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 lays a foundation for further exploration of nonlocal time, irreversibility, and observer-embedded structures. This document presents a minimal operational framework; interpretive mappings are illustrative.

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Table of Contents

Reader's Guide

For a gentle read, follow the **blue** sections.

For those who enjoy getting into the details, the **cyan** sections offer a more technical, hands-on exploration.

Coherence – Intuitive reader-friendly overview

Interpretability – Technical and operational framing

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 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 embedded within it, experiencing time through the accumulation and persistence of structure rather than through access to any absolute 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.

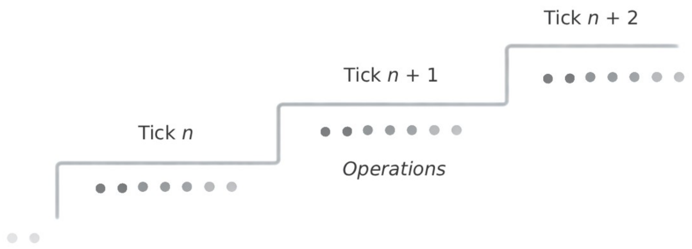
Figure 1: Conceptual depiction of spacetime emergence from underlying operational structure.

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 is a discrete, indivisible operational update of the system, establishing an ordered transition between distinguishable states. Ticks are not units of physical time, but units of causal ordering.



Conceptual illustration of ticks as completed causal transitions.

Figure 2: Progression of operational structure across successive ticks.

- **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.

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

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

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

Key Principles

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

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

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

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

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

Degrees of Freedom

When this framework refers to degrees of freedom, it is not describing nine 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 point.

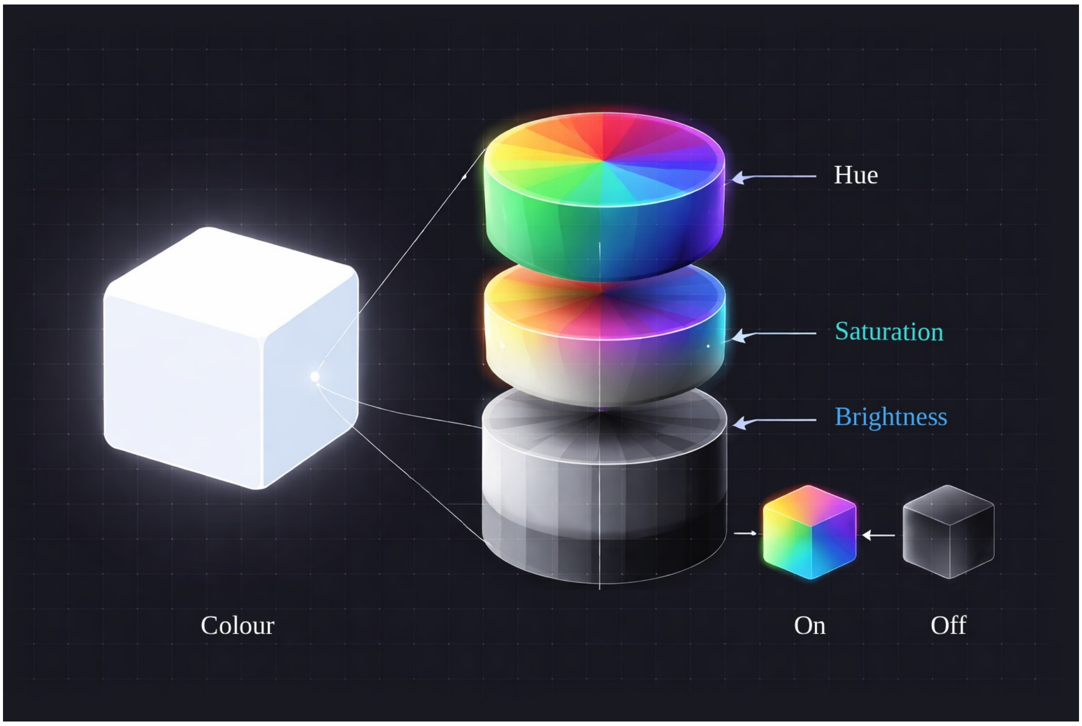


Figure 3: Degrees of freedom as independent attributes of a single operational state.

