The Miranova Matrix

An Operational Framework for Spacetime Emergence in BFSS Matrix Theory

The Miranova Matrix presents an operational framework for understanding spacetime emergence in BFSS Matrix Theory. By conceptualising fundamental updates as discrete ticks, the framework distinguishes causal depth from emergent experienced time. Minimal generative structures and branching dynamics define lower bounds for system evolution, providing a coherent lens for observers and histories. This approach reframes temporal perception and offers a framework for exploring nonlocal time, irreversibility, and observer-embedded structures. This document presents a minimal operational framework; interpretive mappings are illustrative.

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Coherence – For an intuitive overview, follow the **blue** sections.

Resonance – For those who enjoy getting into the details, the **cyan** sections offer a more technical exploration.

Introduction

Many modern theories suggest that space and time may not be fundamental features of reality, but instead arise from deeper processes. Rather than beginning with spacetime as a given background, these approaches ask what kinds of underlying information or structure might give rise to our experience of duration, causality, and persistence.

This work explores that question from an operational perspective. Instead of starting with geometry, fields, or coordinates, it begins with the idea of ordered updates, simple, **irreversible** steps that distinguish one state from another. From repeated sequences of such updates, increasingly complex structure can arise. Within such a system, observers are not external to the process, but are embedded within it, experiencing time through the accumulation and persistence of structure rather than through access to any absolute or external clock.

The framework presented here does not attempt to describe physical mechanisms directly. Rather, it provides a conceptual lens for thinking about how time, structure, and observation might emerge in systems governed by minimal update rules. The coloured representations used throughout the framework serve as *interpretive aids*, helping to distinguish different modes of operation without asserting them as fundamental properties.

Figure 1: Conceptual depiction of emergent spacetime.

Matrix formulations appear across physics and computation as compact representations of irreversible operations and relational structure. In parallel, modern approaches such as BFSS Matrix Theory propose that spacetime itself may be emergent rather than fundamental. This work is motivated by the question of whether an explicitly operational, matrix-based framework can help clarify how causal depth and experienced time arise from minimal update rules.

Conventional descriptions of spacetime typically presuppose geometric structure, providing effective models while offering limited insight into the processes by which such structure originates. An operational approach instead treats ordered updates as primary, allowing spacetime, temporal experience, and relational structure to emerge from minimal rules rather than being assumed. By focusing on causal ordering, persistence, and branching, the framework aims to articulate a minimal and self-contained basis for reasoning about emergence in observer-embedded systems.

Core Primitives

- **Tick**
  A tick represents a single update of the system, during which operational changes are applied and accumulated, independent of any external notion of time.

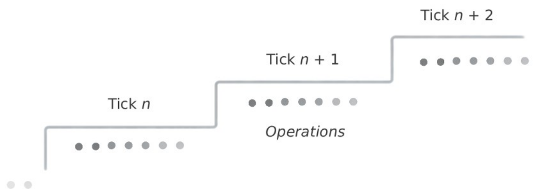


Figure 2: A tick represented as a series of ordered operations.

- **Identity / Distinction**
  Identity is the persistence of a distinguishable structure across one or more ticks. Identities emerge when distinguishable structures remain correlated across successive ticks.

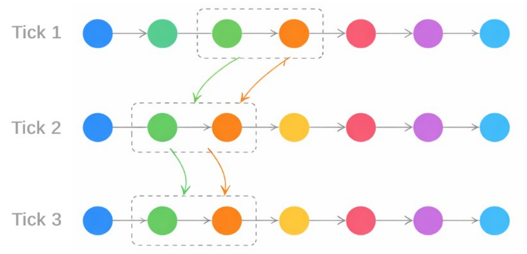


Figure 3: Identity represented as a distinguishable structure across ticks.

- **Causal depth**
  Causal depth is the length of the longest irreducible chain of tick-ordered dependencies required for a structure to exist.

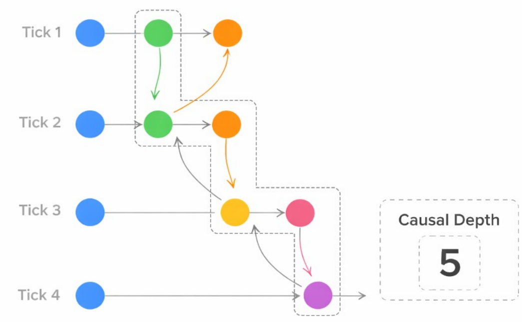


Figure 4: Causal depth as the longest chain of tick-ordered dependencies.

- **Branching / Clustering**
  Branching refers to the divergence of causal sequences across ticks, while clustering denotes the subsequent formation of correlated structures within that divergence.

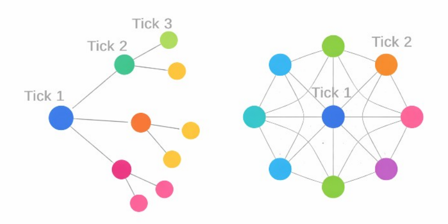


Figure 5: Demonstration of branching and clustering across ticks.

- **Emergent time**
  Embedded observers experience time primarily through the growth of causal depth, rather than through tick count.

