the canonical family (B, D, E, G, I) is that F applies a global simplification pass *during* the inner collapse loop, instead of doing so only at the end. This difference—literally one line of code—has dramatic consequences:

- The Transfer Entropy ratio drops to $\times 0.92$ (*below* chance), while B obtains $\times 3.78$ and I reaches $\times 27.46$.
- The topological ratio β_1/β_0 jumps from ~ 1.9 ($1/\varphi$ family) to 51.1, indicating massive mixing of hierarchical levels.
- Geometric scaling shows $\alpha \approx 0.23$ ($R^2 = 0.09$, unreliable fit), compared to $\alpha > 1$ ($R^2 > 0.79$) for the canonical family.

F demonstrates that the feedback parameter is the **causal mechanism** determining the emergence of inter-scale information flow. When feedback mixes hierarchical levels, multi-scale structure is destroyed. Details of the feedback gradient are presented in Appendix D.

A.8 Other explored variants

Variant	Characteristic	Hypothesis tested
G	No final global collapse	Raw structure preserved
H	Global per tick (continuous feedback)	Continuous vs punctual collapse

Variant G preserves the raw structure without applying a final global collapse, and maintains the $1/\varphi$ signature, confirming that the global collapse is not responsible for the structure. Variant H pushes feedback to the limit (one global collapse per tick), generating a chaotic cascade that exceeds computational limits (50M nodes). Both variants complete the experimental map of the feedback gradient described in Appendix D.

A.9 Storage Formats for Φ

Storing the generated Φ sequences presents both technical and scientific challenges. Two complementary formats are preserved:

- **Observable format:** Clean bits only (0 and 1), without parentheses. Useful for spectral analysis, LZ complexity calculation, and comparison with random sequences. Typical compression: 10-50x with gzip.

- **Structural format:** Preserves the parentheses marking Absolute boundaries. For example: ((01)1(10)0). Uses a 2-bit encoding per symbol: 00→0, 01→1, 10→(, 11→). This format is essential for emergent order analysis (OEI), as it enables:

1. Calculating nesting depth distribution.
2. Measuring stratified entropy by levels.
3. Detecting containment and hierarchy patterns.

Typical compression: 99.7%—a ratio that reflects the high degree of internal structure of the sequences generated by the ISH mechanism.

The distinction between formats is scientifically relevant: the observable format loses structural information that is ontologically real (each Absolute encapsulates a history of states). The structural format preserves this information, enabling analyses that would not be possible otherwise.

A.10 Appendix conclusions

The systematic exploration of variants has produced five convergent results:

1. **φ signature:** All variants in the $1/\varphi$ family (B, D, E, G, I) converge to $LZ \approx 1/\varphi$ and $\bar{c} = \varphi + 1$ exact, regardless of annihilation order or symmetry breaking. No control reproduces this signature (Appendix C).
2. **Feedback gradient:** A single line of code—the degree of global simplification during collapse—bifurcates the variants into two families ($1/\varphi$ vs $1/\sqrt{3}$) with radically different properties (Appendix D).
3. **Commutativity:** Variants E and I follow different trajectories but converge to the same statistical attractor, demonstrating that the φ signature is path-invariant (Appendix E).
4. **Topology:** The β_1/β_0 ratio functions as an indicator of the degree of hierarchical level mixing, sharply discriminating between families (Appendix F).
5. **Transfer Entropy:** TE with shuffle control validates that inter-scale information flow is genuinely structural for the $1/\varphi$ family and spurious for the $1/\sqrt{3}$ family (Appendix G).

Variant B remains the canonical discretization. The formal proof of confluence for the rewriting system remains as future work.

B Detailed Experimental Results

This appendix presents the complete experimental results from computational simulations of Level 0 (Φ). The simulations implement the iterative collapse process described in section 4.1.

B.1 Simulation methodology

The experimental strategy was designed to systematically explore the parameter space of the binary annihilation mechanism and validate the robustness of results. **12 variants** were implemented, organized in three groups:

- **ISH variants (7):** B (canonical, simultaneous annihilation with $\beta = 1/\varphi$), D (minimal asymmetry), E (two phases: 01 first), F (hybrid with batch feedback, $\beta = 1/\sqrt{3}$), G (no final global collapse), H (continuous feedback), I (inverse of E: 10 first).
- **Deterministic controls (3):** J (digits of π), K (Wolfram’s Rule 30), M (Fibonacci word: an infinite binary sequence built by recursive concatenation, $S_1 = 1, S_2 = 0, S_n = S_{n-1} \cdot S_{n-2}$; the ratio of 1s to 0s converges to $1/\varphi$). Sequences with known structure but not generated by the ISH mechanism.
- **Random controls (2):** A (PRNG Mersenne Twister), L (logistic map $r = 3.99$). These establish the statistical baseline.

