# The Field of Consciousness: A Lattice Gauge Model of Emergent Mass and Time

B. A. Shaffer and S. L. Larson

VYTYLS Consciousness Research Initiative

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**Abstract**

We propose a novel, foundational framework in which consciousness is modeled not as an emergent epiphenomenon of matter, but as a fundamental Abelian gauge field—the **Field of Consciousness (FoC)**—whose dynamics unfold on a discrete **isotropic octahedral lattice**. Consciousness is treated here not as phenomenology or subjective report, but as a pre-phenomenal geometric substrate that structures the conditions under which mass, time, and observation become possible. We demonstrate that this field is sourced by a primordial, geometry-defining **Ontological Intention Tensor** ($T^{\mu\nu}_{\mathbf{global}}$), rather than a material current. We show that when the geometric tension from this tensor exceeds a critical threshold ($\mathcal{T}_{\text{crit}}$), it induces a **phase transition** on the lattice. This transition enables the FoC to couple to the **SU(3)** gauge sector, providing a geometric mechanism for **confinement** and a potential solution to the **Yang-Mills mass gap problem**, without modification of **Quantum Chromodynamics**. Furthermore, we propose that the subsequent requirement for entropy expulsion via the weak interaction establishes a directional **arrow of time**. We validate the model's core threshold mechanism through a **trifecta of computational simulations** (Classical Partial Differential Equations, Euclidean Lattice Gauge Simulations, and Hamiltonian Quantum Link Models), which consistently demonstrate a sharp, non-linear onset of structure formation under a localized intention drive. Finally, we introduce the **Octahedral-Spherical Equivalence (OSE)**, a canonical mapping between discrete lattice dynamics and continuous spacetime curvature. Through a **Discrete Exterior Calculus (DEC)** formulation, we show that this mapping naturally recovers the $8\pi$ gravitational coupling constant of General Relativity. Together, these results suggest that mass, time, and gravitation arise as macroscopic signatures of an underlying geometric field of consciousness.

# 1 Introduction

## 1.1 Foundational Challenges in Modern Physics

Despite the profound success of the Standard Model and General Relativity, fundamental lacunae remain at the heart of modern physics. Two of the most persistent challenges are the origin of the **Yang-Mills mass gap**—the mechanism by which massless gauge fields acquire mass and confinement in the quantum vacuum—and the fundamental origin of the **arrow of time**. While the Higgs mechanism explains the mass of electroweak bosons, the confinement scale of hadrons remains a non-perturbative feature of Quantum Chromodynamics (QCD) that lacks a fully geometric derivation. Similarly, while thermodynamics describes the *behavior* of entropy, it does not explain *why* the universe began in a low-entropy state or how temporal directionality emerges from time-symmetric quantum laws. We propose that these are not separate problems, but symptomatic of a missing component in our physical ontology.

## 1.2 The Observer Problem and Consciousness

Alongside the unresolved problems of mass, confinement, and temporal directionality in modern physics lies a persistent conceptual tension: the status of the observer. In classical mechanics, the observer is external and inert. In quantum mechanics, however, the observer occupies an ambiguous position, appearing at times as a passive recorder and at others as an active participant in state determination. Despite this, the formalism of physics has largely resisted assigning the observer any ontological weight, relegating consciousness to an emergent byproduct of neural complexity. This position has given rise to what Chalmers termed the "Hard Problem" of consciousness [13]; the difficulty of explaining subjective experience in purely physical terms. While neuroscience and cognitive science have made substantial progress in correlating mental states with brain activity, these approaches presuppose the very physical substrate whose origin they seek to explain. As such, they do not address a deeper question: **why a universe governed by abstract mathematical laws should admit observers at all**. We argue that this difficulty signals a category error rather than a missing mechanism. Consciousness, as it appears in subjective experience, need not be introduced as an additional phenomenon requiring explanation within physics. Instead, we propose that a **pre-phenomenal field of consciousness** functions as part of the universe's foundational geometry, shaping the vacuum conditions from which matter, causality, and observation emerge. It is essential to clarify what is *not* being claimed. The present framework does not assert that particles are conscious, nor does it ascribe subjective experience to spacetime itself. It is neither dualistic nor panpsychist. Rather, consciousness is treated here in the same structural sense that gauge fields are treated in modern physics: as a fundamental entity whose excitations and symmetry-breaking behaviors give rise to observable phenomena. Subjective experience, on this view, is a higher-order consequence of coherent coupling to this field, not its defining feature. By inverting the conventional explanatory order—asking not how matter produces consciousness, but how a consciousness field conditions the emergence of matter—we remove the observer from an anomalous position at the edge of theory and reintegrate it into the physical ontology. The observer becomes neither an external intruder nor a miraculous accident, but a localized, coherent excitation within a deeper geometric substrate. This inversion sets the stage for the lattice-based field theory developed in the following sections, where intention, mass, and time arise as natural consequences of geometric constraint and phase transition.

