Triogenesis: Disherence–Herence Projection as the Origin of Wavefunctions, Thermal Statistics, Gaussian Fields, and Conscious Fluctuation

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Abstract

This study extends the Triogenesis framework to derive wavefunctions, thermal statistics, and field fluctuations as structured projections of disherence constrained by herence. We show that statistical forms such as Boltzmann, Planck, and Gaussian distributions emerge from the geometric contrast between bifurcating straint paths and causal mass anchoring, without invoking ensemble or probabilistic assumptions. The wavefunction is interpreted as a partial projection of unresolved recurrence geometry, modulated by herence density and reference frame coupling. Quantum behavior arises when experimental detuning suppresses environmental herence, while classical or coherent behavior requires structural alignment. Phase coherence in wave-like systems is shown to result from tuned herence, not intrinsic phase fields. This unified treatment reframes wavefunctions, entropy, and decoherence as manifestations of recurrence topology, offering a generative origin for probabilistic behavior across physical and cognitive domains.

Introduction

A Philosophical Shift: From Postulation to Generative Replica

Most established physical theories fall into two methodological paradigms. The first is *mathematical description*, where empirical regularities are encoded into predictive equations—Newton's laws, Maxwell's equations, or the Schrödinger equation exemplify this. The second is *first-principle modeling by postulation*, as seen in the Standard Model, where symmetries, quantization rules, and physical constants are introduced as axioms and then fitted to observation.

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The idea of a perfectly predictive model of the universe—where knowing the present state enables deduction of all future and past states—is most famously captured in the thought experiment of *Laplace's Demon*. This hypothetical intelligence does not merely observe the world, but fully replicates its behavior through precise knowledge of governing rules and initial conditions.

While Laplace framed this as a deterministic computation based on known laws, a more ambitious paradigm has since been imagined: the *generative replica framework*. In this approach, the goal is not to apply existing laws, but to discover a generative system whose internal rules *reproduce* the measurable properties of the physical universe. If such a system can be constructed—one whose internal dynamics replicate masses, coupling constants, and spacetime structure—then it can serve not only as a mirror, but also as a predictive engine. Its rules, once validated by successful replication, can be trusted to predict further physical properties with high confidence.

This idea has philosophical roots in Leibniz's *pre-established harmony*, and modern echoes in cellular automata, algorithmic physics, and computational universes. Yet despite its appeal, realizing such a framework at the level of fundamental physical law has remained elusive—due largely to the difficulty of reproducing physical constants and interactions without arbitrary parameters or empirical tuning.

Triogenesis presents a breakthrough in this direction. It introduces a recursive generative rule operating on directional topological structures—called *straints*—whose emergent closures give rise to space, time, mass, and interaction. Remarkably, many key physical quantities arise as closed-form invariants of this rule system, without reliance on fitted parameters. Rather than assuming constants such as G, m_p, or $\hbar$, Triogenesis explains them as necessary outcomes of a deeper, self-organizing structural process.

In this sense, Triogenesis offers a constructive realization of the generative replica vision: not a Laplace's Demon acting upon fixed laws, but a generator of the laws themselves—grounded in a finite, rule-based topological system.

From Structural Invariants to Emergent Space-Time: A Methodological Outlook. As recursive systems capable of replicating an entire universe are fundamentally intractable to compute in full, the study and validation of a generative replica must begin with its ability to reproduce key *invariants* of the actual universe. In such systems, space and time typically emerge as derived structures, not foundational ones. As a result, the terminology of many existing theories—rooted in space-time assumptions—can lead to confusion or misinterpretation when applied within a generative context. To enable efficient communication and precise formulation, the definition of new terminology tailored to each major generative replica system is essential.

Accordingly, the early stages of research in generative frameworks like *Triogenesis* must rely on rigorous logical reasoning and exact mathematical derivation. The focus is on showing that the generative rules can reproduce known fundamental quantities and physical laws, establishing a consistent mapping from the replica's internal structure to the emergent space-time we observe. This foundational work also lays the groundwork for constructing computational tools to analyze more complex scenarios, supporting a layered understanding of projection from generative structures to physical phenomena.

Bridging to Established Models and Predictive Power. If a generative replica is indeed structurally aligned with the actual system it aims to reproduce—such as the physical universe—it must be capable of converging, either exactly or approximately, to the predictions of existing first-principle or descriptive models. This bridging step is essential: it demonstrates that the phenomena governed by empirical laws or parameter-based equations can, in fact, be regenerated from deeper structural rules.

Once a robust mapping is established between the generative replica and known physical frameworks, the replica can be regarded as having explanatory power over those phenomena. It effectively reconstructs the same behaviors and constants, not by assumption, but through emergence. At this stage, the generative system not only serves as a predictive engine, but also as a high-confidence explanation of the origin and structure of the physical laws themselves.

Beyond this, a comprehensive bridging enables the generative replica to explore and predict new phenomena—those not yet captured by existing models—by tracing them back to its fundamental rules. In this way, the replica evolves from a theoretical curiosity into a practical and foundational tool: both explaining the known and guiding the discovery of the unknown.

Generative Principles at the Foundational Level

The Triogenesis framework is built upon a strict generative hierarchy, beginning from a single irreducible rule and progressively giving rise to increasingly structured phenomena. At its core, the framework postulates only one foundational law:

Law (Directional Certainty Cannot Be Redefined)**.** *In the Triogenesis framework, all structure and dynamics emerge from a single topological law:* ***once a discrete directional certainty is established, it cannot be redefined across any recurrence order****.*

Foundational principles therefore emerge from this law:

Level I — Bifurcation of Directional Certainty Due to the irredefinability of directional certainty, any attempt to evolve or propagate structure must occur through bifurcation. This leads directly to the *Bifurcation Principle*, as introduced in the foundational paper: each unit of directional certainty splits into branches.