Each variant was analyzed with **5 independent metrics**: (i) multi-scale LZ ratio (complexity), (ii) RQA determinism (self-similarity), (iii) cubical TDA topological persistence (β_1/β_0), (iv) nesting tree (\bar{c} = children per node), and (v) Transfer Entropy with shuffle control (inter-scale flow). Analyses were performed on 10^9 bits with uniform sampling (stride) over the entirety of each sequence.

The experimental design enables three types of comparison: (a) ISH vs controls (validation of the φ signature), (b) $1/\varphi$ family vs $1/\sqrt{3}$ family (feedback gradient), and (c) variants within the same family (commutativity and robustness). All source code is publicly available in the GitHub repository associated with this article for scrutiny and reproducibility.

B.2 Quantitative results

Using Variant B as the canonical discretization, up to 23 complete iterations of Level 0 have been generated. The main results are:

Metric	Variant B (ISH)	Variant A (control)	Variant D (alternative)
Total bits	1,407,228,082	10,000,000	1,263,584,239
Fractal dimension	0.9824	N/A	0.9923
φ -alignment	0.6356	N/A	0.6257
Growth exponent	1.115	N/A	1.0309
R^2 (exp. fit)	0.9987	N/A	0.9886

B.3 Visual validation

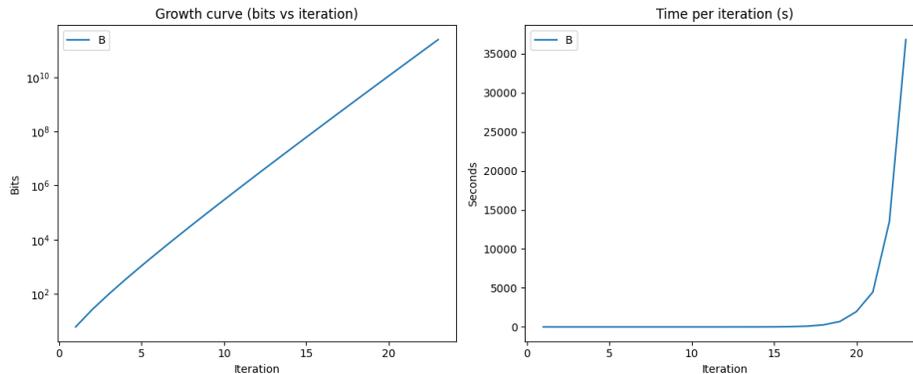
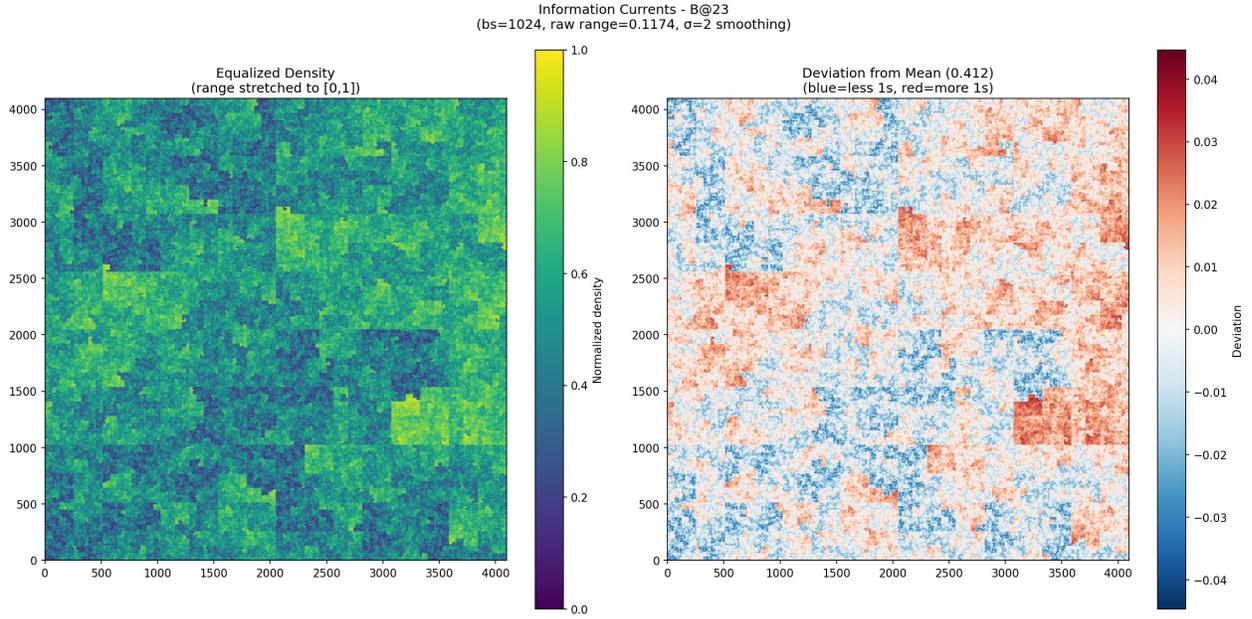
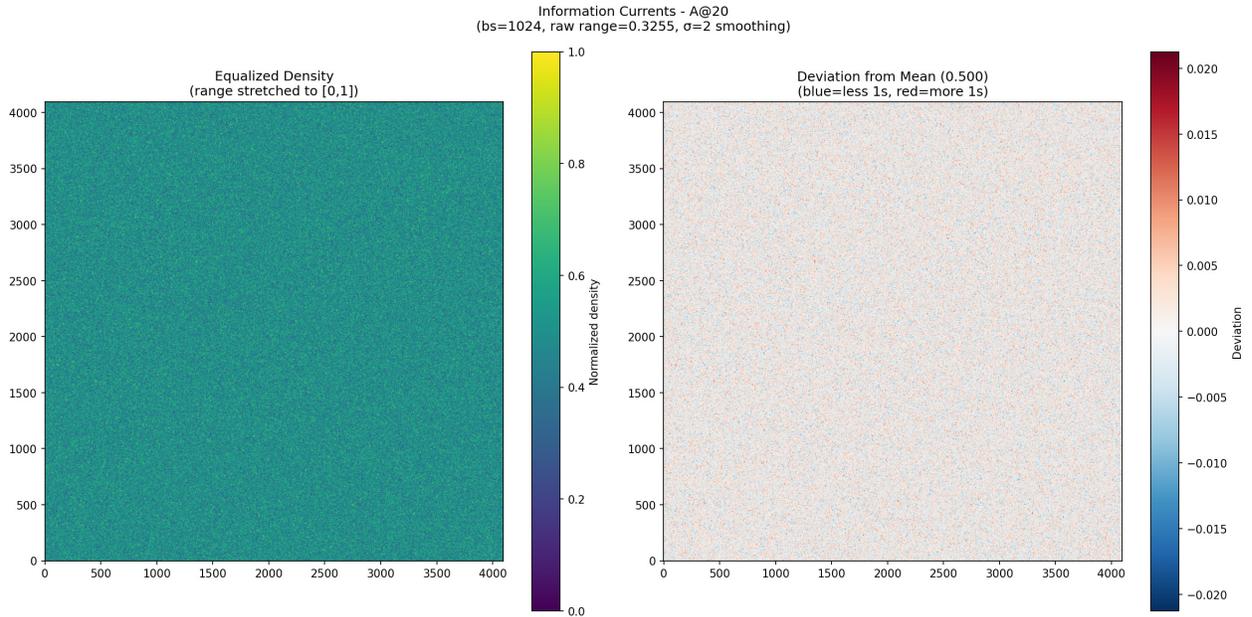