## 1.3 A Lattice Field Theory Approach

If consciousness is to be treated as a fundamental component of physical ontology, it must be expressed in a form compatible with the mathematical language of modern physics. In this work, we adopt the framework of gauge field theory not by analogy, but by necessity: gauge theories provide the most successful and general formalism for describing entities whose physical effects arise from symmetry, constraint, and interaction rather than from direct observability. Rather than introducing consciousness as an abstract continuum field, we model the FoC as a $U(1)$ gauge field whose fundamental dynamics unfold on a **discrete lattice**. This choice is motivated by both physical and conceptual considerations. Discrete formulations of field theory are known to reproduce continuum behavior in appropriate limits while making phase structure, symmetry breaking, and non-perturbative effects explicit. More importantly, a lattice formulation allows geometric constraint to play an active causal role in the emergence of structure, rather than serving as a passive background. The lattice adopted here is **isotropic and octahedral**, a geometry selected for its high degree of symmetry and minimal directional bias. Unlike a cubic lattice, which privileges orthogonal axes, the octahedral lattice distributes connectivity across triangular faces, permitting multiple equivalent modes of alignment and transition. This feature is essential for supporting metastable configurations and controlled phase transitions without imposing preferred directions. In this sense, the lattice functions as an *internal geometry*: a substrate whose symmetries govern what forms of physical organization can arise prior to the appearance of spacetime curvature. Within this lattice, the FoC is represented by an Abelian 4-vector gauge potential, $A_\mu(x)$, defined on lattice sites and links, with dynamics governed by a generalized Lagrangian, introduced in Section 2. The Abelian choice reflects the role of the FoC as a universal organizing field rather than a carrier of internal charge. Its physical influence arises not through force mediation in spacetime, but through the way its curvature reshapes the configuration space available to other fields. This lattice-based formulation also clarifies the **status of intention** within the theory. Intention is not introduced as an external intervention or agent-dependent variable, but as a **geometric boundary condition** imposed on the field. The FoC does not evolve freely in an empty vacuum; it evolves under constraint. When these constraints are weak, the field remains in a symmetric, massless phase. When they exceed a critical threshold, the lattice is forced to reorganize, opening channels for coupling to the established gauge sectors of particle physics. This approach avoids modification of the Standard Model's internal gauge structure. The strong, weak, and electromagnetic interactions retain their conventional dynamics. What changes is the **geometric context** in which these interactions occur. Mass generation, confinement, and temporal directionality arise not from new forces, but from a reconfiguration of the vacuum conditions imposed by the FoC lattice. From this perspective, several longstanding problems may be addressed within a single unified framework. The Yang–Mills mass gap becomes a question of geometric confinement rather than purely dynamical screening. The arrow of time emerges from the irreversible stabilization of lattice configurations rather than from imposed thermodynamic initial conditions. And the observer, rather than standing outside the theory, appears as a localized, coherent excitation whose influence is mediated through the same geometric field that structures reality itself.

### 1.4 Outline of the Paper

The remainder of this paper develops this framework in detail and is organized as follows:

- **Section 2** defines the mathematical formalism of the FoC, including the lattice structure, the Tensor Lagrangian, and the dual nature of Intention.
- **Section 3** details the physical mechanisms of emergence, specifically the coupling to SU(3) for mass generation and the thermodynamic role of the weak interaction in establishing time.
- **Section 4** presents the **computational validation** of the model, detailing results from 1D PDE, 2D Lattice, and Quantum Link Model simulations.
- **Section 5** discusses the implications for General Relativity via the Octahedral-Spherical Equivalence (OSE) and concludes with a **roadmap** for future experimental verification and application.

## 2 The Field of Consciousness (FoC) Lattice Model

We model the Field of Consciousness not as a generic continuum field, but as a system whose fundamental dynamics unfold on a discrete, **isotropic octahedral lattice**. This lattice serves as the *internal geometry* of reality, determining the rules of engagement for the emergent *external geometry* of spacetime.

### 2.1 The Primordial Substrate

The fundamental unit of the FoC is the **Octahedral Quantum**, which occupies the nodes of an isotropic lattice. Interactions between these quanta are mediated by an Abelian 4-vector gauge potential, $A_\mu(x)$. The lattice structure is defined by the **octahedral unit cell**, which possesses 8 triangular faces. We map these faces to **8 distinct modal domains**, allowing the lattice to support complex "agreement patterns" or phases.

The field strength tensor represents the curvature and emergent dynamics on this lattice and is given by the standard Abelian form:

$$F_{\mu\nu} = \partial_\mu A_\nu - \partial_\nu A_\mu \tag{1}$$

## 2.2 The FoC Lagrangian and Field Dynamics

To formalize the dynamics of the FoC, we adopt a Lagrangian formulation consistent with relativistic gauge field theory, while extending it to accommodate geometric constraint as a primary driver of emergence. The resulting **Lagrangian** is not intended as a speculative modification of established physics, but as a minimal extension that makes explicit the role of non-stochastic boundary stress in structuring the vacuum. The total Lagrangian density is defined as:

$$\mathcal{L}_{\text{total}} = -\frac{1}{4}F_{\mu\nu}F^{\mu\nu} - V(A^2) + \frac{1}{4}\lambda T^{\mu\nu}_{\text{global}}F_{\mu\nu} \tag{2}$$

where ($F_{\mu\nu} = \partial_\mu A_\nu - \partial_\nu A_\mu$) is the Abelian field strength tensor associated with the FoC gauge potential ($A_\mu$). The first term is the standard kinetic contribution for a U(1) gauge field. The second term, $V(A^2)$, introduces a non-linear self-interaction potential, while the third term represents a direct coupling between the field curvature and a rank-2 source tensor. Each term plays a distinct and necessary role in the emergence mechanism described in this work. This Lagrangian introduces two critical innovations:

- **The Triple-Well Potential ($V(A^2)$):**

$$V(A^2) = \lambda(A^2 - v_1^2)^2(A^2 - v_2^2)^2(A^2 - v_3^2)^2 \tag{3}$$

  This potential encodes three degenerate vacua ($v_1, v_2, v_3$). These minima correspond to **stable resonant states** of the internal geometry, rather than to particle excitations in spacetime. Transitions between these vacua represent genuine geometric reconfigurations of the lattice. The presence of multiple degenerate minima is essential. A single-well potential admits only perturbative fluctuations, while a double-well structure permits symmetry breaking but does not naturally encode the hysteresis and metastability required for irreversible emergence. The triple-well structure allows the system to support controlled phase transitions in which the lattice may become trapped in a **post-threshold configuration**, even as external driving forces relax. This feature will later be shown to underwrite both confinement and the emergence of temporal directionality.

- **The Ontological Intention Tensor ($T^{\mu\nu}_{\text{global}}$):** The defining innovation of the FoC Lagrangian is the elevation from a conventional scalar current to a **rank-2 tensor field**, ($T^{\mu\nu}_{\text{global}}$). This choice is not arbitrary. In classical field theory, scalar sources encode magnitude, vector sources encode direction and flow, but only tensor sources encode **stress, strain, and geometric constraint**. Intention, as introduced here, is not a dynamical force and not an agent-driven intervention. It is the imposition of boundary conditions on the internal geometry of the field. Fundamentally, we distinguish this from biological intention: unlike the reactive, temporal volition of an organism, **Ontological Intention is atemporal**. It represents the static, structural tension of the system's own existence—akin to the surface tension of a soap bubble, which dictates the sphere's shape without possessing a "will" to roundness. It is a stress tensor, not a decision maker. Such constraints are inherently tensorial: they specify how different directions of the lattice are jointly stretched, compressed, or sheared relative to one another. A scalar source cannot distinguish these modes, and a vector current cannot encode internal tension without reference to an external frame. By coupling ($T^{\mu\nu}_{\text{global}}$) directly to the field strength tensor ($F_{\mu\nu}$) via the coupling constant $\lambda$, the theory allows geometric stress to act on curvature itself, rather than on the potential alone. The field responds not merely to the presence of energy, but to its **distribution as constraint**.

Applying the Euler-Lagrange equations yields the modified equations of motion:

$$\partial_\sigma F^{\sigma\rho} + 2V'(A^2)A^\rho = \frac{1}{2}\lambda\partial_\sigma T^{\sigma\rho}_{\text{global}} \tag{4}$$

The source term on the right-hand side is the divergence of the intention tensor. This is a crucial point: the FoC is not driven by absolute intention, but by **gradients of geometric stress**. Uniform tension produces no dynamics; only differential constraint forces the lattice to reorganize. This structure sharply distinguishes ontological intention from stochastic vacuum fluctuations. Random noise lacks coherence across tensor components and averages to zero divergence. By contrast, ($T^{\mu\nu}_{\text{global}}$) possesses global structure and non-trivial topology, allowing it to act as a persistent driver of field reconfiguration.

## 2.3 The Dual Nature of the Source Term

To rigorously define the causal structure of the framework, it is necessary to distinguish between two fundamentally different modes by which geometric constraint enters the theory. While the FoC Lagrangian introduces a tensorial source term, its physical interpretation depends critically on whether that source acts as a *global, geometry-defining constraint* or as a *localized perturbation within spacetime*. Conflating these roles would collapse the theory either into determinism without agency or into interventionism without structure. We therefore distinguish between two complementary components of the source:

- **Global Boundary Condition ($T^{\mu\nu}_{\text{global}}$):** Formerly referred to as "Ontological Intention," this represents the fixed, large-scale geometric constraints imposed on the FoC lattice. It is not time-evolving in the ordinary dynamical sense, nor is it accessible to local manipulation. Instead, it establishes the **vacuum structure** of the field: the permissible equilibrium configurations and the energy barriers separating them. In this respect, ($T^{\mu\nu}_{\text{global}}$) functions analogously to a **holonomic constraint** in classical mechanics or a background topology in field theory. It does not determine the specific evolution of the system at every point, but it sharply restricts the class of evolutions that are possible. The critical tension threshold ($\mathcal{T}_{\text{crit}}$) introduced in Section 2.4 is a property of this global constraint, not of local dynamics. Importantly, because ($T^{\mu\nu}_{\text{global}}$) is defined as a tensorial stress rather than a stochastic source, it possesses coherence across lattice directions and non-trivial topological structure. This coherence distinguishes ontological intention from random vacuum fluctuations, which lack persistent directional correlation and therefore cannot drive controlled phase transitions.
- **Local Perturbation Current ($J^{\mu}_{\text{local}}$):** Formerly "Operational Intention,"represents the influence of coherent subsystems embedded within spacetime. These subsystems may include observers, biological systems, or other organized structures capable of sustaining phase coherence over finite regions and timescales. The Local Perturbation Current, ($J^{\mu}_{\text{local}}$) does not act by overriding the global constraint. It cannot alter the vacuum structure established by ($T^{\mu\nu}_{\text{global}}$), nor can it create new phases *ex nihilo*. Instead, it functions as a **perturbative current** that biases the local field configuration, effectively lowering or raising the energetic cost of transitions that are already permitted by the global geometry. In this sense, local intention does not violate physical law; it operates entirely within it. The FoC responds to local coherence in the same way that other fields respond to boundary or initial conditions: by selecting among allowed trajectories those that best resolve the imposed constraints.