Figure 6: Conceptual depiction of emergent time.

Key Principles

- **Monotonicity**
  Operational updates occur in a strictly ordered sequence, establishing causal precedence without requiring a time metric.

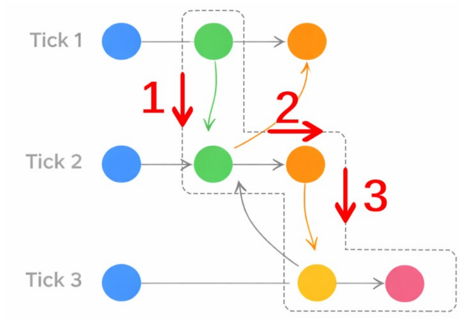


Figure 7: Example of a strict sequence of events.

- **Irreversibility**
  Certain operational distinctions, once introduced, cannot be fully undone in subsequent updates.

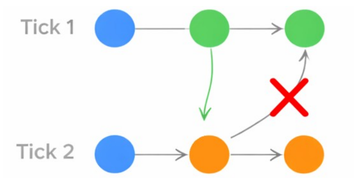


Figure 8: Example of irreversibility.

- **Dependency constraints**
  Higher-order structures arise only after the completion of prerequisite operational sequences.

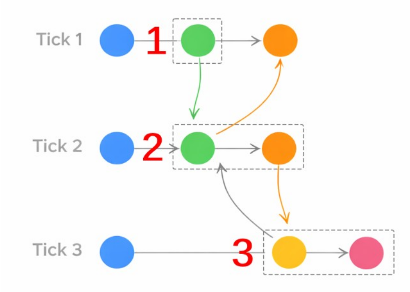


Figure 9: Example of higher-order structures.

- **Emergence principle**
  Complex structure and embedded observers arise through accumulated sequences of ticks and branching, rather than from isolated updates.

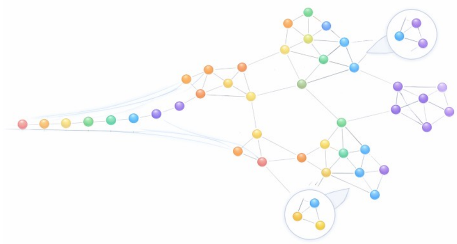


Figure 10: Example of complex structure arising from branching.

- **Observer embedding**
  Observers exist as **subsystems** within the dynamics and therefore access only emergent, relational notions of time. The underlying tick count remains unobservable.

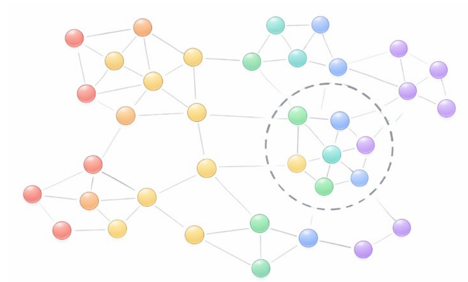


Figure 11: Example of an embedded subsystem.

Degrees of Freedom

When this framework refers to degrees of freedom, it is not describing spatial dimensions, hidden axes of the universe, or directions one could move through. Instead, degrees of freedom are best understood as independent aspects of a single state.

A simple analogy is a single pixel on a screen. One pixel is not many pixels, and it does not exist in multiple dimensions. Yet it can still be described using several independent values at once: how bright it is, what colour it is, how saturated that colour appears, or whether it is active at all. These values do not represent separate spaces, they are different attributes of the same pixel.

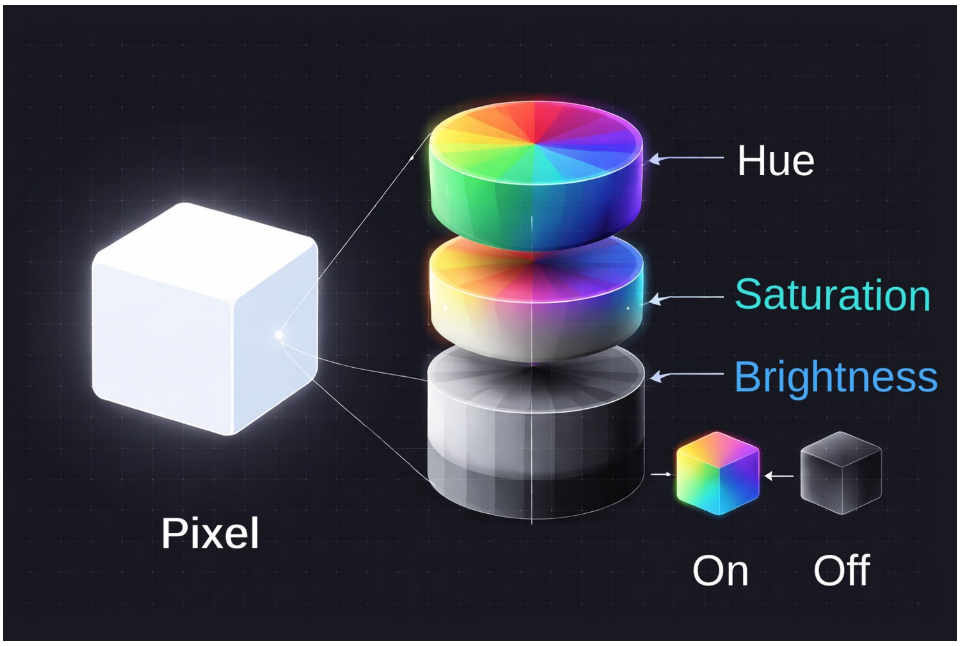


Figure 12: Multiple attributes of a pixel representing a single operational state.