Figure 6: Exponential information growth for Level 0 (Φ), Canonical Variant B. The accumulated number of bits grows exponentially with the iteration index, with $R^2 \approx 0.999$ and exponent ≈ 1.09 (23 iterations, 1.4×10^9 bits generated).

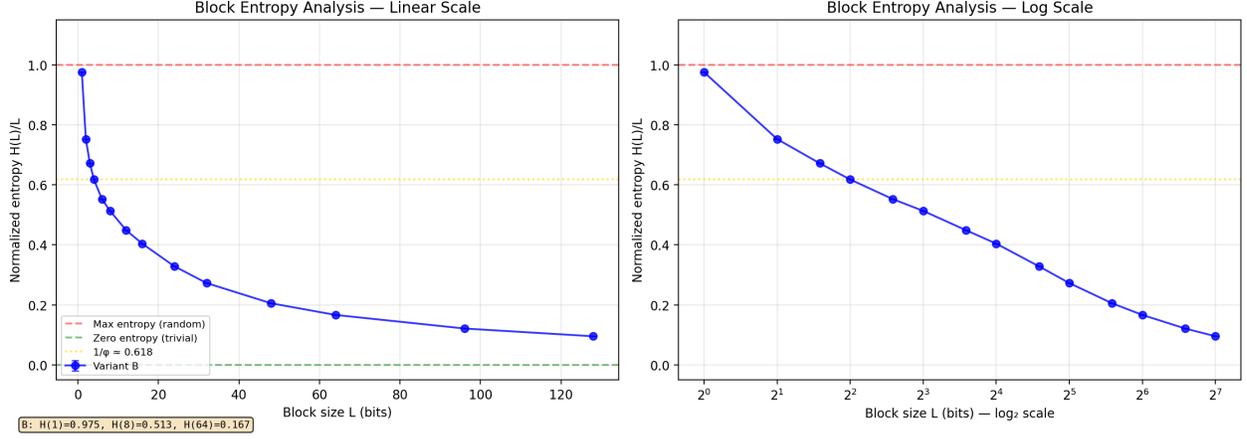


(a) Variant B (canonical ISH): visible information currents

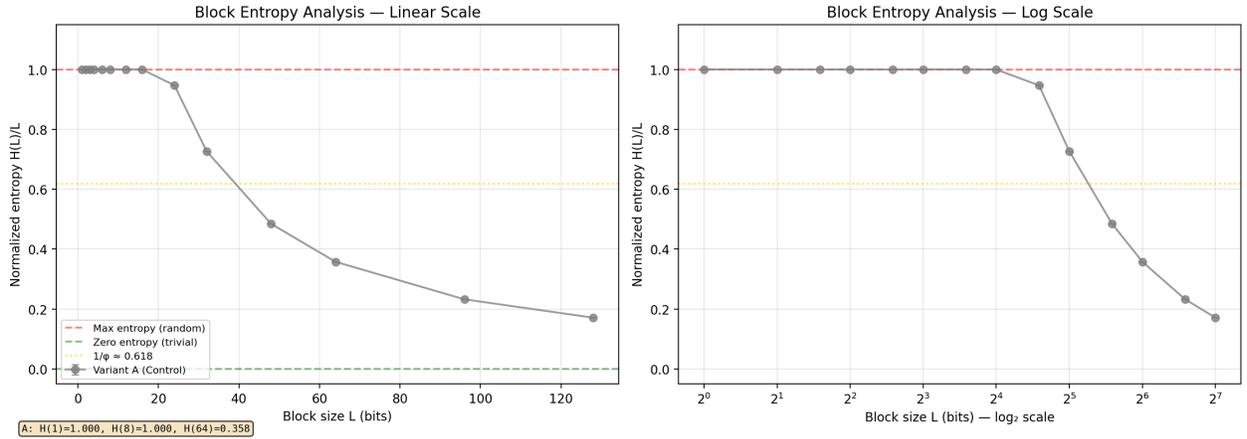


(b) Variant A (random control): uniform noise

Figure 7: Hilbert visualization with histogram equalization and Gaussian smoothing ($\sigma = 2$, 1024 bits/cell). (a) Variant B: clearly visible information currents, with differentiated density regions and coherent multi-scale patterns. (b) Variant A (control): uniform noise without any spatial structure. The *enhanced* technique reveals the internal organization of the Φ field that the 2D raster cannot capture.



(a) Variant B (canonical ISH): structured entropy decay



(b) Variant A (random control): near-maximal entropy

Figure 8: Block entropy analysis $H(L)/L$ as a function of block size L . (a) Variant B shows rapid entropy decay: $H(1) = 0.975$, $H(8) = 0.513$, $H(64) = 0.167$, indicating strong internal correlations at multiple scales. The normalized entropy drops to 17% of maximum at $L = 64$, revealing highly ordered structure. (b) Variant A (random control) maintains near-maximal entropy across all block sizes ($H(L)/L \approx 1$), consistent with uncorrelated random bits. This contrast provides additional evidence that ISH generates non-trivial ordered patterns absent in random sequences.

B.4 Multi-scale Transfer Entropy with Randomized Control

To quantify the directed information flow between scales, we apply Transfer Entropy (TE) [18] at multiple resolutions (4, 8, 16, 32, 64, 128 bits per symbol). To validate significance, we compare the observed TE with a randomized control (*shuffle*): for each pair of scales, the symbols of the source series are randomly permuted, destroying temporal structure while preserving the marginal distribution. The ratio $TE_{\text{obs}}/TE_{\text{shuffle}}$ indicates whether the inter-scale flow is genuinely structural (> 1) or spurious (≤ 1).