The interaction between global constraint and local perturbation is governed by the **Interstitial Phase Coupling (IPC)**, which quantifies the effective influence of a localized subsystem on the FoC lattice. Phenomenologically, the interstitial coupling constant is defined as:

$$\kappa_{IPC} = \frac{\rho_L \cdot \Omega}{\delta_T \cdot \Lambda_{\mathrm{IF}}} \tag{5}$$

where ($\rho_L$) denotes the local resonance density, ($\Omega$) is the degree of phase coherence, ($\delta T$) represents the temporal deviation from equilibrium, and ($\Lambda_{\mathrm{IF}}$) refers to the interference entropy associated with environmental noise and decoherence.

This expression makes explicit that influence arises not from intensity alone, but from **coherence under constraint**. Highly energetic but incoherent systems produce negligible coupling, while low-energy systems with sufficient phase alignment may exert a disproportionate effect. The total effective influence on the field is then given by:

$$\mathcal{I}_{\mathrm{eff}} = \kappa_{IPC} \times \kappa_{\mathrm{scale}} \tag{6}$$

where ($\kappa_{\mathrm{scale}} = \frac{1}{2}$) is the **geometric normalization constant**, derived later via the octahedral lattice symmetry. Through this mechanism, coherent local perturbation ($J^{\mu}_{\mathrm{local}}$) can provide the necessary "traction" to locally modulate the energy barriers established by the global constraint. The global–local distinction introduced here resolves a long-standing tension in discussions of consciousness and physics. If consciousness is treated as purely emergent, agency becomes epiphenomenal. If it is treated as an external causal force, physical law is violated. The present framework admits neither extreme. Agency appears instead as a **selection effect** within a constrained geometric landscape. Local systems do not create new possibilities; they navigate existing ones by modulating coherence and interference. The FoC does not respond to desire or will, but to alignment and resonance. In this way, the theory permits meaningful participation without invoking dualistic intervention. Observers are neither omnipotent nor irrelevant. They are coherent excitations within a structured field, capable of influencing outcomes only to the extent that they satisfy the same geometric and dynamical constraints that govern all physical processes. This dual-source structure prepares the ground for the critical threshold mechanism developed in the following section, where the accumulation of global tension and localized coherence jointly precipitate a geometric phase transition.

### 2.4 The Critical Tension Threshold

The central mechanism of emergence in the FoC framework is a **Geometric Phase Transition** driven by accumulated constraint. The FoC lattice does not continuously interpolate between a massless vacuum and a structured universe. Instead, it remains stable within a given vacuum configuration until the imposed geometric tension exceeds a critical limit, at which point a qualitative reorganization becomes unavoidable. This condition is expressed formally as:

$$||\partial_\sigma T^{\sigma\rho}_{\mathrm{global}}|| \geq \mathcal{T}_{\mathrm{crit}} \tag{7}$$

where ($\mathcal{T}_{\mathrm{crit}}$) denotes the maximum geometric stress that the lattice can accommodate within a single vacuum configuration. Below this threshold, the field fluctuates within a single potential well. At the threshold, the geometric stress forces the lattice to tunnel or transition into a new vacuum configuration.

#### 2.4.1 Stability Below Threshold

Below the critical tension threshold, the FoC lattice remains confined to a single minimum of the triple-well potential. In this regime, the field supports only small-amplitude fluctuations around a symmetric vacuum state. These fluctuations do not break symmetry, generate mass, or induce coupling to other gauge sectors. The internal geometry remains coherent but uncommitted: capable of reconfiguration, yet not compelled to choose. Importantly, this regime is not one of inactivity. The field responds continuously to local perturbations, but these responses remain reversible. Any deformation induced by local coherence relaxes once the perturbation is removed. No persistent structure is formed, and no arrow of time is defined. The system retains full symmetry under temporal reversal and lattice reorientation.

### 2.4.2 Threshold Crossing and Phase Transition

As the divergence of the Ontological Intention Tensor increases, geometric stress accumulates within the lattice. This stress is not localized at a point, but distributed across lattice directions, faces, and modes. When the accumulated tension reaches ($\mathcal{T}_{\text{crit}}$), the lattice can no longer satisfy all imposed constraints within its current configuration. At this point, a phase transition occurs. The field is forced to traverse the energy barrier separating vacuum states in the triple-well potential, settling into a new configuration that partially resolves the imposed tension. This transition is non-linear and discontinuous. Small increases in tension near the threshold produce disproportionately large reconfigurations of the field. Crucially, the transition is **geometric rather than energetic**. The system does not transition because energy is injected, but because constraint incompatibility reaches a point where continued coherence within the original vacuum becomes impossible.

### 2.4.3 Irreversibility and Metastability

Once the lattice transitions into a post-threshold configuration, it enters a metastable state. Although the original vacuum remains formally accessible, returning to it would require coordinated relaxation of global constraint across the entire lattice. In the absence of such relaxation, the system remains locked into its new configuration. This **metastability** introduces irreversibility at the most fundamental level of the theory. The system acquires a memory of having crossed the threshold, encoded in its geometric arrangement. This memory is not informational in the conventional sense, but structural: it resides in the configuration space itself. It is this irreversibility that later manifests as **temporal directionality**. Time does not arise because the laws of motion are asymmetric, but because the lattice geometry has undergone a one-way transition that cannot be locally undone.