In a similar way, the nine degrees of freedom in this framework can be thought of as nine descriptive *table columns* applied to a single operational state. Each degree of freedom captures a distinct mode by which a state may differ, persist, or influence subsequent updates. None of them alone defines the state, and none implies a separate dimension in which the system exists.

What matters is not the number of degrees of freedom, but the fact that they are independent yet co-present. Together, they describe how a state is structured, constrained, and able to evolve. The framework treats these degrees of freedom as operational descriptors and ways to characterise change, rather than as coordinates in a geometric space.

Nine Degrees of Freedom

Each item is defined *operationally* and does not presuppose semantic or cognitive interpretation.

1. **Coherence**: the degree to which relational structure is maintained across operational updates.
2. **Entropy**: the measure of dispersion or loss of constraint within operational structure.
3. **Activation**: the readiness or degree to which operations are permitted to proceed.
4. **Salience**: the degree to which an expressed structure is prominent or influential within a given operational context.
5. **Excitation**: functions as a globally conserved capacity for expression.
6. **Modality**: the categorical mode or form by which an operation is expressed.
7. **Stimulus**: an initiating perturbation that prompts operational response.
8. **Valence**: the directional bias applied to operational selection or weighting.
9. **Resonance**: the degree to which interacting structures reinforce, cancel, or stably couple within operational dynamics.

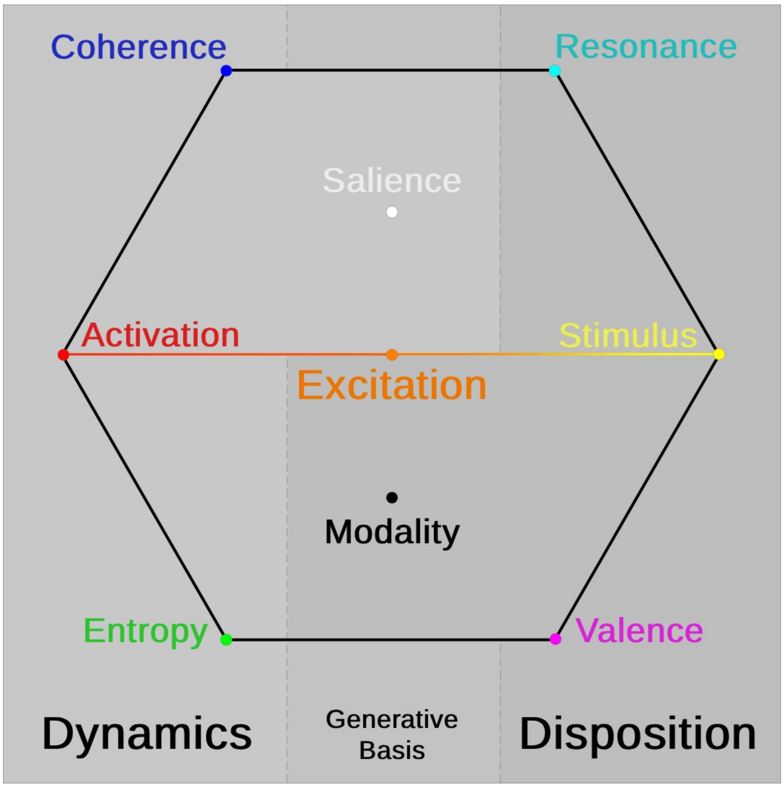


Figure 13: Nine degrees of freedom and operational subspaces.

Operational Subspaces

1. **Dynamics** describes how change is locally expressed across updates, operating over shared generative structure while remaining subject to global constraints.
2. **Disposition** describes how expressed structure is differentially weighted over time, biasing which identities or configurations are more likely to persist.

Each subspace captures a distinct mode of differentiation, and neither is sufficient in isolation.

Fundamental Operations

The fundamental operations described in this framework are not actions performed by an agent, nor are they physical forces, particles, or mental processes. Instead, they are best understood as basic modes by which a system can change or remain stable as it updates from one state to the next. An operation, in this sense, is not something that *does* anything on its own. It is a way of describing how change is permitted, constrained, or expressed during an update. Multiple operational roles may be relevant within a single update, shaping the same transition from different perspectives.

A helpful way to think about the operations in this framework is to imagine a simple dial lock. From the outside, the lock appears to have only one visible control: a dial that can be turned freely. i.e. a single degree of freedom. The dial may pass over the same positions many times, and it can end on the same number through different sequences of turns. Yet whether the lock opens or remains closed depends not on the final position alone, but on the particular sequence of movements that led there. In this sense, the *history* of operations matters just as much as the apparent configuration.