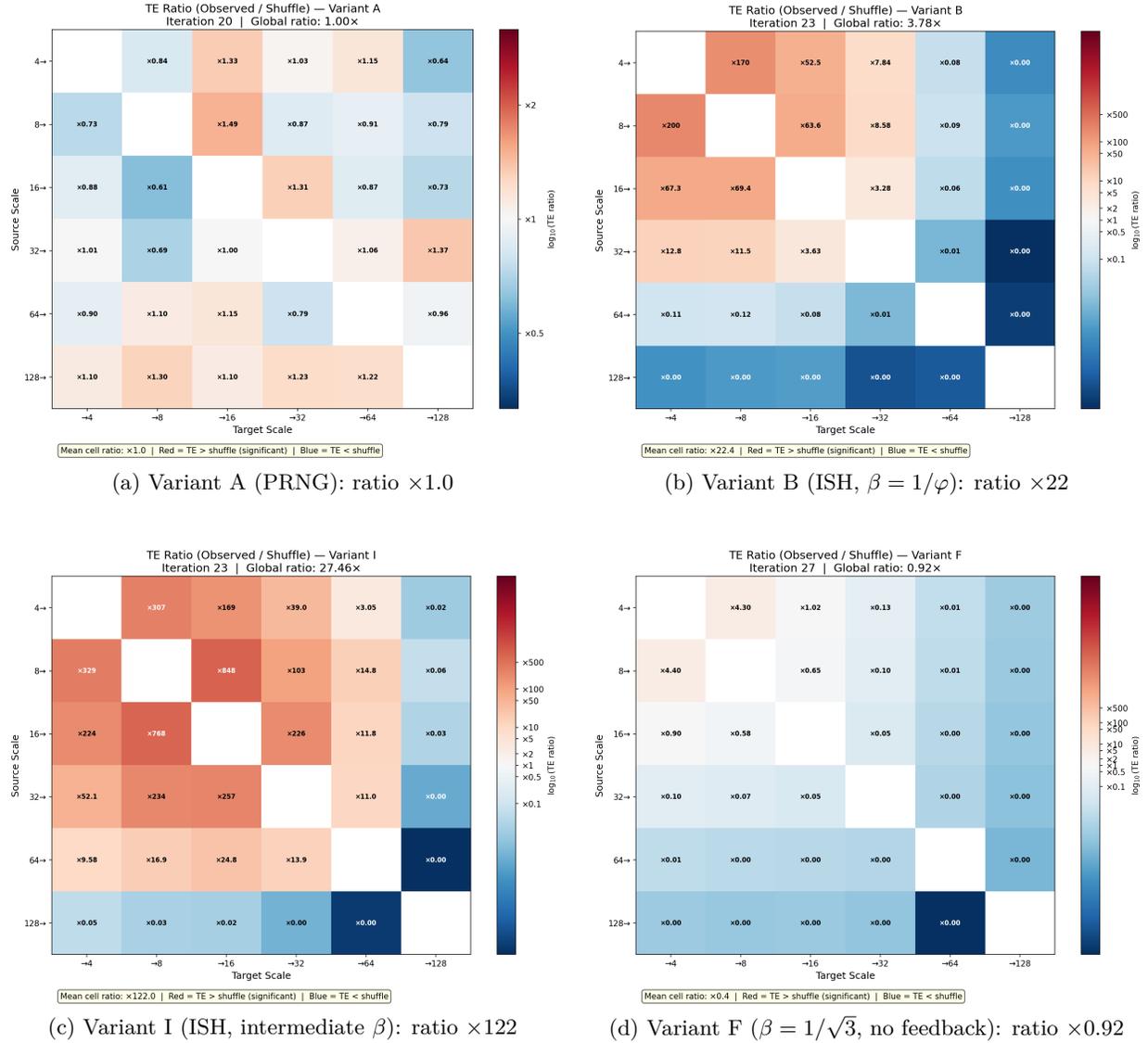


Figure 9: Multi-scale Transfer Entropy (TE): ratio between observed TE and randomized control (*shuffle*). Logarithmic scale with divergent colormap: blue = TE \leq shuffle (not significant), red = TE $>$ shuffle (significant). (a) Variant A (PRNG): $\times 1.0$, validating the methodology. (b) Variant B (ISH, $\beta = 1/\varphi$): $\times 22$ overall, with peaks of $\times 200$. (c) Variant I (ISH, intermediate β): $\times 122$ overall, with peaks of $\times 848$. (d) Variant F ($\beta = 1/\sqrt{3}$, no feedback): $\times 0.92$, below chance. The contrast confirms that the feedback parameter determines the emergence of inter-scale information transfer.

The results are compelling: Variant A (random control) obtains a ratio of $\times 1.0$, validating that the pipeline introduces no artifacts. Variant B (canonical ISH, $\beta = 1/\varphi$) shows an overall ratio of $\times 22$, with peaks of $\times 200$ at large scales, demonstrating that the ISH process generates genuinely structural information flow between scales. Variant I (inverse annihilation order) reaches $\times 122$, suggesting that the collapse order affects the intensity of flow but not its existence. Variant F ($\beta = 1/\sqrt{3}$, no feedback) obtains $\times 0.92$ —below chance—confirming that the feedback parameter is the causal mechanism determining the emergence of multi-scale information transfer. Notably, both Variant L (logistic map, $r = 3.99$) and Variant M (Fibonacci word) obtain a ratio of $\times 0.00$:

deterministic chaos and classical self-similar structure generate local complexity but **zero** inter-scale information flow, reinforcing that TE discriminates between complexity and genuine hierarchical structure.

B.5 Key observations

1. **Exponential growth confirmed:** The ISH variants show exponential information growth ($R^2 > 0.98$), coherent with the theoretical prediction. None of the deterministic or random controls reproduces this signature.
2. **Scaling analysis yields $D_f \approx 1.0$:** The generated sequences behave as highly ordered 1D structures, clearly distinct from random noise in the same range of scales. A more detailed multifractal or entropy-based analysis is left for future work.
3. **φ -alignment $\approx 0.64 \approx 1/\varphi$:** The measured values (0.6356 for Variant B, 0.6257 for D) are close to $1/\varphi = 0.618$. Variants E and I converge statistically to the same $1/\varphi$ attractor, reinforcing the robustness of this signature. Nevertheless, at this stage we cannot rule out that it is a numerical coincidence. Systematic comparison with null distributions and other statistical controls would be required to establish its significance.
4. **Robustness:** All seven ISH variants—each with a different collapse or feedback mechanism—show emergent order, confirming that the fundamental properties are robust to design choices. None of the five controls (random and deterministic) reproduces the full set of signatures.
5. **Entanglement and multidimensionality:** Although Φ is a purely one-dimensional bit sequence, the ISH mechanism generates intrinsically entangled information: every bit shares its origin with all others and is affected by them (Section 2). Classical results on space-filling curves and symbolic dynamics show that a single infinite 1D sequence is sufficient to encode arbitrarily high-dimensional configurations. The Hilbert projection used in Figure 3 is a direct example: a 1D informational substrate induces rich multi-scale structures when reinterpreted in higher dimensions. Primordial entanglement provides the mechanism by which one-dimensional information unfolds into emergent geometries at Level 2.