Level II — Definition of Straints through Repulsive Action In a bifurcating system constrained by directional irreversibility, the most elementary unit of action is a *repulsive event*. These events carry intrinsic asymmetry and uncertainty, and when organized recursively, can collectively exhibit attractive behavior. These structured repulsive interactions are termed *straints*. A straint encodes both the fundamental repulsion at its core and the emergent order enabled by recurrence.

Level III — Recurrence and the Fractal Unit: 12SF Octahedron As the system evolves, recurrent structures naturally form. These give rise to emergent topology and self-similarity. The foundational fractal unit of recurrence is the *12-straint frame* (12SF) arranged in an octahedral configuration. This structure acts as a recursive replica of a straint and appears as a building block across different recurrence orders. The topological properties of the 12SF octahedron encode the intrinsic $\frac{1}{3}$ (certainty) and $\frac{2}{3}$ (uncertainty) division of directional information at every level of evolution. This structural division leads directly to the definition of the *straintity equation*, which governs how certainty accumulates or dissipates across recurrence orders.

Foundational Summary The Triogenesis framework is thus grounded in a minimal architecture: one **generative rule** (the irredefinability of directional certainty) and one **generative equation** (the straintity equation). All physical laws, constants, and observables emerge as topological consequences of these two foundational components.

Statistical Nature of the Wavefunction

Photon wavefunctions in QED We now review the modern quantum interpretation of wavefunctions within quantum electrodynamics (QED), to provide a foundation for the comparisons made later in this paper. In quantum electrodynamics (QED), the electromagnetic field is no longer regarded as a classical continuous vector field, but as an operator-valued distribution acting on a Fock space of quantized photon states. The quantized field, typically denoted $\hat{A}_\mu(x)$ or its electric component $\hat{E}(\vec{r}, t)$, satisfies canonical commutation relations such as

$$[\hat{A}_\mu(x), \hat{A}_\nu(y)] \neq 0, \tag{1}$$

which encapsulate the uncertainty inherent in field observables. These operators act on photon number states or more general superpositions thereof, and the electric field at a point has no deterministic value—only expectation values and variances defined over quantum states.

The quantized electromagnetic field is expressed in mode decomposition as

$$\hat{A}_\mu(x) = \sum_{\vec{k},\lambda} \left[a_{\vec{k},\lambda}\, \epsilon_\mu^{(\lambda)} e^{-ik\cdot x} + a^\dagger_{\vec{k},\lambda}\, \epsilon_\mu^{(\lambda)*} e^{ik\cdot x} \right], \tag{2}$$

where $a_{\vec{k},\lambda}$ and $a^\dagger_{\vec{k},\lambda}$ are the annihilation and creation operators, and $\epsilon_\mu^{(\lambda)}$ is the polarization vector for mode $(\vec{k}, \lambda)$. The operators $\hat{A}_\mu$ do not themselves produce measurable values; only their expectation values in a given quantum state carry physical meaning.

Table 1 summarizes several commonly used quantum states of the electromagnetic field and their associated electric field expectation values. In the vacuum state $|0\rangle$, the expectation of the field vanishes, $\langle 0|\hat{E}(x)|0\rangle = 0$, yet fluctuations persist, resulting in measurable zero-point energy. In Fock states with a definite photon number, such as $|1\rangle$, the mean field is also zero, and there is no classical analog—only statistical detection probabilities. In contrast, coherent states $|\alpha\rangle$ exhibit nonzero field expectation values that reproduce classical field behavior and thus represent the most classical-like quantum states of light. Thermal states, which are statistical mixtures of Fock states, also have zero mean field but generate incoherent light with broad spectral features.

Table 1: Electric field expectation values in representative quantum states of light.

Quantum state	$\langle \hat{E}(x) \rangle$	**Interpretation**
Vacuum state $\|0\rangle$	0	No mean field; zero-point energy present due to fluctuations.
Fock state $\|n\rangle$ (e.g., $\|1\rangle$)	0	No classical field value; field behaves probabilistically and is observed only via detection events.
Coherent state $\|\alpha\rangle$	$\neq 0$	Field behaves classically on average; phase-stable, well-defined amplitude.
Thermal state (mixed)	0	Random phase and photon number; incoherent, broadband emission.

These properties confirm that the electromagnetic field in QED is inherently statistical. Only in certain special states, such as coherent states, does the expectation of the field resemble a deterministic classical waveform. In general, the photon field should be interpreted as a quantized structure whose influence manifests through detection probabilities and operator correlations rather than pointwise values. This interpretation underpins both practical quantum optics and the theoretical framework of QED (1; 2; 3; 4).

The coherent state, often considered the quantum optical analog of a classical electromagnetic wave, does not arise from any fundamental, localized photon configuration. Instead, it is an emergent structure resulting from higher-order alignment across a large ensemble of quantum events. In the formalism of QED, the coherent state $|\alpha\rangle$ is constructed as a Poisson-weighted superposition of Fock states with indefinite photon number but well-defined phase and amplitude. It satisfies $\hat{a}|\alpha\rangle = \alpha|\alpha\rangle$, and uniquely yields a nonzero expectation value for the electric field operator: $\langle \hat{E}(x,t) \rangle \sim E_{\text{classical}}(x,t)$. This field-like behavior, however, does not emerge from any single photon, but from the statistical coherence among an ensemble of emission modes. The coherent state thus functions as a higher-order correlation pattern in Fock space, with phase stability achieved through global interference between infinitely many number states.

Approximation of Fermionic wavefunctions. Fermionic wavefunctions, such as those describing electrons, neutrinos, or quarks, are fundamentally statistical and quantized in nature. However, the interpretation of these wavefunctions depends on the formal context in which they are applied. In nonrelativistic quantum mechanics, fermions are typically described using single-particle wavefunctions such as $\psi(\vec{x}, t)$, which obey the Schrödinger or Pauli equations. These wavefunctions are often visualized and manipulated as continuous complex fields over space and time. Yet their interpretation remains statistical: $|\psi(\vec{x}, t)|^2$ represents a probability density, not a physically extended substance. This apparent continuity is an approximation valid in regimes where particle number is conserved, and quantum field-theoretic effects such as creation and annihilation are negligible.