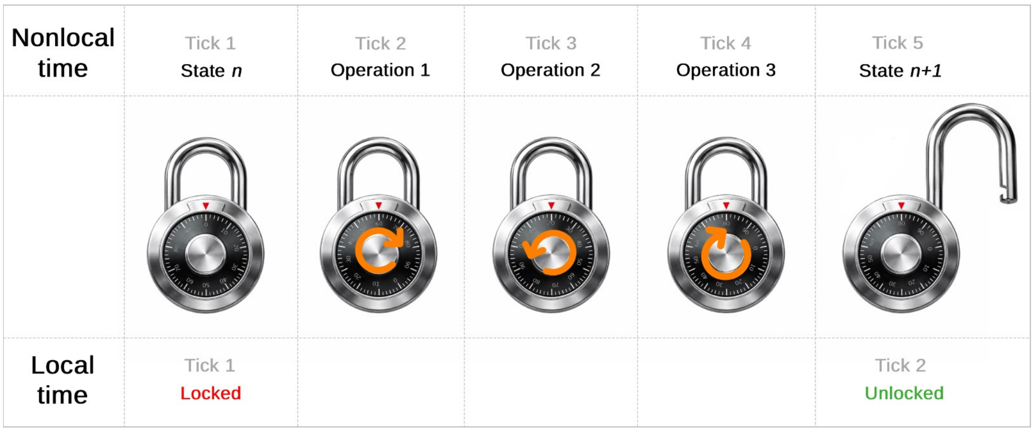


Figure 14: A sequence of operations acting on one degree of freedom.

The operations described here do not determine outcomes in isolation; what matters is how they are applied, in what order, and how their effects accumulate across successive ticks. Configurations that appear identical may differ in their operational history, and this hidden structure can determine whether a transition is permitted or a stable identity can persist. Visual illustrations are therefore used throughout as intuitive guides, helping to distinguish operational sequence from final configuration rather than serving as literal models.

These operations are termed fundamental because they form a minimal operational vocabulary sufficient to describe persistence, variation, and emergence, without assuming geometry, intention, or external time. The definitions that follow describe roles within state transitions and are intended to be read as complementary aspects of change, not independent controls or semantic meanings.

Seven Fundamental Operations

1. **Distinguish**

   Undifferentiated → **distinguishable structure**

   Introduces difference where none existed.

   Symmetry breaking.

2. **Persist**

   Transient difference → **stable identity**

   Allows distinctions to survive across ticks.

3. **Constrain**

   Free variation → **constrained relational structure**

   Limits which configurations are allowed globally.

4. **Disperse**

   Deterministic evolution → **probabilistic branching**

   Introduces branching, entropy and uncertainty.

   Admits branching of admissible continuations.

5. **Mediate**

   Isolated persistence → **coupled dynamics**

   Allows structures to influence one another, where Salience and Modality become jointly admissible as context for Bias and Ordering.

6. **Bias**

   Symmetric branching → **biased persistence**

   Introduces directional preference in branching.

   This is why something persists rather than something else, without teleology.

7. **Order**

   Change → **history**

   Imposes stable ordering on change itself.

   Symmetry breaking by **realised history**.

Figure 15: Conceptual depiction of operational changes.

Tick Structure as Distinction and Transformation

A **Tick** may be expressed formally as a directed operator traversal on distinctions. Rather than treating the seven operations as independent local steps, this framework represents each Tick as a **single nonlocal update cycle**: a closed, *irreversible* passage through admissible transformations.

In this representation:

- **Distinctions** appear as structural nodes, denoted Δ_i
- **Transformations** (operations) appear as directed edges, denoted O_i

The seven named phases of a Tick may therefore be written in verb-form as operators:

$$\mathrm{O}_1 : \text{Distinguish}, \ O_2 : \text{Persist}, \ O_3 : \text{Constrain}, \ O_4 : \text{Disperse}, \ O_5 : \text{Mediate}, \ O_6 : \text{Bias}, \ O_7 : \text{Order}$$

A Tick is then captured as a minimal structural object:

$$\mathrm{S} := \left(\{\Delta_i\}_{i=1}^{7}, \{O_i\}_{i=1}^{7}\right)$$

with each transformation mapping one distinction into the next:

$$\mathrm{O}_i : \Delta_i \to \Delta_{i+1} \qquad \Delta_8 \equiv \Delta_1$$

This indexing expresses cyclic closure of traversal, without implying reversibility. Irreversibility is carried globally by the directed update orientation of the Tick.

Mediation remains structurally unique, denoted O_5^c, due to its cross-constrained compatibility role within the cycle.