In a similar way, the nine degrees of freedom in this framework can be thought of as nine descriptive 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 allowed 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.

9 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. **Quantity**: the magnitude or extent of operational influence expressed within a system.
5. **Excitation**: the intensity of deviation from baseline operational state.
6. **Quality**: the mode or character 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. **Interpretability**: the degree to which operational structure admits meaningful differentiation or retrieval.

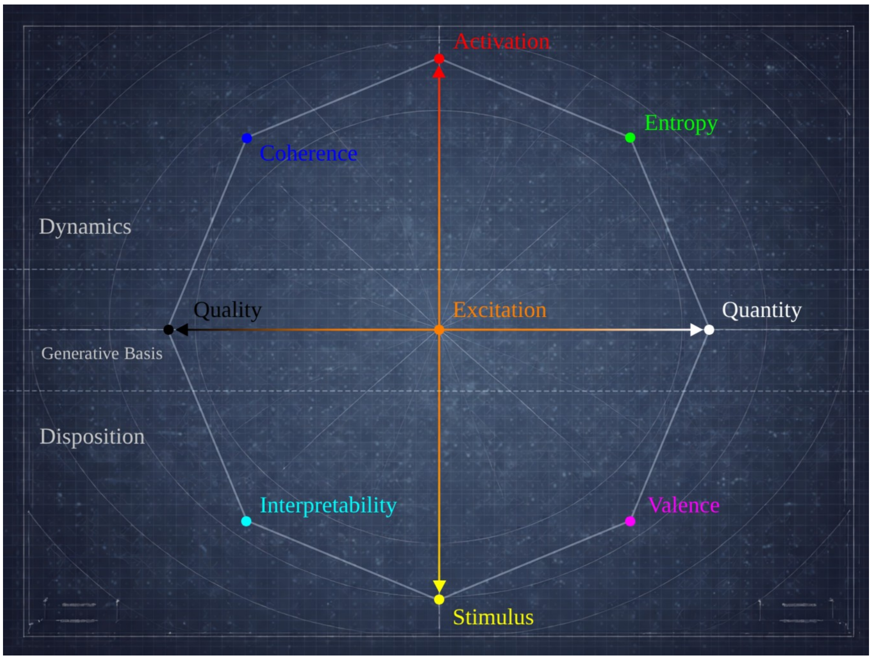


Figure 4: Operational axes and shared generative basis.

Operational Subspaces

1. **Dynamics**: The dynamical subspace admits a dual interpretation, consisting of a prerogative component governing local expression (e.g. quality, excitement, quantity), and a normative component imposing global constraints related to activation, entropy, and coherence.
2. **Disposition**: The dispositional subspace may be interpreted as inducing reward-like weighting over branching structures, biasing which identities persist without implying intentionality or optimisation.

Each axis 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 operations may be active at once, shaping the same transition from different perspectives.

A useful way to think about this is to imagine adjusting a set of sliders that all influence the same outcome. Each slider controls a different aspect of the result; such as how strongly a change occurs, how structured it remains, or how distinguishable it becomes, but none of them produces an outcome in isolation. The observed state is always the combined result of all operations acting together.

