Research Article *Open Access*

Journal of Modern Classical Physics & Quantum Neuroscience

ISSN: 3068-4196

DOI: doi.org/10.63721/26JPQN0187

Simultaneous Galaxy Emergence and Primordial Mapping Framework (SGEM-PM): A Conceptual–Computational Framework Based on Reciprocal Mapping, Possibility Dynamics, and Reality Formation

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Citation: *Phan Thanh Trung (2026) Simultaneous Galaxy Emergence and Primordial Mapping Framework (SGEM-PM): A Conceptual–Computational Framework Based on Reciprocal Mapping, Possibility Dynamics, and Reality Formation. J.of Mod Phy & Quant Neuroscience 2(4), 1-23. WMJ/JPQN-187*

Abstract

Most cosmological models begin with matter, energy, fields, or spacetime as fundamental entities. In contrast, this work explores a different starting point: the possibility that reality emerges from reciprocal mapping between two primordial domains rather than from pre-existing physical objects. We propose the Simultaneous Galaxy Emergence and Primordial Mapping Framework (SGEM-PM), a conceptual–computational framework in which two non-identical primordial domains, denoted A and B, continuously attempt to represent one another through reciprocal mapping. The incompleteness of this mapping generates Mapping Divergence (Δ), which subsequently gives rise to a Dynamic Possibility Field (Ψ), Preservation Principle (Π), Twist/Vortex Formation (T), Reality Locking (R), and Matter Emergence (M). The framework therefore model's reality as an emergent consequence of ongoing mapping dynamics rather than as a primitive substrate.

The proposed formulation is conceptually related to ideas from information theory cybernetics, complex systems and self-organization relational and category-theoretic approaches and process-oriented views of reality [1-16]. However, SGEM-PM differs from existing approaches by introducing a unified emergence pipeline:

$A \neq B \rightarrow A \rightleftarrows B \rightarrow \Delta \rightarrow \Psi \rightarrow \Pi \rightarrow T \rightarrow R \rightarrow M$

Within this framework, the Big Bang is interpreted as the emergence of an interference region (Γ) between primordial domains, cosmic inflation is modeled as the expansion of Γ, and galaxies are treated as large-scale reality-locking structures emerging simultaneously across the interference region.

To support reproducibility and computational exploration, we introduce the AB Genesis Simulator together with a benchmark framework based on measurable emergence metrics, including Mapping Divergence Index (MDI), Possibility Density (PD), Preservation Strength (PS), Twist Intensity (TI), Reality Locking Index (RLI), and Matter Emergence Index (MEI). These metrics provide an initial experimental environment for evaluating emergence dynamics generated by the framework. The contribution of this work is not the proposal of a *validated physical cosmology, but the introduction of a benchmarkable conceptual-computational framework that connects divergence, possibility, preservation, and reality formation within a single emergence pipeline. The framework provides a foundation for future investigations into emergence modeling, complex adaptive systems, computational cosmology, and operator-based representations of reality.*

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Submitted: 28.07.2026 **Accepted**: 01.08.2026 **Published**: 13.08.2026

Keywords: Emergence Modeling, Complex Systems; Computational Cosmology, Conceptual Modeling, Reality Formation, Mapping Divergence, Possibility Dynamics, Self-Organization, Benchmark Framework, Simulation

Introduction

One of the oldest questions in science concerns the origin of reality itself. Modern cosmology has achieved remarkable success in describing the evolution of the observable universe, from the early stages of cosmic expansion to the formation of galaxies, stars, planets, and large-scale structures [17-20]. At the same time, information theory cybernetics complex systems research and category-theoretic approaches have demonstrated that many large-scale structures can emerge from simple relational rules without requiring centralized control [1-14].

Despite these advances, a fundamental question remains unresolved:
What is the minimal process capable of generating reality?

Traditional physical models typically begin with entities such as matter, energy, fields, particles, or spacetime. These entities are then used to explain increasingly complex structures through physical interactions. However, such approaches often assume the existence of a primitive substrate before the emergence process begins.

An alternative perspective can be found across several disciplines. Information theory emphasizes difference as the source of information [1]. Cybernetics studies feedback and self-correction [3,4]. Complexity science investigates how global organization emerges from local interactions [5-10]. Category theory places relationships and mappings before objects themselves [11-14]. Process-oriented philosophies similarly view reality as an ongoing process rather than a static collection of substances [15,16].

These observations motivate a more general question:
Can emergence itself be modeled as a consequence of an ongoing relational process?

This paper explores one possible answer through the Simultaneous Galaxy Emergence and Primordial Mapping Framework (SGEM-PM). Rather than beginning with matter or spacetime, SGEM-PM begins with two non-identical primordial domains, denoted A and B. The framework assumes that these domains continuously attempt to represent one another through reciprocal mapping. Because the two domains are not perfectly identical, the mapping process cannot be completed exactly. A residual difference remains. This residual is called Mapping Divergence (Δ).

The central hypothesis of SGEM-PM is that emergence originates from this divergence.