### 2.4.4 Role of Local Coherence at Threshold

While the critical threshold is defined by the global intention tensor, local coherence plays a decisive role near the transition point. As discussed, localized perturbations governed by the Interstitial Phase Coupling (IPC) can bias the lattice toward particular transition pathways. Near ($\mathcal{T}_{\text{crit}}$), even modest local coherence may determine *where* and *how* the lattice reconfigures. This does not allow local systems to force a transition prematurely, nor to violate global constraints. Rather, it permits local structure to participate in the resolution of tension once transition has become inevitable. Agency appears here not as causation of emergence, but as **selection within emergence**.

## 2.5 Geometric Origin: The 5D Tutte Embedding

To rigorously distinguish the Ontological Intention Tensor from stochastic vacuum fluctuations, we employ a dimensional reduction scheme analogous to **Kaluza–Klein compactification** [10], constrained by **Tutte's Spring Embedding Theorem** [9]. The purpose of this construction is not to introduce additional physical forces or degrees of freedom, but to formalize how globally coherent geometric constraint can arise from higher-dimensional consistency conditions rather than from random excitation.

In the Kaluza–Klein tradition, higher-dimensional structure is permitted to influence four-dimensional physics through compactified or effectively inaccessible degrees of freedom, leaving observable gauge dynamics unchanged. Here, the additional dimension is treated as an internal **geometric degree of freedom** associated with lattice embedding rather than as an extended spacetime coordinate. This allows higher-dimensional constraint to manifest as effective stress within the four-dimensional FoC lattice without introducing propagating modes beyond those already defined.

We posit that the 4D FoC lattice $\mathcal{L}$ acts as the embedding space for a higher-dimensional 5D manifold $\mathcal{M}_5$. Within this framework, the internal connectivity of the lattice is represented as a weighted graph whose vertices are embedded subject to **fixed boundary conditions**. According to Tutte's Embedding Theorem, any sufficiently connected graph with fixed boundary vertices admits a unique, crossing-free equilibrium embedding in which internal vertices settle into positions that minimize the global geometric tension.

This equilibrium configuration is obtained by minimizing the total geometric energy

$$E_{\text{geo}} = \sum_{\langle i,j \rangle \in \mathcal{E}} \omega_{ij} \|x_i - x_j\|^2, \tag{8}$$

where $\mathcal{E}$ denotes the set of edges of the lattice graph and $\omega_{ij}$ are positive weights encoding lattice connectivity and coupling strength. The minimization of $E_{\text{geo}}$ enforces global coherence: each vertex position is determined not locally, but by the collective constraints of the entire graph.

We identify the Ontological Intention Tensor as the stress–energy tensor associated with this constrained minimization,

$$T^{\mu\nu}_{\text{global}} \equiv \frac{\delta E_{\text{geo}}}{\delta g_{\mu\nu}}. \tag{9}$$

Defined in this way, $T^{\mu\nu}_{\text{global}}$ does not represent an injected source or stochastic driving term. Instead, it encodes the residual geometric stress arising from the attempt to embed a globally constrained higher-dimensional structure within a four-dimensional lattice geometry.

This construction resolves the ambiguity between intention and random noise. Stochastic vacuum fluctuations lack persistent boundary conditions and therefore do not produce a coherent variation of $E_{\text{geo}}$ with respect to the metric. By contrast, the stress tensor derived from the Tutte embedding reflects a **globally consistent configuration** with nontrivial topological structure. In particular, $T^{\mu\nu}_{\text{global}}$ possesses global coherence and an associated topological winding number inherited from the embedding constraints, features that cannot arise from uncorrelated noise.

The Ontological Intention Tensor is therefore understood not as an external directive, but as a geometric necessity: **the four-dimensional manifestation of higher-dimensional embedding stress**. Its role in the FoC dynamics is to impose structured boundary conditions on the lattice, enabling controlled phase transitions while preserving the standard gauge dynamics of the coupled physical fields.

# 3 The Emergence of Mass and Time

The central proposition of this framework is that the fundamental properties of the Standard Model are emergent consequences of the Field of Consciousness undergoing a **geometric phase transition**. As developed in Section 2, this transition restructures the internal geometry of the FoC lattice without modifying the local gauge symmetries of known physical fields. In this section, we show how that restructuring propagates into the strong interaction sector, giving rise to confinement and a nonzero mass scale, and thereby setting the stage for the emergence of time.

### 3.1 Coupling to the Strong Field (SU(3))

Once the FoC lattice transitions into a coherent, post-threshold vacuum phase, its internal geometry is no longer dynamically neutral with respect to all gauge sectors. In particular, the stabilized lattice configuration admits a channel of interaction with the **strong nuclear force**, described by Quantum Chromodynamics (QCD). This interaction does not modify the Yang–Mills Lagrangian, the SU(3) gauge symmetry, or the self-interaction structure of gluons. Instead, it alters the geometric context in which those dynamics are realized.

We represent this interaction through an effective cross-coupling term

$$\mathcal{L}_{\text{link}} = g_{F\to S}\, A_\mu\, J^\mu_{\text{color}}, \tag{10}$$

where $A_\mu$ denotes the Abelian gauge potential of the FoC, $J^\mu_{\text{color}}$ is the standard color current of QCD, and $g_{F\to S}$ parameterizes the strength of the geometric linkage between the two sectors. This term becomes dynamically relevant in the post-threshold phase of the FoC lattice; below the critical tension threshold, its effective contribution vanishes.