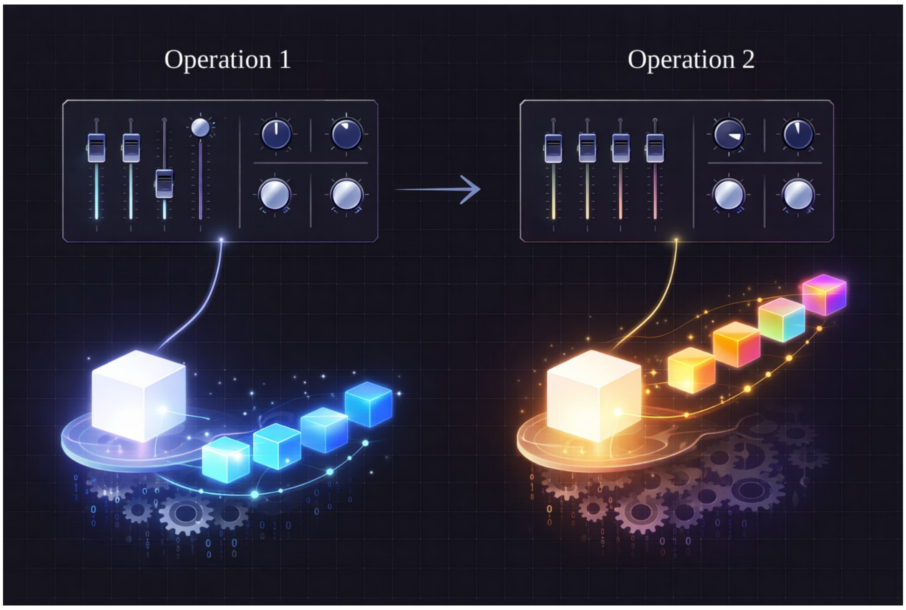


Figure 5: Fundamental operations as co-active constraints on state transitions.

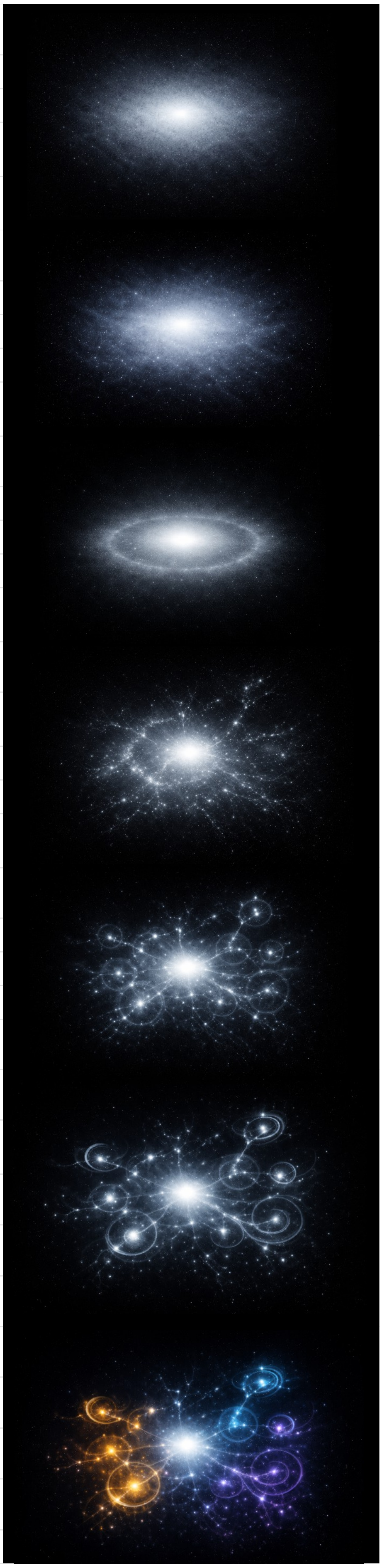
For this reason, the operations are accompanied throughout by visual representations. These figures are not intended to depict physical mechanisms, but to provide intuitive reference points that help distinguish the roles each operation plays within a transition. Readers are encouraged to treat the images as guides for orientation rather than as literal models.

These operations are called fundamental not because they are indivisible physical elements, but because they represent a minimal set of operational distinctions sufficient to describe persistence, variation, and emergence within the framework. They provide a vocabulary for talking about change without assuming geometry, intention, or external time.

The definitions that follow are therefore operational rather than semantic. They describe roles within state transitions, not meanings or experiences, and they are intended to be read as complementary rather than independent.