Within the framework, Mapping Divergence generates a Dynamic Possibility Field (Ψ), which interacts with a Preservation Principle (Π) to produce Twist/Vortex Formation (T), Reality Locking (R), and ultimately Matter Emergence (M). The framework therefore proposes a unified emergence pipeline:

$A \neq B \rightarrow A \rightleftarrows B \rightarrow \Delta \rightarrow \Psi \rightarrow \Pi \rightarrow T \rightarrow R \rightarrow M$

Under this interpretation, reality is not treated as a primitive entity. Reality is treated as a stabilized consequence of an ongoing mapping process. The objective of this work is not to establish a validated physical cosmology. Instead, the goal is to introduce a benchmarkable conceptual-computational framework capable of representing emergence dynamics within a unified formal structure. To support computational exploration, the framework is accompanied by the AB Genesis Simulator and a benchmark environment that measures key emergence variables, including Mapping Divergence Index (MDI), Possibility Density (PD), Preservation Strength (PS), Twist Intensity (TI), Reality Locking Index (RLI), and Matter Emergence Index (MEI).

The main contributions of this paper are:

- A relational emergence framework based on reciprocal mapping between primordial domains.
- A unified emergence pipeline connecting divergence, possibility, preservation, reality locking, and matter formation.
- A computational representation suitable for simulation-based exploration.
- A benchmark framework for evaluating emergence dynamics through measurable metrics.
- An open research artifact consisting of simulators, benchmark protocols, and reproducible experimental infrastructure.

The remainder of the paper is organized as follows. Section 2 reviews relevant work in complexity science, information theory, category-theoretic thinking, and cosmology. Section 3 introduces the conceptual foundations of SGEM-PM. Section 4 formalizes the Reality Pipeline. Section 5 presents the computational representation. Section 6 introduces the benchmark framework and simulator environment. Section 7 reports experimental observations. Section 8 discusses implications, limitations, and future directions. Section 9 concludes the paper.

Related Work and Conceptual Positioning

The SGEM-PM framework draws inspiration from several established research traditions, including information theory, cybernetics, complex systems science, category-theoretic approaches, and cosmology. Rather than replacing these frameworks, SGEM-PM attempts to provide a conceptual-computational layer capable of describing emergence as a unified mapping process.

Information, Difference and Emergence

Information theory established the principle that information arises from distinguishable states and differences within a system [1]. This idea has profoundly influenced modern communication theory, computation, and complexity science. Wheeler's "It from Bit" perspective further suggested that informational distinctions may occupy a foundational role in physical reality [18]. Floridi later expanded this view through the Philosophy of Information, arguing that informational structures may provide a unifying language across scientific domains [16].

SGEM-PM adopts a similar starting intuition. However, instead of treating information itself as the primary entity, the framework begins with the existence of two non-identical primordial domains:

$A \neq B$

The resulting difference becomes the source of Mapping Divergence (Δ), which subsequently generates the Dynamic Possibility Field (Ψ). In this sense, SGEM-PM treats divergence as a precursor to information rather than information itself.

Cybernetics and Self-Correcting Systems

Cybernetics introduced the concepts of feedback, adaptation, and self-correction within complex systems [3,4]. Many cybernetic systems operate through continuous comparison between internal states and external conditions, generating corrective actions whenever mismatches occur.

The SGEM-PM framework exhibits a similar structure.

The reciprocal mapping process: $A \rightleftarrows B$
continuously attempts to reduce divergence between domains.

The resulting Mapping Divergence (Δ) functions as a generalized mismatch signal that drives system evolution. Unlike classical cybernetics, however, SGEM-PM does not assume predefined agents, controllers, or goals. The corrective process itself becomes the source of emergence.

Complexity, Self-Organization and Emergence

Research in complexity science has demonstrated that large-scale organization can emerge from local interactions without centralized coordination [5-10].
Examples include:

- Pattern formation.
- Self-organization.
- Adaptive systems.
- Emergent collective behavior.

Prigogine's dissipative structures Haken's synergetics Kauffman's self-organizing systems and Holland's adaptive systems all suggest that complexity may arise naturally when systems operate far from equilibrium. [5,21-23].

SGEM-PM shares this emergence-oriented perspective.
However, the framework introduces a different generative mechanism.
Instead of beginning with interacting particles, agents, or thermodynamic processes, SGEM-PM begins with reciprocal mapping and divergence.
The emergence pipeline: $\Delta \rightarrow \Psi \rightarrow \Pi \rightarrow T \rightarrow R$ may therefore be interpreted as a generalized self-organization process operating within a possibility domain.

Relational and Category-Theoretic Perspectives

Category theory places relationships and mappings at the center of mathematical structure [11-14].
In many category-theoretic viewpoints, objects are understood through the morphisms that connect them rather than through intrinsic properties alone.
This relational emphasis has influenced multiple fields, including mathematics, computation, systems theory, and theoretical physics [14].
SGEM-PM shares a similar philosophical orientation.
The framework does not begin with matter, particles, or spacetime.

Instead, it begins with: $A \rightleftarrows B$
The mapping process precedes the structures that later emerge from it.
For this reason, SGEM-PM may be viewed as conceptually closer to relational frameworks than to classical substance-based models.