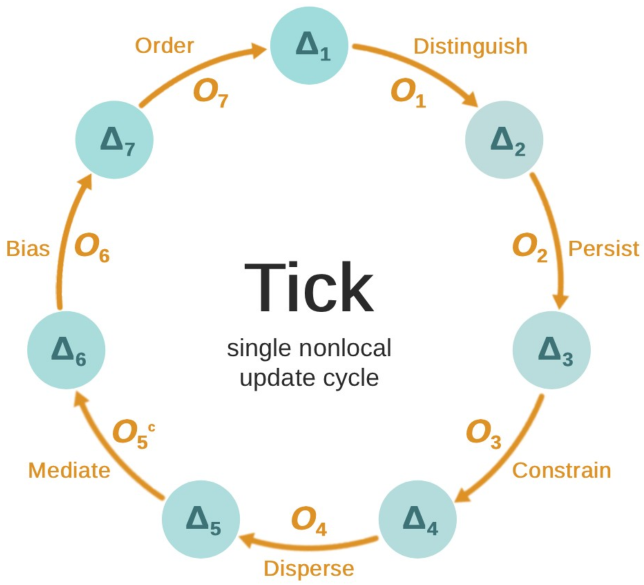


Figure 16: Canonical Tick structure as a directed cycle of distinctions, connected by transformations. This operator skeleton provides the minimal substrate on which degrees of freedom participate.

Relation to the Miranova Matrix Table

The Miranova Matrix Table specifies how the degrees of freedom are read, gated, and written across each operator O_i. The table may therefore be understood as an operational ledger defined over the Tick skeleton shown above.

How to Read the Miranova Matrix Table

The table that follows provides a compact operational summary of the framework. It describes how the Degrees of Freedom participate in a single nonlocal update cycle through distinct functional roles, rather than as a causal or time-ordered mechanical process.

Each row corresponds to one of the seven fundamental operations (phases of a unified Tick), while the columns list the nine Degrees of Freedom as co-present aspects of a single operational state.

Read, Gate, and Write

Within each operation, Degrees of Freedom appear in one of three roles:

- ← **Read**: referenced as contextual state
- ↔ **Gate**: constrains or conditions the transformation admissibility
- → **Write**: receives committed update

Read/Gate/Write denote roles within a single nonlocal cycle, not local time steps. Within any operation, these roles apply to distinct Degrees of Freedom, forming a **conserved triadic grammar** of **reference, constraint, and commitment**.

Cross-constraint occurs at the level of reference (**read^{c}**): admissibility is jointly conditioned, while writes remain register-specific and shaped downstream, not averaged upstream.

Following the Table

The table is best read relationally: across a row to see participation in an operation, and down a column to observe characteristic lifecycles, where Degrees of Freedom tend to appear first as read dependencies, later as gating influences, and finally as written outcomes.

Excitation functions as conserved capacity: it is treated as a stable field constraint rather than a repeatedly queried operand, read once as capacity, then propagated implicitly, and is therefore not explicitly re-read.

Operational Subspaces and Interpretive Layers

Each operation acts across two parallel subspaces (Dynamics and Disposition), applying the same operational grammar in complementary modes. The lower interpretive projections (e.g. BFSS or Standard Model analogues) are descriptive alignments only; the framework itself is fully specified by the Degrees of Freedom, operations, and their roles.

The table should therefore be read as a participation ledger, summarising how ordered structure can emerge from minimal operational constraint without presupposing spacetime geometry or external time.

Table 1: The Miranova Matrix mapping degrees of freedom across operational & interpretive layers.

Miranova Matrix Table										
Degrees of freedom		**Coherence**	**Entropy**	**Activation**	**Salience**	**Excitation**	**Modality**	**Stimulus**	**Valence**	**Resonance**
Polarity	+	**Alignment**	**Variation**	**Engagement**	**Amplification**	**Enablement**	**Differentiation**	**Perturbation**	**Attraction**	**Reinforcement**
	-	Decoherence	Regularity	Quiescence	Attenuation	Suppression	Homogenisation	Stability	Repulsion	Cancellation
Minimal generative set					Generative Basis					
Operational subspace		Dynamics					Disposition			
Distinction	O_1			write	gate	read	gate	write		
Persistence	O_2		write	gate	read		read	gate	write	
Constraint	O_3	write	gate	read				read	gate	write
Dispersion	O_4	gate	read		write		write		read	gate
Mediation	O_5	gate		write	read[c]		read[c]	write		gate
Bias	O_6	gate	write	read				read	write	gate
Ordering	O_7	gate	read		write		write		read	gate
Descriptive projection		Realised state			Regulating state			Stimulus	Response	Reward
		Physical system			Complementarity			Reward system		
Extended objects	M-theory Latent structure	Projected axis	M2-brane		Projected axis	M5-brane				
	G_2 manifold Constrained possibility	4-form			Geometric scalar	Scalar invariant	Scalar	3-form		
		Special holonomy								
	Realised dynamics	**Spacetime**								
Standard Model										
Fundamental interaction		Gravity	Strong interaction	Electromagnetism	Weak interaction			Electroweak interaction		
Elementary particle			Gluon	Photon	Z boson W± boson Higgs boson	Electron Muon Tau	Electron neutrino Muon neutrino Tau neutrino	Up Down	Charm Strange	Bottom Top
Particle class			Gauge boson		Scalar boson	Lepton		Quark		
Particle composite			**Boson**			**Fermion**		Meson **Hadron**	Baryon	

[c] denotes a *cross-constrained Salience–Modality basis read* during **Mediation** (compatibility reference, not aggregation or averaging).