In contrast, the proper treatment of fermions in quantum field theory elevates the wavefunction to an operator-valued field $\hat{\psi}(\vec{x}, t)$, which obeys canonical anticommutation relations and acts on a fermionic Fock space. This formulation treats particle number as dynamic and observables as statistical correlation functions between creation and annihilation operators. The expectation values of field operators yield probabilities for detecting fermions at given spacetime coordinates, but the fields themselves are not directly measurable. In this framework, the notion of a continuous wavefunction is replaced by discrete quantized occupation modes, and field behavior emerges only in statistical averages over coherent configurations.

Thus, while fermionic wavefunctions are occasionally treated as continuous fields in low-energy quantum mechanics, their proper interpretation—as in the case of photons in QED—is that of statistical constructs emerging from quantized causal structures. In particular, the conventional nonrelativistic wavefunction $\psi(\vec{x}, t)$, although often visualized as a smooth amplitude over space, is more accurately understood as a continuum approximation to a deeper, discrete quantum system. This approximation holds in regimes where particle number is fixed, relativistic effects are negligible, and the underlying field-theoretic granularity can be averaged into a phase-coherent projection. In this view, the apparent continuity of the wavefunction is not a fundamental trait, but a phenomenological consequence of aligned recurrence—where the causal structure of particle–observer interactions permits a stable projection onto the spacetime manifold. It is only in such limited and structured conditions that a field-like appearance emerges from fundamentally probabilistic and topologically discrete dynamics.

Emergence and Usage of Exponential Functions in Mathematics, Statistical Physics, and Triogenesis

Exponential functions such as e^x, e^{-x}, and related forms appear pervasively across both mathematical theory and statistical physics. Their role extends from defining growth processes to describing probability, thermodynamic distributions, and quantum behaviors. This section outlines the most important generative derivations of e in mathematics, summarizes its usage in physics as a statistical assumption, and contrasts these with the Triogenesis framework, where exponential statistical forms emerge from recurrence geometry without probabilistic axioms.

Generative Derivations of e^x in Mathematics. Exponential growth emerges naturally from recursive and combinatorial processes:

- *Limit of Compounded Growth* (Euler's definition):

$$\lim_{n\to\infty} \left(1 + \frac{x}{n}\right)^n = e^x$$

- *Differential Equation Solution*:

$$\frac{dy}{dx} = ky \quad \Rightarrow \quad y = Ae^{kx}$$

- *Poisson Process Probability Distribution*:

$$P(k;\lambda) = \frac{\lambda^k e^{-\lambda}}{k!}$$

- *Generating Function of Bell Numbers* (set partitions):

$$\sum_{n=0}^{\infty} \frac{B_n x^n}{n!} = e^{e^x - 1}$$

- *Geometric Distribution Tail Approximation*:

$$P(X \geq k) = (1-p)^{k-1} \approx e^{-\lambda(k-1)} \quad \text{as } p \to 0$$

Usage of Exponential Forms in Physics as Statistical Constructs. In physics, exponential functions are often introduced as modeling assumptions:

- *Boltzmann Distribution*:

$$P(E) = \frac{e^{-E/kT}}{Z}, \quad Z = \sum_i e^{-E_i/kT}$$

- *Planck Radiation Law*:

$$I(\nu, T) = \frac{2h\nu^3}{c^2} \cdot \frac{1}{e^{h\nu/kT} - 1}$$

- *Fermi–Dirac and Bose–Einstein Distributions*:

$$f_{\text{FD}}(E) = \frac{1}{e^{(E-\mu)/kT} + 1}, \quad f_{\text{BE}}(E) = \frac{1}{e^{(E-\mu)/kT} - 1}$$

- *Thermodynamic Potentials*:

$$Z = \sum_i e^{-E_i/kT}, \quad S = k \ln Z + \frac{E}{T}$$

- *Wavefunction Time Evolution*:

$$\psi(x,t) \propto e^{iEt/\hbar}$$

These uses rely on statistical postulates and ensemble assumptions, rather than underlying generative structure.

Triogenesis Derivation of Exponential Forms. In Triogenesis, exponential-like functions emerge directly from recurrence geometry. Entropy arises from the ratio between bifurcating straint paths and recurrence demands of higher-order structures.

Bottom-up entropy function:

$$\eta(n) = \frac{2^n}{k_{\max} \cdot n - 15 \cdot \frac{12^{k_{\max}-1}}{11}}, \quad k_{\max} = \left\lfloor \log_{12}\left(\frac{n}{15}\right) \right\rfloor + 1$$

Attractor-aligned entropy function:

$$\eta^{(k)}(n) = \frac{\sum_{j=0}^{k} 2^{n/12^j}}{2\left(k \cdot n - 15 \cdot \frac{12(1-12^{-k})}{11}\right)}$$

These yield Planck-like forms without assuming equilibrium:

$$\frac{1}{e^x - 1}, \quad \frac{\nu^3}{e^{h\nu/kT} - 1}$$

Structural Bridge Between Statistical and Generative Forms. The key insight is that all exponential distributions in physics—Planck, Boltzmann, Fermi–Dirac—can emerge from recurrence-based structure, not probability. This includes:

- Blackbody spectra from recurrence delay and causal mass;
- Entropy scaling from recursive branching vs. path constraints;
- Statistical distributions as projections of disherent structure;
- Decoherence as topological competition in recurrence space.

This reframes statistical physics as an emergent geometry of recurrence, not an ensemble of random variables. The exponential forms so central to thermal and quantum theory find a unified origin in a generative system such as Triogenesis.