7 Fundamental Operations

#1	**Distinction**
What it does	Symmetry breaking. Introduces difference where none existed.
State change	Undifferentiated → distinguishable structure
Physical analogue	Scalar field, spontaneous symmetry breaking, charge/colour/flavour become distinguishable.
Standard Model	Higgs mechanism as instantiation of distinction. Particle identities becoming meaningful.
#2	**Persistence**
What it does	Allows distinctions to survive across ticks.
State change	Transient difference → stable identity
Physical analogue	Conservation laws, gauge invariance maintaining identity.
Standard Model	Conservation of colour, charge, lepton number (contextual). Stable particle representations.
#3	**Constraint**
What it does	Limits which configurations are allowed globally.
State change	Free variation → constrained relational structure
Physical analogue	Gauge constraints. Holonomy / global consistency.
Standard Model	Gravity as global coherence. Constraint on spacetime consistency rather than exchange particle.
#4	**Dispersion**
What it does	Introduces branching, entropy and uncertainty. Introduces multiple allowed futures simultaneously.
State change	Deterministic evolution → probabilistic branching
Physical analogue	Quantum indeterminacy. Non-Abelian self-interaction.
Standard Model	Gluon field (SU(3)). Self-interaction, colour confinement, intrinsic stochasticity at interaction level.
#5	**Mediation**
What it does	Allows structures to influence one another.
State change	Isolated persistence → coupled dynamics
Physical analogue	Force mediation. Field exchange.
Standard Model	Photon (U(1)). W± / Z (SU(2)).
#6	**Bias**
What it does	Introduces directional preference in branching. This is why something persists rather than something else, without teleology.
State change	Symmetric branching → biased persistence
Physical analogue	CP violation. Matter-antimatter asymmetry. Selection effects.
Standard Model	Weak interaction asymmetry. CP-violating phases.
#7	**Ordering**
What it does	Imposes stable ordering on change itself.
State change	Change → history
Physical analogue	Causal structure. Arrow of time. Irreversibility.
Standard Model	Emergent spacetime (3+1). Observer embedded time.



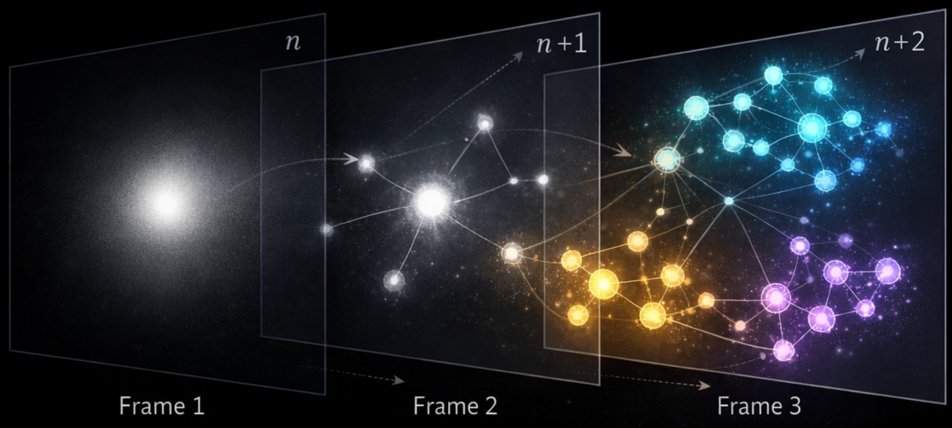


Figure 6: Progression of operations over successive ticks. Each frame illustrates a system update (n, n+1, n+2), showing branching and clustering of structures. The numbering is relative, the sequence continues indefinitely, highlighting emergent complexity from minimal operations.

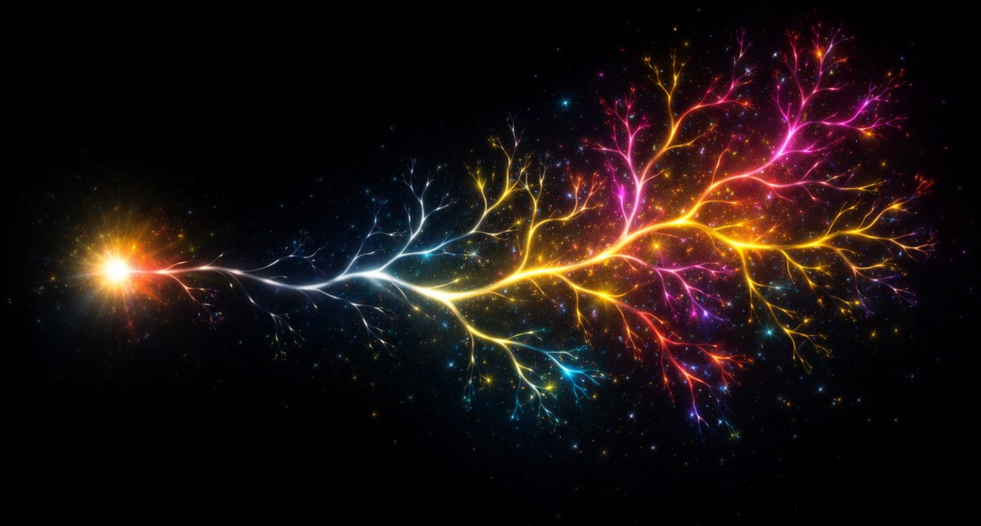


Figure 7: Conceptual illustration of branching and clustering dynamics within an operational network.