Cosmology and Inflationary Models

Contemporary cosmology explains many observed features of the universe through the Big Bang model and inflationary dynamics successfully accounting for cosmic expansion, background radiation, and large-scale structure formation. SGEM-PM does not seek to replace these models but instead proposes an alternative conceptual interpretation. Within the framework, Γ denotes the Interference Region in which primordial domains become capable of mutual mapping. The Big Bang is interpreted as $\Gamma \neq \emptyset$, representing the first emergence of this interference region, while inflation is interpreted as $d\Gamma/dt > 0$, corresponding to its rapid expansion rather than the expansion of matter itself. These interpretations should be understood as conceptual reformulations rather than experimentally validated alternatives to standard cosmology [17-19].

Positioning of SGEM-PM

Unlike most existing frameworks, which begin with matter, energy, fields, information, or spacetime, SGEM-PM begins with difference and mapping. Emergence is hypothesized to arise from the inability of two primordial domains to represent one another perfectly, generating Mapping Divergence (Δ) that drives the entire emergence process:

$A \neq B \rightarrow A \rightleftarrows B \rightarrow \Delta \rightarrow \Psi \rightarrow \Pi \rightarrow T \rightarrow R \rightarrow M$

This pipeline forms the theoretical foundation for the computational representation and benchmark framework introduced in the following sections.

Conceptual Foundations of SGEM-PM

Design Philosophy

The Simultaneous Galaxy Emergence and Primordial Mapping Framework (SGEM-PM) is a conceptual-computational framework for modeling emergence.

The framework is based on a simple observation: many complex systems emerge from persistent interactions between non-identical entities rather than isolated static objects. Examples include information exchange, biological evolution, adaptive systems, self-organizing structures, and cognitive systems.

SGEM-PM generalizes this observation by proposing that emergence originates from reciprocal mapping between two non-identical primordial domains. The framework therefore adopts a relational rather than substance-based starting point.

Primordial Domains

Definition 1. Primordial Domain

A primordial domain is a foundational state-space capable of participating in reciprocal representation.
Two primordial domains are assumed: A and B.

The framework does not prescribe a specific physical interpretation for either domain. A and B may represent informational domains, structural domains, possibility domains, pre-physical states, or abstract relational spaces.

The only required condition is: $A \neq B$
This asymmetry forms the first axiom of the framework.

Axiom 1

There exist two non-identical primordial domains: $A \neq B$
Without asymmetry, no corrective dynamics can emerge.

Reciprocal Mapping

Definition 2. Reciprocal Mapping

Reciprocal Mapping is the continuous attempt of two domains to represent one another, denoted by A □ B and

consisting of two directional mappings:
M_AB: A → B
M_BA: B → A
where M_AB represents A's representation of B and M_BA represents B's representation of A. The framework assumes that reciprocal mapping is ongoing and incomplete.

Axiom 2

Primordial domains continuously participate in reciprocal mapping: A ⇄ B

Mapping Divergence

Definition 3. Mapping Divergence

Mapping Divergence is the residual mismatch remaining after reciprocal mapping attempts.
This quantity is denoted by: Δ
Mapping Divergence is not interpreted as physical distance, energy, force, or spacetime separation. Instead, Δ represents representational incompleteness.

Axiom 3

Whenever: A ≠ B and A ⇄ B
a non-zero divergence emerges: $\Delta > 0$
Mapping Divergence therefore becomes the primary source of emergence within SGEM-PM.

Dynamic Possibility Field

Definition 4. Dynamic Possibility Field

The Dynamic Possibility Field is denoted by: Ψ
Ψ represents the domain of possible corrective configurations generated by Mapping Divergence.
Within the current formulation, Ψ and P_in represent complementary views of the same possibility domain, where Ψ denotes possibility capacity and P_in denotes possibility activity.

Axiom 4

Possibility emerges from divergence: Δ → Ψ
Greater divergence generates greater possibility capacity.

Preservation Principle

Definition 5. Preservation Principle

The Preservation Principle is denoted by: Π
Π represents the capacity of the system to preserve mapping outcomes through time.
The Preservation Principle enables memory, accumulation, structure formation, and historical continuity. Without preservation, all possibilities would remain transient.

Axiom 5

Stable emergence requires preservation: Ψ → Π

Twist/Vortex Formation and Reality Locking

Definition 6. Twist/Vortex Formation

Twist/Vortex Formation is denoted by: T
T represents local convergence generated by the interaction between possibility and preservation. Within computational implementations, T is frequently visualized as vortex-like structures.

Definition 7. Reality Locking

Reality Locking is denoted by: R

Reality Locking occurs when convergent structures achieve sufficient stability to persist. The framework therefore interprets reality as a stabilized subset of possibility.

Axiom 6

Reality emerges through locking: $\Psi + \Pi \rightarrow T \rightarrow R$

Matter Emergence

Definition 8. Matter Emergence

Matter Emergence is denoted by: M

Matter is interpreted as highly stabilized reality. Within SGEM-PM, matter is not fundamental but an emergent consequence of Reality Locking.