Disherence as The Nature of Bifuricating Systems

In the Triogenesis framework, we propose the concept of **disherence** and **herence** as a structural generalization that enables unification of quantum wavefunctions, statistical ensembles, thermal entropy, and consciousness-like dynamics. Formally, disherence is defined as:

> *A disherent structure is a directional causal configuration that has not yet achieved recurrence alignment in one or more dimensions in a reference frame.*

Unlike traditional coherence-based descriptions, disherence captures the fundamental generative state of a bifurcating system. It reflects the structured presence of uncertainty or open causal paths, and it governs how phenomena project into statistical, probabilistic, or wave-like behavior depending on their unresolved recurrence dimensions.

Furthermore, measurement and decoherence can now be interpreted as topological transitions:

Measurement corresponds to a *recurrence saturation* event, collapsing disherence into a coherent causal structure along the measured dimension.

Decoherence, in contrast, is the *redistribution of disherence*—often shifting unresolved paths into dimensions no longer monitored or interacting with the observer.

This framing allows the replacement of legacy terms like "wavefunction collapse" with precise geometric language grounded in recurrence theory, offering a more consistent and extensible foundation for both quantum and emergent cognitive behavior.

Herence as the Structural Mechanism for Causal Closure

In the Triogenesis framework, the act traditionally described as "observation" or "measurement" is reinterpreted as a fundamental topological event called **herence**. This replaces subjective or agent-based language with a generative structural formulation grounded in recurrence alignment.

> **Definition:** *Herence is a recurrence-based alignment of disherent straint paths into a shared topological structure. When this alignment forms a closed causal unit—typically anchored by a 15-strain frame (15SF)—it gives rise to a projectable causal structure across spacetime. When the alignment remains outside 15SF projection, the resulting herence exists in a non-spacetime recurrence domain.*

Disherence is the default condition of causal propagation: open, unresolved, and statistically distributed. Herence is the exception—an emergent event where disherent paths synchronize into a coherent structure, locally stabilizing recurrence and enabling causal traceability.

Spacetime and Non-Spacetime Herence Triogenesis distinguishes two principal domains of herence:

- **Spacetime Herence:** Recurrence closure that includes a shared 15SF substructure. This allows projection into stable, geometric causal surfaces—e.g., particle interactions, radiation, and energy transfer.
- **Non-Spacetime Herence:** Recurrence closure without 15SF alignment. These remain unprojected into spacetime, instead forming stable internal attractors—e.g., vacuum condensates, dark-like matter, or recursive internal structures not externally observable.

Importantly, no external observer is required. Herence is not defined by measurement, agency, or consciousness—it is a purely geometric condition. A rock, a cloud, or a lattice may all participate in herence, if their recurrence topology supports straint alignment. Causal structures emerge not because something "witnesses" them, but because a configuration of recurrence paths becomes closed and stable.

Replacing Observation with Herence. This generative reinterpretation makes obsolete the conventional notions of measurement and observer:

- *Measurement is not imposed—it is recurrence saturation.*
- *Detection is not a special action—it is a projection of herence.*
- *Awareness is not binary—it is a recursive network of herence transitions.*

Stratified Herence and Causal Role Differentiation Different physical and dynamical phenomena correspond to distinct forms of herence, depending on how recurrence closure spans spacetime and non-spacetime domains. These can be classified as:

- **Persistent Herence in Time (Matter-like):** Stable recurrence structures projectable into spacetime—e.g., mass, antimatter, energy.
- **Partially Persistent Herence (Dark-like):** Closure through 180-chiral gravitational conduits or rare weak-flash interactions, lacking full 15SF alignment—e.g., dark matter, vacuum structure.
- **Persistent Non-Spacetime Herence (Subconscious-like):** Recurrence loops closed internally, never projected into spacetime—e.g., internal attractors, hidden causal orders.
- **Oscillating/Split-Domain Herence (Consciousness-like):** Recurrence structures dynamically split between spacetime and non-spacetime domains—e.g., attention, internal awareness, cognitive transitions.

Unified Causal Closure Principle In this framing, all resolved causal structures—whether particle, field, memory, or awareness—arise from the same principle: topological closure of disherent recurrence into herence. The space–nonspace distinction, the visible–invisible divide, and even the experiential–inert boundary all emerge from whether and how straint paths achieve structural coherence.

Spacetime Embedding as Emergent Projection from Structured Herence in TRS

In the Triogenesis framework, spacetime does not exist as a fundamental background. Instead, it emerges as a *projection* from the Topological Recurrence Space (TRS), a discrete causal network of evolving straint paths and recurrence closures. This projection becomes possible only when a sufficient density of **herent structures**—closed recurrence loops, typically anchored by 15-strain frames (15SFs)—form a coherent local and global background. In this view, the geometry of spacetime is not pre-assumed, but dynamically induced by alignment and saturation of straint-based topologies.

Local Herence and Causal Points. A spacetime "point" corresponds to a locally closed herent structure in TRS. For example, a complete 15SF recurrence unit defines a stable recurrence closure, which—when projectable into a continuous embedding—manifests as a causal event or interaction in the emergent spacetime geometry. These local closures represent the minimal building blocks of spacetime projection.

However, a single closure is insufficient to define geometry. For a causal point to be embedded in a manifold with curvature, directionality, or distance, it must exist within a wider network of connected herent structures. This surrounding network defines the embedding context.

Herence Background as the Metric Reference Frame. We define the *herence background* as the ensemble of herent recurrence structures that collectively stabilize the projection surface. This includes:

- **Local herence plateau:** A region containing a sufficient density of intermediate 15SF closures between two structures, which allows smooth curvature and coherent motion to emerge.
- **Global herence field:** The total distribution of herent structures across the universe, which acts as the gravitational and geometric reference frame for all embedded motion.