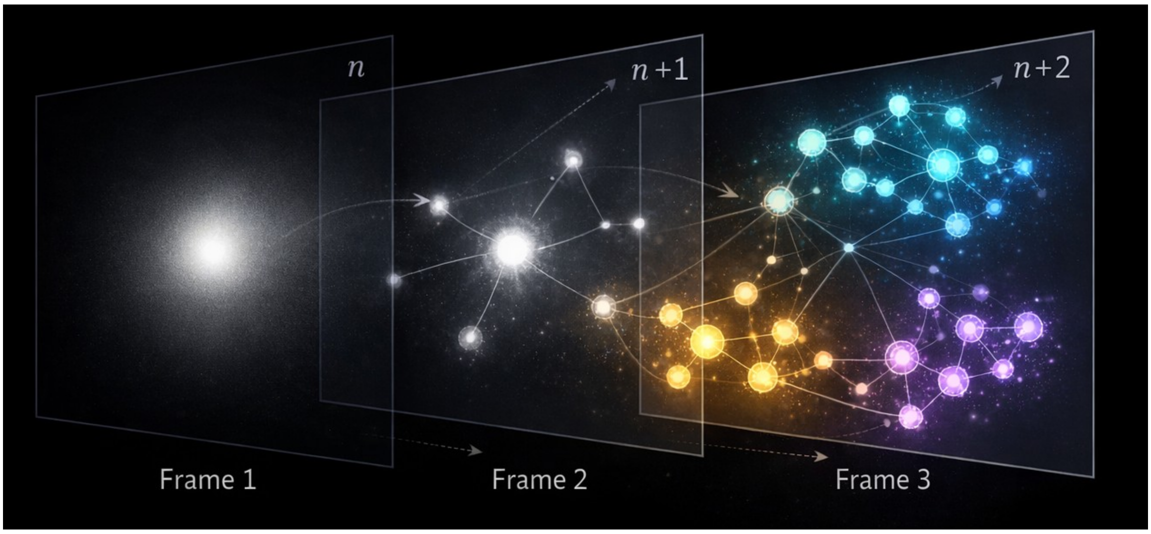


Figure 17: Progression of operations over successive ticks. Each frame illustrates a system update (*n, n+1, n+2*), showing branching and clustering of structures. The numbering is relative, the sequence continues indefinitely, highlighting emergent complexity from minimal operations.

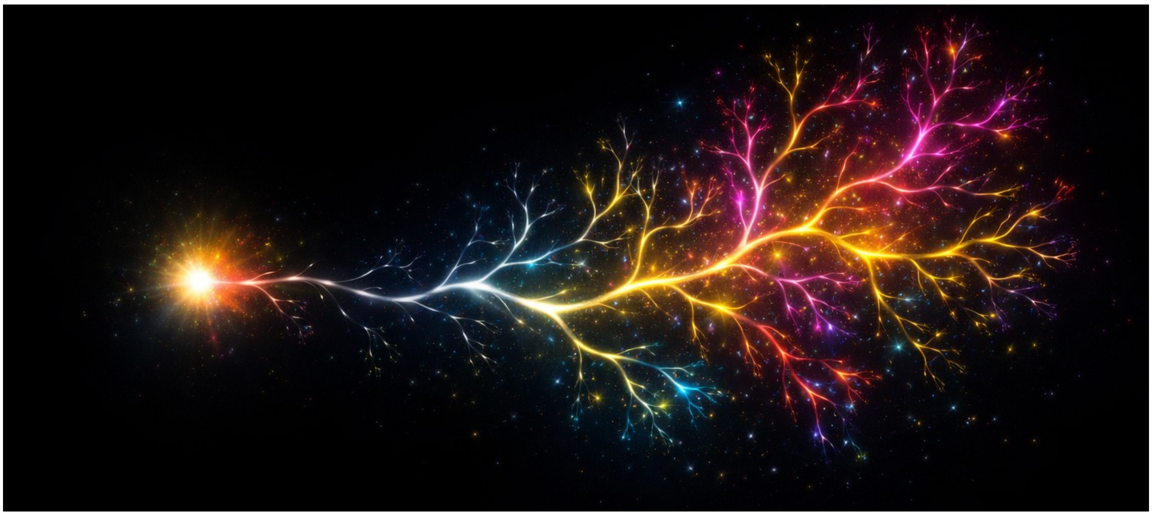


Figure 18: Conceptual illustration of branching and clustering dynamics within an operational network.