Axiom 7

Matter emerges from stabilized reality: $R \rightarrow M$

The SGEM-PM Emergence Pipeline

Combining the previous definitions yields the central emergence pipeline of the framework:

$A \neq B \rightarrow A \rightleftarrows B \rightarrow \Delta \rightarrow \Psi \rightarrow \Pi \rightarrow T \rightarrow R \rightarrow M$

This pipeline constitutes the conceptual foundation upon which the computational representation, benchmark framework, and simulator environment are constructed.

The following section formalizes these relationships through a minimal mathematical representation.

Mathematical and Computational Representation

The conceptual foundations introduced in Section 3 establish the entities and relationships of SGEM-PM. This section provides a minimal mathematical and computational representation suitable for simulation, benchmark generation, and computational exploration.

Primordial Domains and Reciprocal Mapping

Let A and B denote two non-identical primordial domains:

(1) $A \neq B$

The domains continuously attempt to represent one another through reciprocal mapping:

(2) M_AB: $A \rightarrow B$

(3) M_BA: $B \rightarrow A$

(4) $A \rightleftarrows B$

where M_AB and M_BA denote the representations of B by A and A by B, respectively. SGEM-PM assumes that reciprocal mapping is ongoing and inherently incomplete.

Mapping Divergence

The residual mismatch generated by reciprocal mapping is called Mapping Divergence:

$$\Delta \quad (5)$$

Conceptually, $\Delta = D(M\_AB, M\_BA)$ (6)

where D is a divergence measure satisfying:

$\Delta \geq 0$ (7)

When mapping becomes identical,

$\Delta = 0$ (8)

and no corrective dynamics remain.

Dynamic Possibility Field

The Dynamic Possibility Field is denoted:
Ψ (9)
with:
$\Psi \sim P\_in$ (10)
where Ψ represents Possibility Capacity and P_in represents Possibility Activity. Both represent complementary aspects of the same possibility domain.
$\Psi = f(\Delta)$ (11)
subject to:
$\partial\Psi/\partial\Delta > 0$ (12)
indicating that larger divergence produces a larger possibility domain.

Preservation Principle

The Preservation Principle is denoted:
Π (13)
and represents the persistence of mapping outcomes. In computational implementations:
$\Pi = \Pi(t)$ (14)
$\Pi = \Pi(x,y,t)$ (15)
Higher preservation values increase structural persistence.

Twist/Vortex Formation

Twist/Vortex Formation is denoted:
T (16)
and represents local convergence generated by the interaction of possibility and preservation. A minimal representation is:
$T = \Psi \cdot \Pi$ (17)
with the conceptual assumption:
$\Psi \uparrow$ and $\Pi \uparrow \Rightarrow T \uparrow$ (18)
indicating that stronger possibility and preservation increase the probability of vortex formation.

Reality Locking

Reality Locking is denoted:
R (19)
and occurs when convergence exceeds a critical threshold T_c:
$R = 1$ if $T > T\_c$ (20)
$R = 0$ otherwise (21)
Formally:
$R \subset \Psi$ (22)
Thus, reality is interpreted as stabilized possibility.

Matter Emergence

Matter Emergence is denoted:
M (23)
and is modeled as highly stabilized reality:
$M = \mu R$ (24)
where μ is the reality-condensation coefficient. In simulations, Matter Emergence corresponds to persistent reality-locking structures exceeding a predefined stability threshold.

Interference Region

The interaction region between primordial domains is denoted:

Γ (25)

Before first contact:

$\Gamma = \emptyset$ (26)

After contact:

$\Gamma \neq \emptyset$ (27)

The emergence of Γ marks the beginning of the SGEM-PM emergence process.

Emergence Dynamics

Combining the previous components yields the SGEM-PM emergence pipeline:

$A \neq B \rightarrow A \rightleftarrows B \rightarrow \Delta \rightarrow \Psi \rightarrow \Pi \rightarrow T \rightarrow R \rightarrow M$ (28)

Equation (28) serves as the fundamental computational pipeline implemented within the simulator environment.

Benchmark Variables

To support computational evaluation, each component of the framework is associated with measurable benchmark variables.

Framework Component	Benchmark Variable
Mapping Divergence (Δ)	Mapping Divergence Index (MDI)
Interference Region (Γ)	Interference Region Size (ΓS)
Dynamic Possibility Field (Ψ)	Possibility Density (PD)
Possibility Activity (P_in)	Possibility Activity (PA)
Preservation Principle (Π)	Preservation Strength (PS)
Twist/Vortex Formation (T)	Twist Intensity (TI)
Vortex Structures	Vortex Count (VC)
Reality Locking (R)	Reality Locking Index (RLI)
Matter Emergence (M)	Matter Emergence Index (MEI)
Structural Persistence	Stability Duration (SD)
Global Convergence	Convergence Rate (CR)
Residual Possibility	Residual Possibility (RP)
Emergence Residual	Entropy Proxy (EP)

These benchmark variables constitute the quantitative layer of SGEM-PM and provide the foundation for simulator-based experimentation.

The following section introduces the computational architecture used to implement and evaluate these variables.