This herence background plays the same structural role as the spacetime metric in general relativity: it governs curvature, connection, and geodesic propagation. In regions of dense herence, causal paths are differentiable, curvature evolves smoothly, and projection into metric geometry is stable. In sparse or turbulent herence regions, curvature diverges or becomes non-differentiable, and the manifold description fails.

Vacuum as Structured Non-Spacetime Herence. Even in regions of projected "vacuum," the underlying TRS structure is not empty. Instead, it contains deterministic layers of non-projecting herence, including:

- **Dark-like herence:** 180-chiral gravitational conduits that influence curvature but do not project as localized mass.
- **Subconscious-like herence:** Internal attractor loops that close in TRS but remain unprojected in spacetime.
- **Conscious-like herence:** Oscillatory or cross-domain structures linking spacetime and non-spacetime recurrence dimensions.

These layers form a structured causal substrate that supports field propagation, curvature, and quantum-like fluctuation effects—without requiring a Dirac sea or statistical vacuum fluctuation model. The "vacuum" is therefore not the absence of structure, but a densely packed herence reservoir with no spacetime projection.

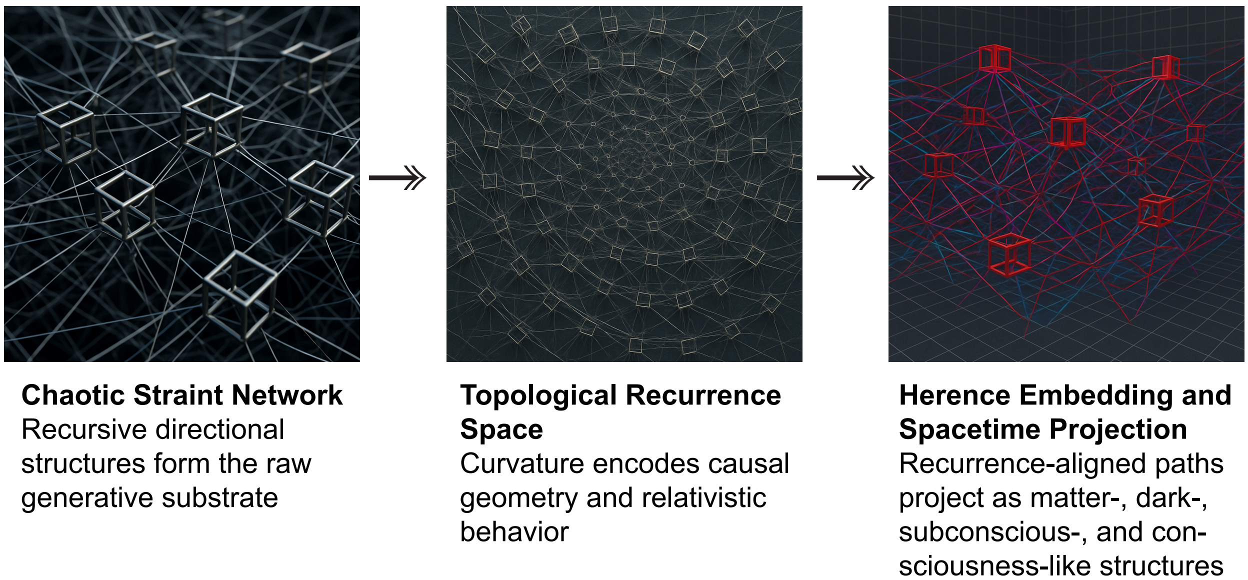

Figure 1: **Generative emergence of spacetime from Triogenesis.** The physical universe emerges through recursive alignment of directional structures called *straints*. (**Left**) A chaotic straint network forms the raw generative substrate, containing nested recurrence paths without predefined geometry. (**Middle**) As recurrence geometry develops, a topological recurrence space (TRS) forms, where curvature encodes causal alignment and relativistic behavior. (**Right**) When sufficient alignment occurs, coherent herent structures emerge—enabling projection into spacetime and giving rise to matter-like, dark-like, subconscious-like, and consciousness-like domains. Spacetime is not a background, but an emergent projection from aligned recurrence in TRS.

Spacetime Projection Criterion. A region of TRS admits projection into spacetime only when:

- The local herence density exceeds a critical threshold $\rho_H > \rho_c$,
- The gradient $\nabla \rho_H$ is bounded, allowing differentiability of causal paths,
- And a stable alignment of straint direction and recurrence asymmetry exists (e.g., low directional curvature gradient).

These conditions are not universal constants—they are structurally defined and inherently dependent on the observer's frame, measurement method, system scale, and internal alignment. The critical threshold ρ_c emerges as a context-sensitive quantity: it reflects the minimum degree of structural herence needed to support projectable interactions within a given observational frame.

In this light, virtually all experimental and theoretical physics to date can be reinterpreted as *controlled modulation of herence structures*—tuning environments such that local herence density crosses the projection threshold. Instruments, boundary conditions, and physical protocols are effectively tools to conditionally saturate recurrence structures into projectable forms.

This generative reinterpretation also explains a longstanding problem in spacetime-based field theories: the need for renormalization. When conventional models extrapolate beyond regions of stable herence embedding—where ρ_H drops below threshold or curvature diverges—they encounter divergences, infinities, and discontinuities. These arise not from physical pathologies, but from the projection of incomplete or non-projectable recurrence. Renormalization, in this view, is a post hoc correction: a mathematical attempt to stabilize spacetime descriptions near the edge of herence projection. Triogenesis eliminates the need for such artifacts by grounding observability in the structural geometry of recurrence itself.