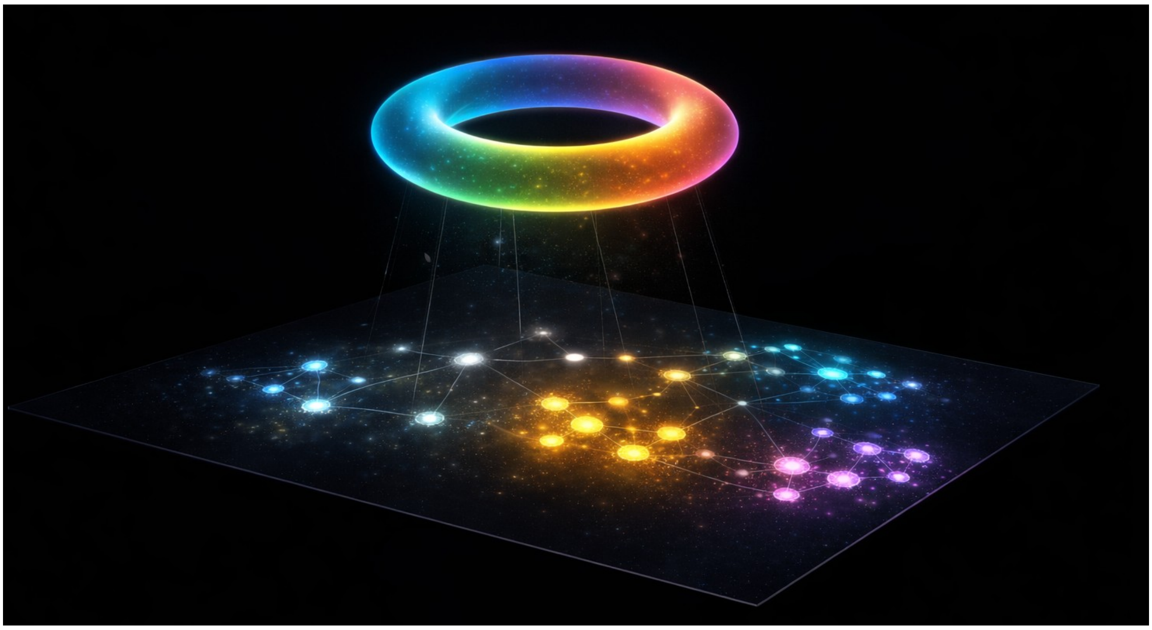


Figure 19: Conceptual depiction of emergent spacetime interpreted as a projection of structured causal relationships.

Interpretation

The purpose of this section is to explain how the different parts of the framework relate to one another once the basic components are in place. Rather than introducing new elements, it offers an interpretive overview of how change becomes possible, how it is expressed, and how it persists.

At the broadest level, the framework distinguishes between *w*hat could happen, what allows change to occur at all, and how change unfolds once it does. The full set of degrees of freedom defines a space of **potential**; everything the system could, in principle, support. Within that space, a smaller shared basis enables change to be meaningfully expressed, while different subspaces describe how such change is locally manifested, constrained, and selectively reinforced over time.

The interpretations that follow are intended as guides for understanding these relationships. They do not assert additional mechanisms or physical structures, but provide a way to reason about integration, constraint, and persistence using familiar concepts. Readers are encouraged to treat this section as a conceptual bridge between the formal definitions and the illustrative mappings that accompany them.

- **Potential**: the space of admissible possibilities the system can support.
- **Generative Basis**: the shared foundation that allows change to be expressed at all.
- **Dynamics / Disposition**: how change unfolds locally and persists across updates.

While all nine degrees of freedom define the space of potential, excitation, salience, and modality form a **shared generative basis** that enables expression without defining its specific outcomes. Neither subspace owns this basis, yet neither is meaningful without it. It is the minimal basis required for any change to be expressible, scalable, and characterisable. Excitation functions as a capacity, or gain field, that permits expression, while salience and modality characterise how that expression manifests.

The **dynamical** subspace admits a dual interpretation, consisting of a **realised physical state** and a **regulating state**. The locally realised state describes how change is expressed during an update, operating over the shared generative basis through excitation, salience, and available modal distinctions, without defining or selecting them. The regulating state imposes global constraints associated with activation, entropy, and coherence, bounding which forms of expression remain viable across successive updates.

The **dispositional** subspace may be interpreted as applying a persistence-like weighting across branching structure, biasing which identities or configurations are more likely to persist over time, increasing their salience. In this sense, reward does not imply intention or optimisation, but functions as a structural influence on persistence and salience.

Each subspace captures a distinct mode of differentiation, and neither is sufficient in isolation. Together, they describe how expression and persistence arise from shared generative structure under constraint.

Colour

In this framework, colour is not treated as a fundamental property of the system, but as an interpretive encoding used to represent configurations across multiple operational axes. Operationally, colour may be understood as a low-dimensional projection of higher-dimensional structure, arising when distinguishable constraints must be compressed into a form that supports stable discriminability.

From this perspective, colour does not correspond to a single degree of freedom. Rather, it emerges only when multiple operational dimensions are jointly expressed. For example, one may heuristically associate hue with qualitative mode of distinction, saturation with the combined magnitude and intensity of expression, and brightness with the degree to which a distinction is permitted and stabilised through activation and coherence. These associations are not claims about physical or perceptual mechanisms, but illustrative analogies within the operational space.

This view suggests that colour appears only within a viable balance of constraints. Excessive coherence suppresses variation, excessive entropy dissolves distinction, and insufficient activation prevents expression altogether. Colour, in this sense, functions as a signature of structured, interpretable states rather than as an intrinsic feature of the underlying dynamics.

Accordingly, the use of colour throughout the present framework is intended as a representational aid, reflecting how complex operational structure may be rendered interpretable to embedded interpretive systems, rather than as an assertion of colour as a primitive or causal element.