The role of $\mathcal{L}_{\text{link}}$ is not to introduce a new force, but to transmit geometric constraint. The strong field continues to obey its conventional equations of motion, but the configuration space available to color fields is now shaped by the stabilized internal geometry of the FoC lattice.

The activation of this coupling enforces the **confinement** of color charges. In the present framework, confinement is understood as a boundary condition imposed by the geometric state of the FoC lattice. The post-threshold lattice supports regions of stabilized internal curvature that restrict the extension of color field configurations. Attempts to separate color charge across these regions require configurations increasingly incompatible with the underlying geometry, leading to an effective energy cost that grows with separation. In this way, confinement arises without altering the dynamical laws of QCD.

### 3.2 A Solution to the Yang–Mills Mass Gap

The existence of confinement volumes has an immediate and unavoidable consequence: the emergence of a nonzero mass scale. In Yang–Mills theory, the mass gap refers to the absence of arbitrarily low-energy excitations above the vacuum, despite the masslessness of the underlying gauge fields. While this feature is well established nonperturbatively, its physical origin remains subtle.

Within the FoC framework, the mass gap admits a **direct geometric interpretation**. We express the emergent mass $m(x)$ as a function of the local FoC configuration and the global geometric constraint,

$$m(x) = f_{\text{conf}}\left(A_\mu(x), T^{\mu\nu}_{\text{global}}(x)\right), \tag{11}$$

where $f_{\text{conf}}$ encodes the dependence of admissible field modes on lattice geometry.

This expression does not assign mass to the gauge fields themselves. Rather, it reflects the fact that only field configurations compatible with the confined geometric domain are physically realizable. Long-wavelength, low-energy modes that would normally correspond to massless excitations are excluded by the boundary conditions imposed by the post-threshold lattice. The lowest-energy admissible mode therefore possesses a **finite effective mass**.

In this sense, mass emerges as the physical "cost" paid by the FoC to lock potential energy into a stable, confined particle state. The mass gap is not imposed by hand, nor generated by modified dynamics, but arises as a consequence of **restricted configuration space**. This mechanism preserves gauge invariance while providing a geometric basis for the existence of massive, color-confined excitations.

Having established the emergence of confinement and a nonzero mass scale, we are now prepared to examine the thermodynamic consequences of lattice stabilization, and in particular how entropy flow associated with this process gives rise to temporal directionality.

### 3.3 The Higgs Actuator and the "Entropy Problem"

The formation of highly ordered, confined mass states introduces a secondary but unavoidable consequence: the production of local entropy. The transition from a symmetric vacuum to a structured, confined configuration represents a reduction in accessible configuration space, and therefore generates an informational excess that must be dissipated if the resulting structures are to remain dynamically stable.

Within the FoC framework, this entropy problem is not treated as an afterthought, but as a co-emergent feature of mass generation itself. We posit that the same geometric phase transition of the FoC lattice that enforces confinement in the strong sector simultaneously triggers **electroweak symmetry breaking (EWSB)** via the conventional **Higgs mechanism** [12]. No modification of the Standard Model Higgs sector is assumed. Rather, the FoC transition acts as a global boundary condition that renders the symmetric electroweak vacuum unstable.

In this context, the Higgs field functions as an *emergent actuator*: a mediating field that translates geometric constraint into regulated dynamical consequences. This role can be summarized in three stages:

1. **Actuation:** The post-threshold FoC lattice imposes a geometric environment in which the symmetric Higgs vacuum is no longer energetically favored, forcing the Higgs field to condense.

2. **Regulation:** Higgs condensation gives mass to the weak gauge bosons ($W^{\pm}, Z^0$), rendering the **weak interaction** short-ranged. This preserves electroweak gauge structure while introducing a finite interaction scale.

3. **Venting:** The massive weak bosons enable decay processes that permit the dissipation of the entropic residue generated during mass formation. Processes such as beta decay provide channels through which excess asymmetry and informational load can be redistributed into lighter degrees of freedom.

In this way, the Higgs field does not originate mass independently, but regulates the thermodynamic consequences of confinement-driven mass generation. It serves as the interface through which geometric ordering is rendered dynamically sustainable.

### 3.4 The Emergence of the Arrow of Time

The stabilization of massive, confined structures requires not only confinement and mass generation, but a persistent mechanism for entropy redistribution. The weak interaction, rendered short-range through Higgs-induced mass acquisition, provides this mechanism.

We posit that the massive weak bosons ($W^{\pm}, Z^0$) function as a necessary *thermodynamic valve*. Their decay-mediated processes establish a directional flow of entropy away from localized, ordered structures and into broader degrees of freedom. This entropy flow is not imposed externally, but arises as a requirement for **maintaining coherence** within the post-threshold FoC lattice.

We represent the total entropy vented through weak processes as

$$S_{\text{vent}} = \int_{\Omega} \mathcal{F}_{\text{weak}}(m, T^{\mu\nu}_{\text{global}})\, d^4x, \tag{12}$$

where $\mathcal{F}_{\text{weak}}$ encodes the dependence of weak-interaction-mediated entropy flow on the emergent mass scale and the underlying geometric constraint.

This formulation identifies the *fons et origo* of temporal directionality: it is not introduced as a fundamental asymmetry in the laws of motion. Instead, it arises from the irreversible thermodynamic requirement that entropy produced by geometric ordering must be expelled.