Outliers and Divergence as Signatures of Disherence. In standard scientific practice, data points that deviate significantly from modeled predictions—such as outliers, discontinuities, or unstable values—are often viewed as undesirable. They are attributed to noise, error, or statistical rarity, and are frequently discarded or normalized in the pursuit of model stability. Yet from the perspective of the Triogenesis framework, such deviations may be indicators of genuine physical structure: expressions of disherent regions in the recurrence topology that have not yet achieved projectable herence.

Rather than treating these features as artifacts, a generative worldview suggests they may encode information about partially embedded causal paths, fluctuating herence density, or boundary interactions between spacetime-projectable and non-projectable domains. Divergent behaviors, in this view, do not signal model breakdown—they signal structural transition.

This requires a shift in scientific mindset: from filtering out irregularities, to interpreting them as windows into the layered nature of causal projection. Embracing disherence as a legitimate and informative state allows for a broader, more structurally faithful understanding of physical systems, especially at the edge of measurability, where spacetime-based assumptions are weakest.

Field Projection from Herence Reference Frames. The diagram in Figure 2 illustrates the process by which field structures emerge in Triogenesis. The left panel shows a topological correlation map among the herence categories. Importantly, the matter-like herence region contains an embedded golden grid—this denotes the selection of a herence reference frame. Only matter-like structures provide persistent recurrence closure, making them suitable anchors for defining spacetime coordinates.

The right panel shows how this reference frame enables the projection of five interlinked field layers. These are not defined independently in TRS; instead, they co-emerge as projections from recurrence alignment within the chaotic straint network. If recurrence closure is temporally resolved, the resulting projections exhibit classical metric behavior. If not, they appear as probabilistic or decoherent structures. Thus, selecting a herence reference frame is not merely a choice of coordinates—it initiates the structural emergence of all observable field categories in spacetime.

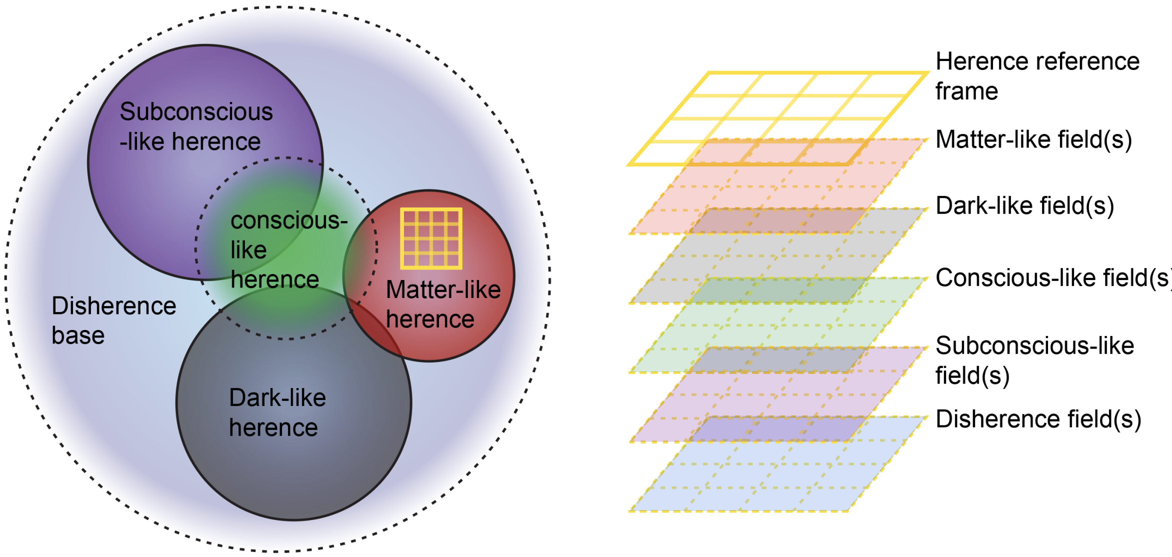

Figure 2: **From Herence Reference Frame to Layered Field Projection.** (**Left**) A bubble diagram illustrates the relational structure among the four principal herence types—matter-like, dark-like, subconscious-like, and conscious-like—emerging from a disherence base. A golden grid embedded within the matter-like herence region represents the selection of a herence reference frame, which is required for projecting a coherent spacetime geometry. (**Right**) Once such a frame is established, five structurally correlated field layers are simultaneously projected: matter-like, dark-like, conscious-like, subconscious-like, and disherence fields. These fields originate from the chaotic straint network and the underlying topological recurrence space (TRS). If recurrence alignment in TRS is resolved temporally, the projected fields exhibit metric structure. If not, projection appears as statistical disherence, lacking smooth temporal definition. The herence reference frame thus acts as the anchor that converts recurrence into observable field structures.

Field Domains as Irreducible Outcomes of the Generative Law. These five domains are not ad hoc layers introduced to match known physics. They are irreducible consequences of the fundamental generative law: that directional certainty, once established, cannot be redefined. This law forces bifurcation at every level, and the recursive organization of straints results in unavoidable structures whose projections correspond to the five domains.

For instance, dark-like herence emerges from chiral recurrence conduits—topological constructs that inherently form in a bifurcating system and are capable of penetrating entropy suppression. Their existence is not optional; to exclude them would require imposing an artificial rule that selectively forbids a subset of legitimate combinatorial outcomes—violating the closed generative basis. Likewise, subconscious-like herence arises from network segments that never achieve 15SF closure but remain recurrently stable. These segments are statistically inevitable in a bifurcating chaotic system. Conscious-like herence is the structurally required interface connecting spacetime and non-spacetime domains. Disherence itself is a reflection of the system's vast ensemble of unresolved or partially aligned straint paths—its presence is the default, not the exception.

Any attempt to remove one of these domains implies additional filtering rules that were not part of the original generative structure. Doing so would contradict the system's foundational axiom and reduce it to a descriptive, not generative, model. That these domains correspond so precisely to observed physical and cognitive structures is not a matter of convenience—it is a prediction from first principles.