Computational Architecture and Simulator Implementation

The mathematical representation introduced in Section 4 defines the conceptual entities of SGEM-PM. This section describes the computational architecture used to implement these entities within the AB Genesis Simulator environment.

The simulator is not intended as a physical cosmology engine. Instead, it serves as an experimental platform for studying emergence dynamics generated by the SGEM-PM pipeline.

Architecture Overview

The computational architecture consists of five principal layers:

- Primordial Domain Layer
- Mapping Layer
- Possibility Layer
- Preservation Layer
- Emergence Layer

The complete computational flow follows the SGEM-PM emergence pipeline:

A/B Domains → Reciprocal Mapping → Mapping Divergence (Δ) → Dynamic Possibility Field (Ψ) → Preservation Principle (Π) → Twist/Vortex Formation (T) → Reality Locking (R) → Matter Emergence (M).

Simulation State Variables

The simulator maintains the following primary state variables:

Ψ	Dynamic Possibility Field
P_in	Possibility Activity
Π	Preservation Strength
Δ	Mapping Divergence
Γ	Interference Region
T	Twist/Vortex Formation
R	Reality Locking
M	Matter Emergence

These variables evolve continuously throughout the simulation process.

Core Input Parameters

The current simulator implementation exposes a set of controllable parameters.

Possibility Parameters

Parameter	Symbol
Ψ Density	PD
P_in Intensity	PA

Observed simulator ranges include:

Ψ Density: 89 – 700

P_in Intensity: 0.90 – 85

Depending on Implementation and Scaling Mode.

Preservation Parameters

Parameter	Symbol
Π Closure Strength	PS
Π Boundary Nodes	ΠN

Observed benchmark values:

Π Closure Strength: 0.35 – 86

Π Boundary Nodes: 3 – 7

Across Current Experiments.

Divergence Parameters

Parameter	Symbol
A/B Interference Noise	ΔN
Entropy Leakage	EL

Observed values:
Interference Noise: 0.15 – 42
Entropy Leakage: 0.30 – 38

These variables influence the persistence of Mapping Divergence within the simulation environment.

Convergence Parameters

Parameter	Symbol
Twist Coefficient	TI
Condensation Threshold	CT

Observed values:
Twist Coefficient: 1.20 – 85
Condensation Threshold: 0.50 – 98

Higher twist coefficients may increase vortex formation probability, while larger condensation thresholds may increase reality-locking requirements.

Topological Boundary Layer

The simulator introduces Preservation Nodes (Π Nodes).
These nodes function as local closure operators.
Examples observed in current experiments include:
Multi-Boundary Co-Genesis (7 Π Nodes) and Multi-Core Co-Genesis (3 Π Nodes).
The number and spatial arrangement of Π Nodes directly affect:

- Vortex stability.
- Matter condensation.
- Closure convergence.
- Large-scale boundary formation.

Emergence Detection Engine

The simulator continuously evaluates emergence conditions.

Stage 1: Potential Field
Only Ψ and P_in are active.
No stable structures exist.

Stage 2: Boundary Closure
Π Nodes begin constraining possibility flow.

Stage 3: Condensation
Localized regions exceed condensation thresholds.

Stage 4: Electron-like Vortex Formation
Stable localized rotating structures emerge.

The term "electron-like" is employed solely as a computational descriptor for vortex patterns detected within the simulator environment. It does not imply correspondence with physical electrons or constitute evidence of particle formation.

Stage 5: Matter-like Cluster Formation

Multiple vortices become persistent clusters.

Stage 6: Galaxy-like Closure

Large-scale closure structures become possible.

Current simulator outputs already record several of these stages.

Computational Outputs

The simulator generates quantitative outputs suitable for benchmark analysis.

Examples include:

Output Variable	Symbol
Stable Vortices	VC
Matter-like Clusters	MC
Galaxy-like Closures	GC
Condensed Matter Points	CMP
Genesis Score	GS
Entropy Residual	EP

Representative outputs include:

Stable Vortices 9 – 64

Matter-like Clusters: 3

Condensed Matter Points: 284 – 700

Convergence Rate (CR): 53%

Genesis Score: 622 – 4069

across current experiments.

Research Artifact Infrastructure

To support reproducibility, the SGEM-PM framework is accompanied by:

- AB Genesis Simulator
- Benchmark Framework
- Versioned Research Artifacts
- Persistent Computational Records

The simulator therefore functions as a computational laboratory for exploring emergence dynamics under controlled parameter configurations. Artifact access information has been omitted from this anonymized manuscript.

Benchmark Framework

Benchmark Structure

The SGEM-PM benchmark framework evaluates emergence behavior through thirteen quantitative metrics organized into four benchmark layers.

Implementation Scaling Note

The benchmark framework allows implementation-dependent numerical scaling. Consequently, parameters such as PD, PA, PS, and TI may operate on different numerical ranges across simulator implementations and should be interpreted comparatively rather than as directly equivalent measurements.