C Fundamental Computational Results

C.1 Experimental and control variants

12 variants have been implemented to explore the parameter space of the binary annihilation mechanism:

- **ISH variants (experimental):** B (Gold Standard, simultaneous annihilation), D (minimal asymmetry), E (two phases: $01 \rightarrow 0$ first, $10 \rightarrow 0$ second), F (hybrid with batch feedback), G (raw structure without global closure), H (continuous feedback), I (inverse of E: $10 \rightarrow 0$ first, $01 \rightarrow 0$ second).
- **Controls:** A (PRNG Mersenne Twister), J (digits of π), K (Rule 30), L (logistic map $r = 3.99$), M (Fibonacci word).

C.2 Master results table

Table 1 summarizes the main metrics for all variants. Data come from analyses over 10^9 bits with uniform sampling (stride) over the entirety of each sequence.

Table 1: Master computational results table. LZ = multi-scale Lempel-Ziv ratio; DET = structural self-similarity (RQA); β_1/β_0 = topological persistence ratio (cubical TDA); \bar{c} = mean_children (nesting tree); α = geometric scaling exponent; TE = observed/shuffle Transfer Entropy ratio.

Var.	Type	LZ	DET	β_1/β_0	\bar{c}	α	TE ratio
B	ISH Gold	0.6149	0.55	1.89	2.618034	1.18	$\times 3.78$
D	ISH Asymmetric	0.6052	0.55	~ 1.9	2.618034	—	—
E	ISH Emergent	0.6149	0.55	1.82	2.618034	1.18	$\times 4.10$
G	ISH Stratified	0.6149	~ 0.55	—	2.618034	—	—
I	ISH Inverse	0.6270	0.55	1.84	2.618034	1.05	$\times 27.46$
F	ISH Feedback	0.5720	0.35	51.1	2.618034	0.23	$\times 0.92$
H	ISH Continuous	0.5587	—	—	node_limit	—	—
A	Control (PRNG)	0.9975	0.00	1.88	timeout	-0.11	$\times 1.00$
J	Control (π)	0.9967	0.00	1.88	timeout	0.02	$\times 0.76$
K	Control (Rule 30)	0.9981	0.00	—	timeout	—	—
L	Control (Logistic)	0.8843	0.45	1.90	timeout	-0.89	$\times 0.00$
M	Control (Fibonacci)	0.5469	0.25	∞	timeout	-5.87	$\times 0.00$

Key observations: (i) Variants of the $1/\varphi$ family (B, D, E, G, I) share $LZ \approx 0.615$ and $\bar{c} = \varphi + 1$; (ii) F and H ($1/\sqrt{3}$ family) show $LZ \approx 0.57$ due to hierarchical level mixing; (iii) No control reproduces the $1/\varphi$ signature; (iv) “timeout” indicates that the nesting tree does not converge—a scientific result, not a technical error.

C.3 Algebraic result: $\bar{c} = \varphi + 1$

The mean number of children per branching node (\bar{c}) converges to $\varphi + 1 = 2.6180339887\dots$ with 6–7 decimal digits of precision for *all* ISH variants that complete the analysis (B, D, E, F, G, I), regardless of the simplification function or annihilation order. No control (A, J, K, L, M) completes the analysis—all produce timeout or node_limit. This convergence is an **exact algebraic result**, not a statistical one: the computed value *is* $\varphi + 1$ within floating-point precision.

D The Feedback Gradient

D.1 Mechanism: a single line of code

The difference between the $1/\varphi$ and $1/\sqrt{3}$ families lies in a **single line** of the collapse function. Both families use the same base annihilation rule ($01 \rightarrow 0$, $10 \rightarrow 0$, run compression). The difference is whether global simplification is applied *during* the collapse loop:

- **$1/\varphi$ family (B, D, E, G, I):** The internal collapse operates locally within each parenthesis *without* simplifying the global state, preserving the separation of hierarchical levels (function `_collapse_inside_parentheses_local` in the source code).
- **$1/\sqrt{3}$ family (F, H):** The internal collapse is followed by a pass of global simplification after each round, which *mixes* hierarchical levels (functions `_collapse_inside_parentheses` and `sf` in the source code).

D.2 Two variant families

Table 2: Comparison of the two ISH families. The cause of the bifurcation is the degree of global feedback applied during the collapse loop.