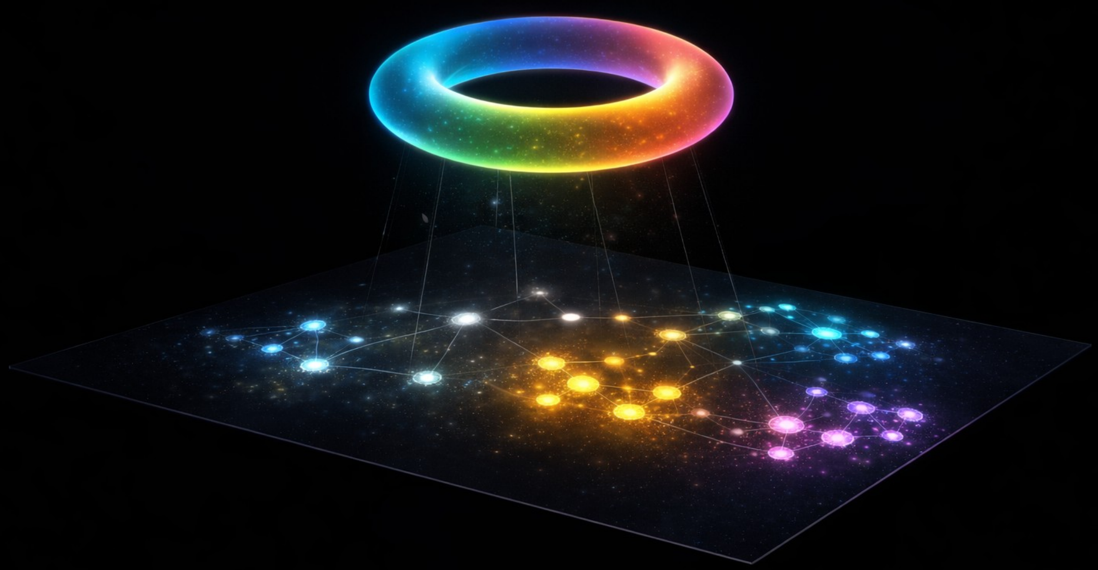


Figure 8: Conceptual depiction of emergent spacetime interpreted as a projection of structured causal relationships within a Miranova Matrix frame.