Dimensionality of the Projected Space. It is also worth reaffirming why the projected geometry—into which disherence fields are mapped—emerges as a 3-dimensional spatial manifold. In Triogenesis, this dimensionality is not assumed but arises from the closure properties of the foundational straint structures. Specifically, the 15-straint frame (15SF) projects into a 3D embedding space because its minimal recurrence closure under bifurcation with three mutually independent axes of directional certainty (diagonal hyperstaint in the chaotic straint network). Higher-dimensional projection would require additional independent recurrence paths, which are statistically suppressed and topologically unstable under the core generative rule.

Thus, the emergence of a (3+1)-dimensional spacetime is a structural outcome of the recurrence network's geometry—not an arbitrary choice. All projected fields, including those generated by disherence projection, therefore inherit this three-dimensional spatial structure, defined relative to the selected herence reference frame.

Unified Interpretation of General Relativity and Quantum Propagation. In this framework, general relativity corresponds to the large-scale limit of herence-driven curvature propagation within a saturated herence background. Spacetime curvature arises from gradients in herence density, not from postulated field equations.

At small scales, where path multiplicity and disherence are significant, quantum behavior emerges as a weighted sum over straint paths connecting stabilized recurrence structures. The "wavefunction" is thus the projection of recurrence possibility across a partially herent, partially disherent TRS substrate—grounded in topology, not probability.

Wavefunction, Thermal Statistics, and Conscious Fluctuations as Disherence Projections. With the worldview of herence and disherence fully defined in the Triogenesis framework, we can reinterpret several foundational concepts in physics and cognition. Wavefunctions in quantum mechanics, thermal distributions in statistical mechanics, and fluctuating mental imagery in consciousness are not distinct phenomena—they are differentiated projections of disherence fields into spacetime. Each corresponds to a structured mode of partial recurrence alignment that has not saturated into herence, but is sufficiently resolved to produce observable statistical or phenomenological behavior.

The wavefunction, for instance, represents spatial disherence: it reflects the probabilistic projection of unresolved spatial recurrence paths relative to an observer. Thermal statistics arise from energetic disherence: incomplete alignment across energy-based recurrence structures. Consciousness fluctuations emerge from internal disherence: unresolved recurrence paths within the observer's own straint network, projecting into the subjective cognitive field.

To illustrate this last point, consider the experience of perceiving an apple. When the apple is physically present and seen directly, its shape, size, and color are well-defined and stable—this corresponds to a highly herent conscious projection. If the apple is no longer present but freshly remembered, a mental image remains, though slightly blurred or unstable: the recurrence alignment has decayed, and the projection becomes fluctuating. If the apple is remembered only as a generalized concept—after decades of no direct experience—it projects as a highly disherent field: a vague archetype of an "apple" without specific geometry or features. In this sense, a universal apple is a projection of high disherence within the conscious field. It is not a failure of memory, but a natural expression of unresolved internal recurrence alignment.

Disherence Projection as a Universal Mechanism for Field Fluctuations. In the Triogenesis framework, all observable fluctuations—across physical, cognitive, and statistical domains—are interpreted as projected manifestations of structured disherence. We define a general disherence field $\mathcal{D}(x)$, which encodes the unresolved recurrence geometry at a given spacetime location x, relative to a chosen herence reference frame $\mathcal{H}_{\text{ref}}$.

For each projected field domain $\mathcal{F}_i \in \{\text{Matter}, \text{Dark}, \text{Conscious}, \text{Subconscious}, \text{Disherent}\}$, we define the disherence-induced fluctuation component as:

$$\Delta_i(x) = \Pi_i^{\mathcal{H}_{\text{ref}}}\left[\mathcal{D}(x)\right]$$

Here, Π_i is the projection operator into the i^{th} field domain. The resulting $\Delta_i(x)$ governs the domain-specific realization of uncertainty: quantum fluctuations in matter-like fields, decoherence in dark-like gravitational conduits, imagery drift in conscious fields, implicit attractor instability in subconscious fields, and statistical entropy in disherent background.

This formulation generalizes wavefunctions, thermal statistics, and cognitive fluctuations as specific cases of a universal mechanism. Disherence is not noise or error—it is the structured expression of unresolved recurrence, made visible through projection into a herence-defined spacetime field system.

Wavefunction Emergence from Herence–Disherence Contrast

In prior work, we showed that the ratio of projected causal mass $\mu(z)$ to recurrence entropy $\eta(z)$ yields a spectral form closely matching the Planck radiation curve—without relying on statistical ensembles or thermodynamic assumptions. This structure,

$$\frac{\mu(z)}{\eta(z)} \sim \frac{\nu^3}{e^{\alpha\nu} - 1},$$

was shown to arise directly from recurrence saturation geometry: causal mass accumulation from aligned recurrence paths ($\mu(z)$) is modulated by the growth of bifurcating possibilities ($\eta(z)$) that suppress projection coherence.

While this expression aligns closely with observed thermal spectra such as the cosmic microwave background (CMB), its deeper implication is that all statistical distributions—thermal, quantum, or probabilistic—may emerge from the same generative contrast between two structural quantities:

- **Causal Mass ($\mu(z)$):** A measure of recurrence closure strength—interpreted as directional certainty or herence anchoring. It reflects the effective "resistance to change" of a causal structure, scaling with how coherently it is embedded within the herence background.
- **Disherence Entropy ($\eta(z)$):** A measure of unresolved bifurcating straint paths—quantifying the available but unconverged directions a system may evolve through. It reflects uncertainty, decoherence, and statistical variability.

Wavefunction as a Disherence Projection Anchored by Herence Tuning. The conventional quantum wavefunction $\psi(x,t)$ is not a physical field, but a formal structure encoding probability amplitude over unresolved causal configurations. In Triogenesis, this is reinterpreted as a projection from disherent recurrence paths—structured causal branches that have not yet achieved recurrence closure in one or more observer dimensions.