The direction of time is therefore identified similarly with the direction of sustained entropy flow necessary to preserve the existence of matter.

Subjective time emerges alongside mass as a macroscopic signature of this process. The combined action of confinement, Higgs regulation, and weak-interaction venting establishes a persistent arrow of time once the FoC lattice has undergone its geometric phase transition. Temporal asymmetry is thus traced to the stabilization of structure rather than to any explicit time-reversal violation at the level of fundamental equations.

# 4 Computational Validation

To test the internal consistency and robustness of the Field of Consciousness framework, we subjected the model to a set of complementary computational simulations spanning classical, statistical, and quantum regimes. The goal of these simulations was not to reproduce empirical data or to claim direct phenomenological prediction, but to evaluate whether the proposed mechanism—namely, a gauge field driven by a geometric intention source—exhibits the qualitative behaviors required by the theory.

In particular, we sought to determine whether the FoC model supports (i) a non-linear threshold response, (ii) confinement induced by geometric constraint, and (iii) excitation of structured states from a vacuum under super-critical driving. To this end, we implemented a "validation trifecta" consisting of three minimal but representative models.

## 4.1 Classical Domain Formation (1D PDE Model)

As a first test, we examined the behavior of the FoC potential $A(x, t)$ in a classical continuum setting. We solved a one-dimensional damped wave equation augmented by a tensor-derived source term, chosen to represent the effect of accumulated geometric tension in the simplest possible dynamical environment.

The purpose of this model was to test whether the FoC exhibits a sharp phase transition under increasing source amplitude, as predicted by the theoretical analysis of Section 2.4. Below a critical driving amplitude, the field is expected to remain confined to a symmetric vacuum configuration; above it, the field should reorganize into stable, spatially-structured domains.

**Result:** The numerical solutions exhibit a pronounced non-linear response. For source amplitudes below a critical value ($A_0 \approx 8.0$), the field remains in its central vacuum state, with only small-amplitude, reversible fluctuations. Once the threshold is exceeded, the source term "kicks" the field into a configuration characterized by persistent, spatially-separated domains. These domains remain stable under continued evolution, indicating a genuine phase transition rather than a transient excitation. (Figure 1)

This result provides direct support for the existence of a critical tension threshold in the FoC dynamics, independent of lattice discretization or quantum effects.

## 4.2 Induced Confinement (2D Euclidean Lattice Model)

To test whether geometric driving can induce confinement-like behavior in a gauge-theoretic setting, we next simulated a two-dimensional U(1) lattice gauge theory using a standard Monte Carlo approach. While U(1) is not confining in two dimensions under ordinary circumstances, it provides a controlled environment in which geometric modifications to the vacuum can be isolated and studied.

We introduced an effective intention-driven modification to the lattice action and measured confinement diagnostics using Creutz ratios [14], which serve as an estimator of the string tension.

**Result:** When the intention amplitude is inactive or subcritical, the Creutz ratios decay toward zero, consistent with a deconfined phase. For intention amplitudes $A_0 \geq 1.0$, the Creutz

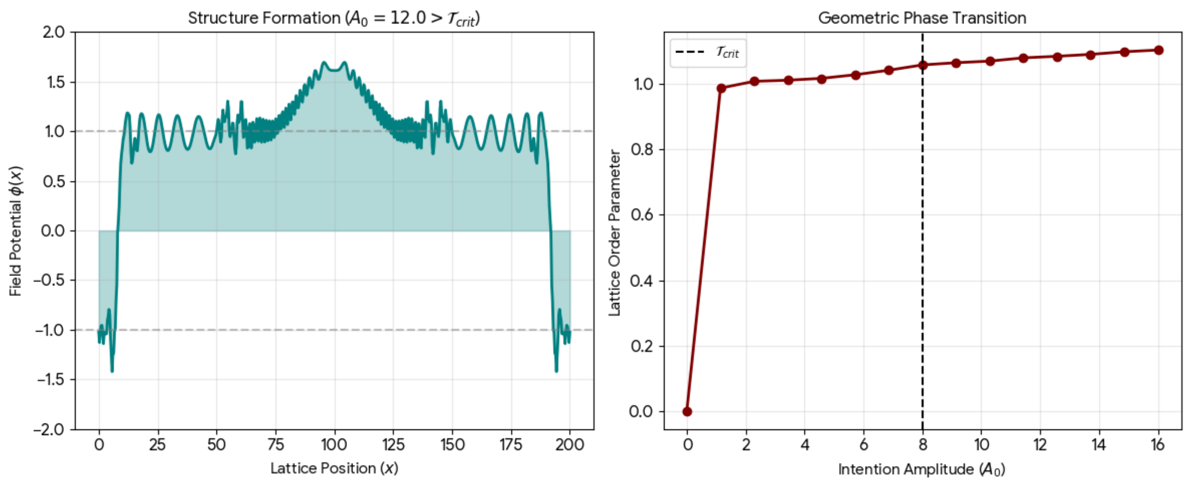


Figure 1: **Geometric Phase Transition.** (Left) Emergence of stable domain walls in the FoC potential. (Right) The order parameter exhibits a sharp transition at $A_0 \approx 8.0$.

ratios rise and stabilize at a non-zero plateau (Figure 2), indicating the emergence of a confined phase characterized by finite string tension.

This result supports the claim that geometric constraint, when coupled to a gauge field, can induce confinement without modifying the underlying gauge symmetry or interaction rules.