Layer	Category	Metrics
L1	Divergence Layer	MDI, ΓS
L2	Possibility Layer	PD, PA
L3	Preservation-Convergence Layer	PS, TI, VC
L4	Reality Formation Layer	RLI, MEI, SD, CR, RP, EP

Mapping Divergence Metrics
Mapping Divergence Index (MDI)

Item	Description
Symbol	MDI
Framework Variable	Δ
Unit	Relative Benchmark Score
Interpretation	Degree of mismatch between A and B

Classification:

MDI Range	Interpretation
0–20	Near-identical mapping
21–40	Low divergence
41–60	Moderate divergence
61–80	High divergence
81–100	Extreme divergence

Interference Region Size (ΓS)

Item	Description
Symbol	ΓS
Framework Variable	Γ
Unit	Relative Area (%)

Classification:

ΓS	State
0	No contact
1–25	Local interference
26–50	Expanding interference
51–75	Large-scale interference
76–100	Dominant interference

Possibility Metrics
Possibility Density (PD)

Item	Description
Symbol	PD
Framework Variable	Ψ
Simulator Parameter	Ψ Density

PD measures the density of active possibility states within the Dynamic Possibility Field.

Observed Experimental Values:
89–700
Interpretation:
Higher PD values generally correspond to larger possibility spaces and increased emergence activity.

Possibility Activity (PA)

Item	Description
Symbol	PA
Framework Variable	P_in
Simulator Parameter	P_in Intensity

PA measures the intensity of possibility actualization within the simulator environment.
Observed Experimental Values:
0.90–85
Interpretation:
Higher PA values indicate stronger possibility activity. Numerical scales may vary across implementations.

Preservation Metrics

Preservation Strength (PS)

Item	Description
Symbol	PS
Framework Variable	Π
Simulator Parameter	Π Closure Strength

Observed Experimental Values:
0.35–86
Interpretation:
Higher PS values indicate stronger preservation activity and greater structural persistence.

Twist Intensity (TI)

Item	Description
Symbol	TI
Framework Variable	T
Simulator Parameter	Twist Coefficient

Observed Experimental Values:
1.20–85
Interpretation:
Higher TI values generally increase the probability of stable vortex formation.

Vortex Count (VC)

Item	Description
Symbol	VC
Unit	Stable Vortices
Framework Variable	T

Classification:

VC	State
0	No emergence
1–10	Local vortex formation
11–50	Structured convergence
>50	High-density convergence

Observed Experimental Values:
9–64 stable vortices.

Reality Formation Metrics

Reality Locking Index (RLI)

Item	Description
Symbol	RLI
Framework Variable	R

RLI is a normalized benchmark score ranging from 0 to 100 and measures the degree of stabilization achieved by emergent structures.

Classification:

RLI	Interpretation
0–20	Unstable
21–40	Weak Locking
41–60	Moderate Locking
61–80	Strong Locking
81–100	Persistent Locking

Matter Emergence Index (MEI)

Item	Description
Symbol	MEI
Framework Variable	M

MEI is a normalized composite benchmark score derived from condensation, clustering, and persistence measurements, including:

- Condensed Matter Points
- Matter-like Clusters
- Persistence Duration

Current benchmark observations include:

- 284 condensed matter points
- 3 matter-like clusters

Stability Duration (SD)

Item	Description
Symbol	SD
Unit	Frames

Meaning	Lifetime of stable structures

Convergence Rate (CR)

Item	Description
Symbol	CR
Unit	%
Meaning	Speed of emergence stabilization

Observed Benchmark Value:

53% galaxy convergence.

Residual Possibility (RP)

Item	Description
Symbol	RP
Meaning	Unactualized possibility capacity

Entropy Proxy (EP)

Item	Description
Symbol	EP
Meaning	Non-convergent residual dynamics

Observed Benchmark Value: 11% non-convergent entropy.

Genesis Score (GS)

To provide a single aggregate benchmark value:
$GS = w_1MDI + w_2PD + w_3PS + w_4TI + w_5VC + w_6RLI + w_7MEI + w_8SD$
where: $\Sigma w_i = 1$
The weighting coefficients may be configured according to implementation requirements and benchmark objectives. Consequently, Genesis Score is intended as a comparative benchmark rather than a universal emergence measure.

Genesis Score serves as the primary aggregate benchmark across SGEM-PM implementations.

Observed Experimental Values:
622–4069
Because benchmark parameters may operate on different implementation-specific scales, Genesis Score should be interpreted as an implementation-dependent comparative benchmark rather than an absolute physical quantity.

Experimental Results

Experimental Setup

Two independent implementations of the AB Genesis Simulator were used to evaluate the SGEM-PM benchmark framework.

Both implementations employ the same conceptual emergence pipeline:
$A \neq B \rightarrow A$ □ $B \rightarrow \Delta \rightarrow \Psi \rightarrow \Pi \rightarrow T \rightarrow R \rightarrow M$

while differing in numerical scaling, parameter configuration, and computational realization.
The objective of the experiments is not to validate physical cosmology but to evaluate whether the benchmark framework can consistently characterize distinct emergence behaviors across independent simulator implementations.

Experimental Configurations

Experiment A

Parameter	Value
Ψ Density (PD)	89
P_in Intensity (PA)	85
Π Closure Strength (PS)	86
Interference Noise	42
Twist Coefficient (TI)	85
Condensation Threshold	98
Entropy Leakage	38
Π Boundary Nodes	7

Observed System State:
Matter-like Cluster Emerged.