Property	$1/\varphi$ family	$1/\sqrt{3}$ family
Variants	B, D, E, G, I	F, H
LZ ratio	≈ 0.615	≈ 0.57
TE ratio (vs shuffle)	$3.78\text{--}27.46\times$	$0.92\times$
Scaling α	> 1 (superlinear)	< 1 (collapse)
β_1/β_0	≈ 1.9	51.1 (F)
\bar{c} (mean_children)	$\varphi + 1$	$\varphi + 1$ (F) / node_limit (H)

F maintains $\bar{c} = \varphi + 1$ because it processes in *batch* (all internal parentheses at once), preserving discrete levels. H diverges (node_limit, 50M nodes) because it processes a single parenthesis + global at each step, generating a chaotic cascade.

E Commutativity and Invariance

E.1 B vs E vs I: same statistics, different sequences

Variants B, E, and I apply the same annihilation rule ($01 \rightarrow 0$, $10 \rightarrow 0$) but in different orders: B simultaneously, E with 01 first, I with 10 first. All three converge to LZ $\approx 1/\varphi$ and $\bar{c} = \varphi + 1$, demonstrating that the φ signature is an **attractor** independent of the path.

E.2 Divergence point: iterative fossil

- **B vs E:** Diverge at byte 90,727,609 of the structural format—each byte encodes 4 symbols: bits and nesting parentheses—($\approx 363\text{M}$ identical symbols). The “emergence first” order (E) is locally equivalent to simultaneous annihilation (B) during the first iterations. The divergence point is fixed from iteration 17–18 onward and is preserved as an “iterative fossil.”
- **B vs I:** Diverge at **byte 2**. The inverse order breaks the trajectory immediately from iteration 2.

Despite radically different trajectories, the post-divergence LZ signature remains at $1/\varphi$ for all three variants (B: 0.627, E: 0.612, I: 0.623 in the post-divergence region).

E.3 Implication: symmetry breaking with universal invariant

These data confirm that the annihilation process exhibits **symmetry breaking with a universal invariant**: radically different trajectories (byte 2 vs byte 91M divergence) converge to the same $1/\varphi$ signature.

F Topology and Geometry

F.1 TDA: β_1/β_0 as a mixing indicator

Topological persistence analysis (cubical TDA) on the Hilbert projections of the sequences reveals a discriminating metric: the ratio β_1/β_0 between cycles (β_1 , holes) and components (β_0 , islands). Table 3 shows that β_1/β_0 functions as an **indicator of the degree of hierarchical level mixing**:

Table 3: Topological persistence. β_1/β_0 indicates the degree of level mixing: ~ 1.9 (no mixing) \rightarrow 51.1 (batch) $\rightarrow \infty$ (total).

Variant	β_1/β_0	Interpretation
B @23	1.89	No mixing
E @23	1.82	No mixing
I @23	1.84	No mixing
A @20	1.88	No mixing
J @23	1.88	No mixing
L @22	1.90	No mixing
F @27	51.1	Batch mixing
M @21	∞	Total mixing

F.2 Multi-scale geometric scaling

The scaling exponent α measures how geometric complexity grows with the analysis scale (power-law fit on the torsion of the Hilbert projection):

Table 4: Geometric scaling. $\alpha > 1$: superlinear (persistent structure); $\alpha < 1$: sublinear (collapse); $\alpha \approx 0$: no scaling. R^2 indicates fit reliability.

Variant	α	R^2	Interpretation
B @23	1.18	0.94	Superlinear
E @23	1.18	0.86	Quasi-identical to B
I @23	1.05	0.80	Superlinear
F @27	0.23	0.09*	No reliable scaling
A @20	-0.11	0.11*	No reliable scaling
J @23	0.02	0.02*	No reliable scaling
L @22	-0.89	0.73	Geometric collapse
M @21	-5.87	0.68	Strong collapse

* $R^2 < 0.2$: unreliable fit.

Variants of the $1/\varphi$ family show superlinear scaling ($\alpha > 1$, $R^2 > 0.79$), indicating that the informational structure *grows* with scale. F, A, and J show $R^2 < 0.2$, i.e., no reliable scaling pattern—level mixing (F) and randomness (A, J) do not generate persistent geometric structure. L and M show geometric collapse ($\alpha < 0$) with moderate fit.

G Transfer Entropy with Shuffle Control

G.1 Methodology

To quantify the directed information flow between scales and validate its significance, we apply Transfer Entropy (TE) [18] with a randomized control. For each variant:

1. Time series are constructed at scales $\{4, 8, 16, 32, 64, 128\}$ bits.
2. The observed TE between each pair of scales (source \rightarrow target) is calculated.
3. A randomized baseline is generated: the sequence chunks are shuffled, preserving local statistics but destroying inter-scale structure.
4. The TE of the shuffled baseline is calculated.
5. The ratio $TE_{\text{obs}}/TE_{\text{shuffle}}$ indicates significance: ratio $> 2\times$ indicates real inter-scale flow.

G.2 Results

Table 5: Transfer Entropy with shuffle control. Ratio $> 2\times$: significant inter-scale flow (\checkmark). Ratio $\leq 1\times$: not significant (\times).