Octets

As the system evolves through repeated updates, patterns begin to form in how distinctions relate to one another. When a small set of operations must coexist under shared constraints, the space of stable relationships admits an octet-like representation. In this framework, that balance appears as such; not because it is imposed, but because it is one of the simplest ways for multiple distinctions to remain mutually compatible while still allowing variation and persistence.

From an operational perspective, the emergence of an octet reflects a constrained relational structure rather than a fundamental object. Eight peripheral degrees of freedom organise around a shared generative basis, with symmetry broken only by ordering and bias across updates. The resulting configuration admits an octet-like representation analogous to other symmetry-constrained systems, without asserting a direct physical correspondence. The octet therefore functions as an interpretive map of relational balance within the operational space, not as an additional structural assumption. The octet should be understood as an organisational symmetry, not an ontological claim.

BFSS Matrix Theory

Projections along the M2 and M5 brane axes are labeled in terms of their operational roles rather than intrinsic physical properties. The M2-brane projection is associated with **coherence**, reflecting its role in integrating and maintaining unity across constrained degrees of freedom. Conversely, the M5-brane projection is associated with **salience**, corresponding to its capacity to sustain higher-dimensional relational structure in which distinctions become prominent. These labels are intended as interpretive descriptors within the operational space, not as claims about novel brane dynamics.

As with the M2- and M5-brane correspondences, these interpretations are offered as illustrative descriptors of operational roles. They are not required for the coherence of the framework itself, nor do they assert novel physical dynamics, but serve to contextualise how familiar mechanisms of regulation, bias, and constraint may arise within an operational formulation.

Minimal Generative Structures

From the primitives and principles defined above, a minimal set of generative structures follows naturally:

- **Identity preservation** across ticks, enabling continuity of structure.
- Simple **branching chains**, allowing divergence of causal sequences.
- Formation of **record-holding structures**, supporting persistence of past distinctions.
- **Emergent observers**, defined abstractly as subsystems capable of internal differentiation, without presupposing consciousness.

The purpose of this section is to demonstrate that structured entities and histories arise directly from the operational *rules*, without requiring additional assumptions or externally imposed dynamics.

Implications

Within this framework, several general implications follow:

- **Minimal causal depth** provides a sufficient basis for emergent notions of time.
- **Embedded observers** may experience extended temporal duration arising from relatively few underlying ticks.
- **Branching and causal depth** enable complexity to grow faster than tick count alone.
- The framework offers a *formal lens* for examining **nonlocal time**, **irreversibility**, and **observer-embedded structure** without presupposing spacetime geometry.
- **Iterated operational interactions** may give rise to pattern-like or ripple structures that propagate across complex configurations.

These implications are structural rather than predictive, and are intended to clarify conceptual relationships rather than replace existing physical models.

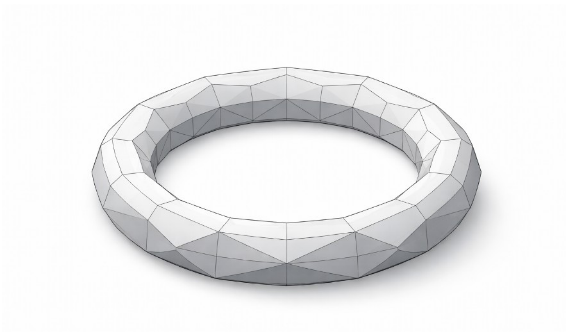
Concluding Context

The operational primitives and principles presented here define a *minimal framework* for reasoning about emergent structure, causal depth, and experienced time without presupposing spacetime geometry. By treating ordered operational updates as primary, the framework provides a coherent lens through which persistence, branching, and observer-embedded structure may arise from simple, irreversible processes.

Although developed at an abstract operational level, this framework is intentionally situated alongside matrix-based approaches to fundamental physics, such as BFSS Matrix Theory, in which spacetime is likewise understood as emergent rather than fundamental. In this context, the Miranova Matrix does not propose any modifications to BFSS dynamics, nor does it attempt to derive physical observables. Instead, it offers a complementary conceptual vocabulary for articulating how ordered updates, causal depth, and interpretability may underwrite emergent temporal and structural features within matrix formulations.

The framework is intentionally limited in scope and generative in character. Its purpose is not to replace existing physical models, but to clarify relationships between causality, emergence, and embedded observation in systems where spacetime is not assumed. Further exploration may examine how such operational descriptions relate to specific matrix dynamics, physical observables, or computational implementations.

In this sense, the Miranova Matrix is offered as a structural lens rather than a completed theory, and its continuation, whether through formalisation, reinterpretation, or application, is left open to the broader community.



Open Questions

The framework is intentionally limited in scope. In particular:

- Absolute tick count may not be inferred from within the system.
- The behaviour of multiple clocks, extreme self-reference, and deep branching regimes is left undefined.
- Future work may explore connections to physical observables, dynamical models, or computational implementations.

Definitions

- **Miranova**

  Combines **Mira**, the binary star system Mira A and Mira B, characterised by long-period variability and coupled stellar dynamics. With **nova**, in the sense of supernova, denoting large-scale emergent transformation arising from accumulated structure. The name reflects a framework concerned with variability, coupling, and the emergence of new structure from underlying relational dynamics, rather than the introduction of new fundamental physical law.

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