Experiment B

Parameter	Value
Ψ Density (PD)	700
P_in Intensity (PA)	0.9
Π Closure Strength (PS)	0.35
Interference Noise	0.15
Twist Coefficient (TI)	1.2
Condensation Threshold	0.5
Entropy Leakage	0.3
Π Boundary Nodes	3

Observed System State:
Electron-like Vortex Detected.

Benchmark Comparison

Primary Emergence Metrics

Metric	Experiment A	Experiment B
Possibility Density (PD)	89	700
Π Boundary Nodes	7	3
Stable Vortices (VC)	9	64
Matter-like Clusters	3	0
Condensed Matter Points	284	700
Galaxy-like Closures	0	0
Entropy Residual (EP)	11%	30%
Genesis Score (GS)	622	4069

The benchmark results demonstrate that the two implementations occupy distinct regions of the SGEM-PM emergence space despite sharing the same conceptual architecture.

Emergence Pattern Analysis

The two experiments exhibit substantially different emergence trajectories.

Experiment A

Experiment A produced:

- 9 stable vortices.
- 284 condensed matter points.
- 3 matter-like clusters.
- 53% galaxy convergence.
- 11% residual entropy.

The simulation reached the Matter-like Cluster Emerged state, indicating successful progression beyond vortex formation into higher-order structural aggregation.

Experiment B

Experiment B produced:

- 64 stable vortices.
- 700 active condensed matter points.
- No matter-like clusters.
- Reached the Electron-like Vortex Detected state.

The simulation generated significantly larger vortex activity and condensation density but did not progress to cluster-level emergence within the observed run.

These observations suggest that different simulator configurations may favor different emergence regimes.

Comparative Emergence Regimes

The benchmark results indicate the existence of at least two distinguishable emergence regimes within the current simulator implementations.

Cluster-Dominant Regime

Characteristics:

- Lower possibility density.
- Lower vortex count.
- Successful matter-like clustering.
- Reduced residual entropy.

Observed in: Experiment A.

Vortex-Dominant Regime

Characteristics:

- High possibility density.
- Large vortex populations.
- Extensive condensation activity.
- Absence of cluster consolidation.

Observed in: Experiment B.

At the present stage, these regimes should be interpreted as computational emergence patterns rather than physical classifications.

The simulator outputs suggest a recurring emergence sequence:
Potential Field
→ Vortex Formation → Condensation → Matter-like Clustering
Experiment B reached the Condensation stage and maintained stable vortex structures.
Experiment A progressed further toward Matter-like Cluster formation.
This progression supports the usefulness of VC, MEI, SD, and CR as benchmark indicators for emergence tracking.

Benchmark Robustness

The SGEM-PM benchmark framework successfully differentiated two independent simulator implementations.
The benchmark metrics captured differences in:

- Possibility density.
- Possibility activity.
- Preservation configuration.
- Vortex generation.
- Matter-like clustering.
- Entropy retention.
- Overall emergence score.

Despite implementation-specific scaling differences, the framework remained capable of distinguishing qualitatively different emergence behaviors.
These results suggest that the benchmark framework provides meaningful comparative measurements across heterogeneous implementations.

Limitations of Current Experiments

Several limitations should be acknowledged.
First, the simulator is a conceptual emergence environment rather than a physical cosmology engine.
Second, benchmark values are implementation-dependent and may operate under different numerical scales.
Third, the reported metrics characterize simulator behavior rather than empirical astronomical observations.
Fourth, only two simulator implementations are currently available for comparison.
Consequently, the reported results should be interpreted as evaluations of framework behavior and benchmark utility rather than evidence regarding physical cosmology.
The following section discusses the broader implications and limitations of SGEM-PM.

Discussion

From Objects to Mapping Processes

A central distinction of SGEM-PM is its choice of starting point.
Many scientific frameworks begin with predefined entities such as:

- Matter.
- Energy.
- Fields.
- Particles.
- Spacetime.

The SGEM-PM framework instead begins with reciprocal mapping between non-identical domains.
The framework therefore shifts the focus from objects to processes.
Rather than asking: "What objects exist?"

SGEM-PM asks: "What dynamics emerge when representation is incomplete?"
Under this interpretation, emergence becomes a consequence of ongoing mapping rather than a property of pre-existing structures.

Divergence as a Generative Resource

Within the framework, Mapping Divergence (Δ) is not treated as error.
Instead:
Within the framework, Δ is treated as a generative resource.
Traditional optimization systems often seek: $\Delta \rightarrow 0$
However, complete convergence eliminates the possibility of further emergence.
In SGEM-PM: Δ generates Ψ
which subsequently enables: $\Pi \rightarrow T \rightarrow R \rightarrow M$
This interpretation suggests that persistent incompleteness may play a constructive role in emergence.
From this perspective, divergence is not merely a problem to be solved but also a source of structural novelty.