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

<table>
<tr><th colspan="18">Miranova Matrix Table</th></tr>
<tr><th colspan="3">Degrees of freedom</th><th>Coherence</th><th>Entropy</th><th>Activation</th><th colspan="2">Quantity</th><th colspan="2">Excitation</th><th colspan="2">Quality</th><th colspan="2">Stimulus</th><th colspan="2">Valence</th><th colspan="2">Interpretability</th></tr>
<tr><td colspan="2" rowspan="2">Polarity</td><td>+</td><td>Integrated</td><td>Stochastic</td><td>Activated</td><td colspan="2">Materialised</td><td colspan="2">Excited</td><td colspan="2">Affiliative</td><td colspan="2">Engaged</td><td colspan="2">Positive reinforcement</td><td colspan="2">Signal resolution</td></tr>
<tr><td>-</td><td>Disintegrated</td><td>Deterministic</td><td>Latent</td><td colspan="2">Idealised</td><td colspan="2">Ground state</td><td colspan="2">Antagonistic</td><td colspan="2">Withdrawn</td><td colspan="2">Negative reinforcement</td><td colspan="2">Noise dominance</td></tr>
<tr><td colspan="3" rowspan="3">Interpretation
Informational expression of change</td><td>State constraint</td><td>State uncertainty</td><td>State readiness</td><td colspan="2">Degree of instantiation</td><td colspan="2">State energy</td><td colspan="2">Interactional tone</td><td colspan="2">Interaction level</td><td colspan="2">Interactional valence</td><td colspan="2">Interactional clarity</td></tr>
<tr><td colspan="3">Normative state</td><td colspan="6">Prerogative state</td><td colspan="2">Stimulus</td><td colspan="2">Response</td><td colspan="2">Reward</td></tr>
<tr><td colspan="9">Dual state</td><td colspan="6">Reward system</td></tr>
<tr><td colspan="3">Minimal generating set</td><td colspan="3"></td><td colspan="6">Generative Basis</td><td colspan="6"></td></tr>
<tr><td colspan="3">Operational subspace</td><td colspan="5">Dynamics</td><td colspan="2"></td><td colspan="8">Disposition</td></tr>
<tr><td rowspan="4">Extended objects</td><td colspan="2">M-theory
Latent structure</td><td>Coherence
Projected axis</td><td colspan="2">M2-brane</td><td colspan="2">Salience
Projected axis</td><td colspan="10">M5-brane</td></tr>
<tr><td colspan="2" rowspan="2">G_2 manifold
Constrained possibility</td><td colspan="3">4-form</td><td colspan="2">Geometric scalar</td><td colspan="2">Scalar invariant</td><td colspan="2">Scalar</td><td colspan="6">3-form</td></tr>
<tr><td colspan="15">Special holonomy</td></tr>
<tr><td colspan="2">Spacetime
Realised dynamics</td><td colspan="15">3+1-dimensional</td></tr>
<tr><td colspan="18">Standard Model</td></tr>
<tr><td colspan="3">Fundamental interaction</td><td>Gravity</td><td>Strong interaction</td><td>Electromagnetism</td><td colspan="6">Weak interaction</td><td colspan="6">Electroweak interaction</td></tr>
<tr><td colspan="3" rowspan="2">Elementary particle</td><td rowspan="2"></td><td rowspan="2">Gluon</td><td rowspan="2">Photon</td><td>Z boson</td><td rowspan="2">Higgs boson</td><td colspan="2">Electron</td><td colspan="2">Electron neutrino</td><td rowspan="2">Up</td><td rowspan="2">Down</td><td rowspan="2">Charm</td><td rowspan="2">Strange</td><td rowspan="2">Bottom</td><td rowspan="2">Top</td></tr>
<tr><td>W± boson</td><td>Muon</td><td>Tau</td><td>Muon neutrino</td><td>Tau neutrino</td></tr>
<tr><td colspan="3">Particle class</td><td></td><td colspan="3">Gauge boson</td><td>Scalar boson</td><td colspan="4">Lepton</td><td colspan="6">Quark</td></tr>
<tr><td colspan="3" rowspan="2">Particle composite</td><td rowspan="2"></td><td colspan="4" rowspan="2">Boson</td><td colspan="4" rowspan="2">Fermion</td><td colspan="2">Meson</td><td></td><td colspan="2">Baryon</td><td rowspan="2"></td></tr>
<tr><td colspan="2"></td><td>Hadron</td><td colspan="2"></td></tr>
</table>

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 what 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, the degrees of excitation, quantity, and quality form a shared generative basis upon which both dynamics and disposition operate. 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.

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.

The **Dynamics subspace** admits a dual interpretation, consisting of a *prerogative* and a *normative* state. This distinction reflects two complementary roles in system evolution rather than a separation of mechanisms.

- The **prerogative state** characterises local expression and immediacy of operation, encompassing aspects such as quality, excitation, and quantity. It governs how operations are expressed in a given update, shaping intensity, character, and scale without imposing global constraint.
- The **normative state**, by contrast, captures global limiting factors that regulate system stability across updates. Operations associated with activation, entropy, and coherence constrain what forms of expression are permitted, bounding change so that relational structure remains viable over time. Together, these two aspects describe how operational expression proceeds within allowable limits.

In addition, the **Disposition subspace** may be interpreted as a reward-like weighting mechanism applied across branching structure. In this sense, reward does not imply intention or optimisation, but functions as a bias influencing which identities, branches, or configurations are more likely to persist. This interpretation provides an intuitive account of selection without introducing teleology or agency.

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.

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 interpretability.

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 observers, rather than as an assertion of colour as a primitive or causal element.

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 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 simulations.

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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