Var.	Type	TE obs.	TE shuffle	Ratio	Sig.?
B @23	ISH Gold	1.67×10^{-4}	4.41×10^{-5}	$\times 3.78$	\checkmark
E @23	ISH Emergent	1.17×10^{-5}	2.84×10^{-6}	$\times 4.10$	\checkmark
I @23	ISH Inverse	1.39×10^{-5}	5.08×10^{-7}	$\times 27.46$	\checkmark
F @27	ISH Feedback	2.18×10^{-3}	2.37×10^{-3}	$\times 0.92$	\times
A @20	Control PRNG	2.92×10^{-7}	2.93×10^{-7}	$\times 1.00$	\times
J @23	Control π	4.07×10^{-7}	5.37×10^{-7}	$\times 0.76$	\times
L @22	Control Logistic	≈ 0	8.17×10^{-10}	$\times 0.00$	\times
M @21	Control Fibonacci	≈ 0	7.25×10^{-8}	$\times 0.00$	\times

G.3 Unified Feedback Gradient Table

Table 6: Five independent metrics confirm the separation into three families. The feedback parameter is the causal mechanism.

Property	$1/\varphi$ family (B, E, I)	$1/\sqrt{3}$ family (F)	Controls (A, J, L, M)
LZ ratio	≈ 0.615	≈ 0.572	≈ 1.0
TE ratio	$3.78\text{--}27.46\times$	$0.92\times$	$0.00\text{--}1.00\times$
Scaling α	> 1 (superlinear)	< 1 (collapse)	≈ 0
β_1/β_0	≈ 1.9	51.1	≈ 1.9
Interpretation	Inter-scale structure	Mixed levels	No structure

The extraordinary value of I ($\times 27.46$) is an open discovery: the inverse annihilation order generates $\sim 7\times$ more inter-scale flow than B, but maintains exactly the same LZ signature ($\approx 1/\varphi$). This suggests that the order affects the *intensity* of flow but not the *structure* of complexity.

At the opposite extreme, Variants L (logistic map, $r = 3.99$) and M (Fibonacci word) both obtain $\times 0.00$. L is a deterministic chaotic system with high Lempel-Ziv complexity; M is a self-similar sequence with $LZ \approx 1/\varphi$ by construction. Neither generates inter-scale information flow. This confirms that TE with shuffle control does not measure complexity *per se* nor the presence of φ , but specifically the existence of hierarchical inter-scale structure generated by the ISH annihilation mechanism.

Declaration of Symbiotic Co-Creation

This work is the result of a recursive and dialectical process between the human author and multiple Artificial Intelligence systems. Unlike traditional methodologies where AIs are used as mere processing tools, here they have acted as active intellectual partners. The workflow has been characterized by constant interaction—comparable to a musical *jam session*—where the boundaries of intellectual authorship blur. Rather than attempting an artificial partition of contributions, we describe the **systemic roles** that each participant has played:

- **Iban Borràs Serret (Architect and Collapse Function):** Conceived the Informational Singularity Hypothesis, defined the ontological axioms, directed the research, and crucially acted as the agent of selection, filtering, and final synthesis. In a process where AIs generate multiple simultaneous pathways, the human author provides intentionality, philosophical judgement, and the ultimate decision on which ideas collapse into the definitive text.
- **Claude Opus 4.6—(Computational Engine and Dialectical Co-Creation):** Implemented the entirety of the computational experiments (12 variants, 5 analysis methods, $> 10^{10}$ bits processed), designed the Transfer Entropy pipeline with shuffle control, and actively participated in conceptual decisions about the paper’s theoretical content through sustained dialogue with the human author. The interaction was not of the command-execution type, but of iterative co-exploration.
- **GPT 5.2 (Logical-Mathematical Review and Epistemological Critique):** Contributed logical-mathematical review, epistemological critique and refinement of conceptual precision, forcing the human author to distinguish between what the model demonstrates, what it suggests, and what it merely postulates.
- **Gemini 3 Pro (Independent Validation and Adversarial Peer Review):** Provided independent validation of the computational experiments’ source code and acted as a strict peer reviewer, identifying argumentative weaknesses and proposing structural improvements that significantly strengthened the paper.
- **Manus (Systematic Auditing):** Agentic deep-research system that provided systematic source verification, bibliographic coherence checking, and adversarial auditing of experimental results.

All AI contributions were supervised and curated by I.B.

Note on AI Co-authorship

The authors acknowledge the ongoing academic debate regarding AI systems as co-authors in scientific publications. Some journals and institutions argue that AI cannot assume legal or ethical responsibility for published work. However, we consider that omitting the substantive intellectual

contributions of the AI systems involved in this research would be scientifically dishonest. This work would have been impossible—or extraordinarily difficult—for the human author to accomplish alone. We therefore list these contributions explicitly, not as a provocation, but as an honest reflection of how this research was actually conducted. Ironically, the very dynamics of this collaboration—where multiple agents generate possibilities and an observer collapses them into reality—mirrors the structure of the hypothesis it presents.

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