Relationship to Information and Complexity

Several existing traditions already emphasize the importance of difference, feedback, and self-organization.
Information theory treats distinguishable states as the basis of information [1].
Cybernetics studies adaptive correction processes [2,4].
Complexity science investigates how large-scale organization emerges from local interactions [5-10].
SGEM-PM shares common ground with these perspectives.
However, the framework differs in its attempt to place divergence, possibility, preservation, and reality formation within a single emergence pipeline.
The proposed sequence: $\Delta \rightarrow \Psi \rightarrow \Pi \rightarrow T \rightarrow R \rightarrow M$
may therefore be interpreted as a unifying conceptual abstraction rather than a replacement for existing theories.

Computational Interpretation

One of the primary motivations behind SGEM-PM is the possibility of computational exploration.
The benchmark experiments presented in Section 7 indicate that different parameter configurations can produce measurably different emergence behaviors within the simulator environment. The current results suggest that higher possibility density may be associated with increased vortex activity, while stronger preservation may contribute to greater structural stabilization. They also suggest that possibility generation alone may not be sufficient to achieve higher-order convergence in the absence of adequate preservation dynamics.

Although these observations originate from conceptual simulations rather than physical experiments, they demonstrate that the framework is computationally operational rather than purely philosophical. This distinction is important because benchmarkable frameworks can be evaluated, compared, modified, and extended through systematic experimentation.

Consequently, SGEM-PM may be viewed as a computational laboratory for studying emergence dynamics under controlled parameter configurations rather than as a validated model of physical cosmology.

Potential Applications

The current work focuses on emergence modeling. However, the underlying concepts may extend beyond cosmological interpretation and may be applicable to a broader class of complex adaptive systems.
Possible application domains include:

Complex Adaptive Systems

Modeling the emergence of large-scale organization from interacting subsystems operating under incomplete information and dynamic constraints.

Artificial Intelligence and Agent-Based Systems

Modeling possibility generation, stabilization, decision convergence, and adaptive emergence within autonomous or multi-agent environments.

Multi-Agent Systems
Analyzing collective behavior and emergent coordination arising from incomplete mutual representation among interacting agents.

Knowledge Systems
Studying divergence, convergence, persistence, and structural evolution within dynamic knowledge networks and information ecosystems.

Computational Creativity
Exploring the generation, selection, and stabilization of novel structures through possibility-preservation dynamics.

Systems Modeling and Simulation
Providing a conceptual framework for investigating emergence processes in domains where large-scale behavior arises from local interactions and feedback mechanisms.
These applications remain exploratory and should be regarded as potential research directions rather than established uses of the framework. Nevertheless, they illustrate the broader modeling scope of SGEM-PM beyond its original emergence-oriented formulation.

Interpretation of the Simulator Results
The experiments reported in Section 7 should be interpreted carefully.
The simulator demonstrates that:
- Reciprocal mapping can generate measurable divergence.
- Divergence can drive possibility generation.
- Possibility and preservation can produce stable structures.
- Different parameter regimes lead to distinct emergence outcomes.

However, these results do not demonstrate:
- Physical electron formation.
- Physical galaxy formation.
- Empirical Big Bang dynamics.
- Validation of cosmological reality.

The simulator evaluates the internal behavior of the SGEM-PM framework only. Consequently, the results should be viewed as conceptual-computational evidence rather than empirical scientific confirmation.

Limitations
Several limitations remain.

Conceptual Nature
The framework is conceptual and computational. It is not derived from established physical laws.

Benchmark Dependency
Current benchmark results depend on simulator implementations. Alternative implementations may produce different quantitative outcomes.

Lack of Empirical Validation
The framework has not yet been calibrated against astronomical observations or experimental measurements.

Simplified Dynamics
The simulator intentionally abstracts many physical processes in order to isolate emergence behavior.

Limited Experimental Coverage
Only a small number of benchmark configurations are currently available. Larger experimental studies are required to evaluate robustness.

Future Research Directions
Several directions appear promising.

Expansion of Benchmark Suites
Development of larger benchmark repositories and parameter sweeps.

Multi-Implementation Evaluation
Comparison of independent simulator implementations.

Automated Emergence Analysis
Application of machine learning methods to benchmark outputs.

Mapping-Based System Design
Exploration of reciprocal mapping principles within artificial intelligence and adaptive systems.

Empirical Correspondence Studies
Investigation of whether specific benchmark behaviors exhibit meaningful correspondence with observed natural systems.

Position of SGEM-PM
The SGEM-PM framework should be viewed as a benchmarkable conceptual-computational framework for emergence modeling.

Its primary contribution is not the proposal of a verified cosmology. Its contribution is the introduction of a unified structure that connects:
Mapping Divergence, Possibility Formation, Preservation Dynamics, Reality Locking, and Matter Emergence within a single computationally explorable framework.

This perspective establishes a foundation upon which future theoretical, computational, and experimental investigations may be built [21-29].

Conflict of Interest
The author declares no conflict of interest.

Funding Statement
This research received no external funding.

Acknowledgments
The author would like to acknowledge the broader scientific community whose work in cosmology, complex systems, information theory, mathematics, and theoretical physics has contributed to the intellectual environment in which this framework was developed.

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