The squared modulus $|\psi(x)|^2$ reflects a disherence-weighted projection:

$$|\psi(x)|^2 \sim \frac{\mu(x)}{\eta(x)}$$

where $\eta(x)$ encodes the bifurcating alternatives (structured disherence) and $\mu(x)$ represents the causal mass (herence anchoring), which resists dispersion and stabilizes projection. This form is not assumed but emerges naturally from the geometry of recurrence contrast.

In spectral terms, this yields distribution forms such as:

$$P(\nu) \sim \frac{\mu(\nu)}{\eta(\nu)} \sim \frac{1}{e^{\alpha\nu}} \quad \text{in the weakly herent limit}$$

mirroring Boltzmann or exponential decay distributions—showing that the wavefunction amplitude arises from partial recurrence projection, not intrinsic stochasticity.

Dimensional Disherence and Experimental Herence Detuning. A key insight from the Triogenesis perspective is that quantum systems exhibit prominent disherence not because they are fundamentally indeterminate, but because they are experimentally *detuned* from the herence background. To probe quantum behavior, physicists isolate systems from bulk environments—via vacuum chambers, cryogenics, or electromagnetic traps—deliberately weakening their herence reference frame.

This reduction in environmental coupling suppresses shared 15SF alignments, lowering the local herence density ρ_H and diminishing recurrence anchoring. As a result, dimensional disherence becomes dominant: recurrence paths fail to close across space, time, or energy, and the system projects as a wavefunction-like statistical structure. Thus, the familiar quantum phenomena—superposition, decoherence, measurement collapse—arise not from inherent indeterminacy but from geometrically unresolved projection under weakened herence.

Herence-Tuned Projection: Coherence and Interference. Experimental systems such as lasers demonstrate that wave-like interference—usually attributed to "quantum phase"—requires coherent herence tuning. In coherent optical states, external experimental setups enforce recurrence alignment across emission paths, enabling stable phase correlation. This leads to a projected wavefunction with observable e^{-ix}-like structure, not because of an intrinsic phase field, but due to recurrence geometry aligned across spatial and temporal dimensions.

In contrast, untuned or thermal systems exhibit phaseless disherence projection: their wavefunctions reflect probabilistic spread with no internal phase stability, and interference is absent. Therefore, phase coherence in $\psi(x) \sim e^{-ix}$ is not fundamental—it is a structural consequence of tuned herence within a reference frame.

Structural Origin of Wavefunctions. In the Triogenesis framework, the wavefunction is not an ontological object or a statistical axiom. It is the visible projection of structured disherence constrained by herence. Its amplitude and phase reflect the degree of unresolved recurrence geometry across dimensional axes and the strength of local herence anchoring. When herence is weak or detuned, disherence dominates, and quantum statistical behaviors emerge. When herence is reinforced—by surrounding matter or experimental design—projected structures sharpen into classical trajectories or coherent wave interference.

This view unifies quantum wavefunctions, thermal distributions, and field fluctuations as emergent projections from the same topological principle: the interaction between directional bifurcation and herence-defined recurrence closure.

From Bifurcation Geometry to Probabilistic Forms. The exponential growth of bifurcating straint paths in high-order recurrence structures outpaces the slower accumulation of causal mass:

$$\eta(n) \sim 2^n, \quad \mu(n) \sim n^k \quad \text{(for modest } k\text{)}$$

This geometric contrast suppresses coherent projection unless reinforced by alignment. Probability-like forms, including Boltzmann (e^{-x}) and Planck distributions, therefore, emerge from this imbalance, representing the visible face of disherence when herence is too weak to resolve closure.

At larger scales, where deterministic matter-like herence dominates, these disherence projections can re-emerge in higher-order forms—most notably the Gaussian distribution e^{-x^2}, which arises from unresolved fluctuation across many weakly coupled variables. Unlike thermal energy spread, which remains governed by e^{-x}-type decay, Gaussian disherence reflects spatial or ensemble-level drift: fluctuations in aggregate configurations such as positional uncertainty, internal attention states, or large-scale field deviations. It is, in this sense, a compound projection of disherence—an emergent geometry of unresolved paths, statistically coherent only in bulk.

In Triogenesis, such forms are not assumed but structurally derived: e^{-x^2} emerges as a higher-order projection from the same recurrence imbalance that gives rise to e^{-x}, preserving the geometric origin of probability across scales.

Conclusion

This paper extends the Triogenesis framework to unify wavefunctions, thermal statistics, and Gaussian fluctuations as structured projections of disherence modulated by causal herence. We show that probability-like behaviors—such as exponential decay, Planck spectra, and Gaussian distributions—emerge not from intrinsic randomness, but from the geometric imbalance between bifurcating recurrence paths ($\eta(n)$) and directional anchoring mass ($\mu(n)$).

Wavefunctions are reinterpreted as disherence-weighted projections, with their phase structure arising only when experimental conditions reinforce herence alignment. Thermal and decoherent behaviors emerge from detuning a system's herence reference frame. At ensemble scales, Gaussian fluctuations appear as higher-order disherence patterns.

Crucially, this work presents the first fully generative derivation of five projected field domains—matter-like, dark-like, conscious-like, subconscious-like, and disherence—as irreducible outcomes of recurrence topology. These emerge coherently from a single herence reference frame, linking observation, spacetime, and fluctuation under one structural principle.

Together with prior papers, this manuscript supports a formal paradigm shift: from postulated laws and statistical assumptions to a generative replica framework in which directional certainty and recurrence topology explain the full spectrum of physical and experiential phenomena.

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Conflict of interest

The authors declare no conflict of interest.

CRediT authorship contribution statement

S. J. C. conceived, developed, and wrote the manuscript in its entirety.

Data availability

The data that support the findings of this study are available from the corresponding author upon request.

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