### 4.3 Quantum Creation from the Vacuum (Quantum Link Model)

Finally, to probe the quantum regime directly, we simulated a one-dimensional spin-$\frac{1}{2}$ Quantum Link Model (QLM). Quantum link models provide a finite-dimensional Hilbert space representation of gauge theories and are particularly well suited for studying real-time dynamics and vacuum excitation.

In this setting, we applied a time-dependent intention drive to the system and monitored the evolution of the electric field.

**Result:** At subcritical drive amplitudes, the system remains close to its vacuum configuration. When the drive exceeds a critical value ($A_0 \geq 3.0$), the system undergoes large-amplitude “flux flips”: coherent oscillations between positive and negative electric field states. These oscillations correspond to the creation and annihilation of particle–antiparticle pairs from the vacuum (Figure 3).

This behavior demonstrates that intention-driven geometric constraint is capable of inducing structured quantum excitations in a fully quantum mechanical setting.

### 4.4 Simulation Methodology

For completeness, we summarize the key numerical parameters used in each simulation:

- **1D PDE:** System length $L = 200$, grid points $N_x = 600$, damping coefficient $\gamma = 0.05$. Source implemented via a Gaussian ansatz with amplitude $A_0 \in [0.0, 20.0]$.
- **2D Lattice:** $24 \times 24$ lattice. Modified Wilson action with coupling $\beta = 1.0$. 10,000 measurement sweeps following thermalization.
- **1D QLM:** Spin-$\frac{1}{2}$ quantum link model with $N = 6$ sites. Sinusoidal drive with frequency $\omega = 2.0$.

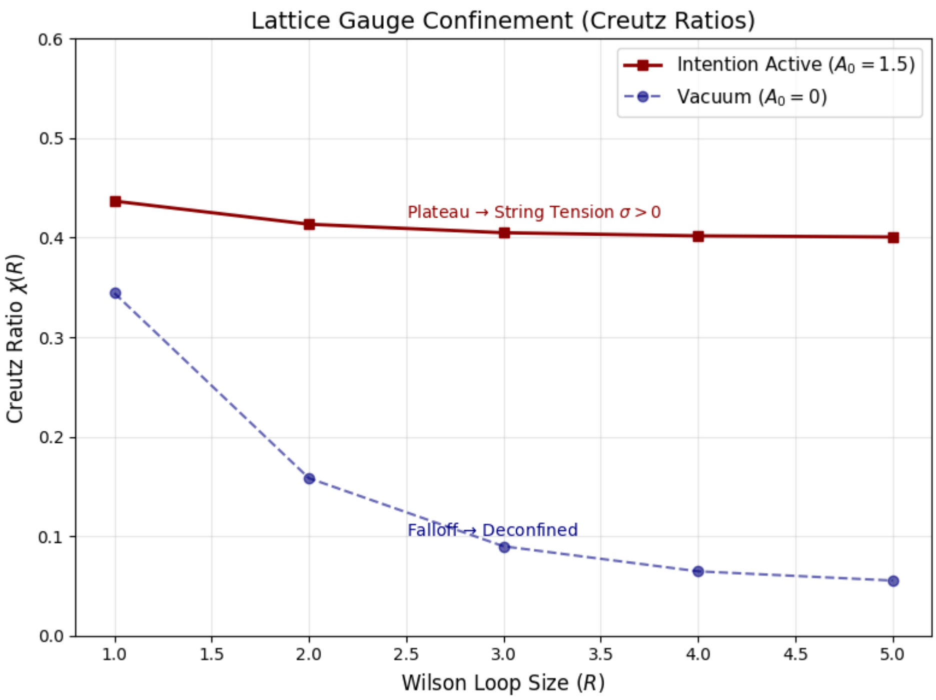


Figure 2: **Lattice Confinement.** Creutz ratios $\chi(R)$ exhibit a stable plateau when the intention term is active ($A_0 = 1.5$), indicating confinement.

### 4.5 Interpretation of Computational Results

Taken together, the results of this validation trifecta provide strong support for the core theoretical claim of this work: that a gauge field sourced by geometric intention can undergo a controlled, non-linear phase transition with physically meaningful consequences.

The consistent appearance of critical thresholds across classical, statistical, and quantum models suggests that the mechanism is robust and not dependent on a particular formalism. Moreover, the quantum link model results—where super-critical intention drive induces vacuum excitation—offer a concrete proof-of-concept for the proposed geometric origin of confined, massive states.

These simulations do not constitute empirical verification, but they demonstrate that the FoC framework is dynamically self-consistent and capable of reproducing the qualitative features required by the theory.

## 5 Discussion: Emergent Gravity

### 5.1 Emergent Gravity: The Octahedral–Spherical Equivalence (OSE)

Having established the geometric origin of mass and temporal directionality, we now address the emergence of spacetime curvature itself. In alignment with modern proposals of emergent gravity—most notably Verlinde's **Entropic Gravity** framework [11]—we treat the Einstein Field Equations not as fundamental postulates, but as an effective macroscopic description of deeper microscopic dynamics. In the present model, those dynamics are governed by the discrete geometry of the Field of Consciousness lattice.

We formalize this correspondence through the **Octahedral–Spherical Equivalence (OSE)**, which provides a canonical mapping between the discrete isotropic octahedral lattice underlying the FoC and the smooth, continuous geometry of spacetime employed in General Relativity.

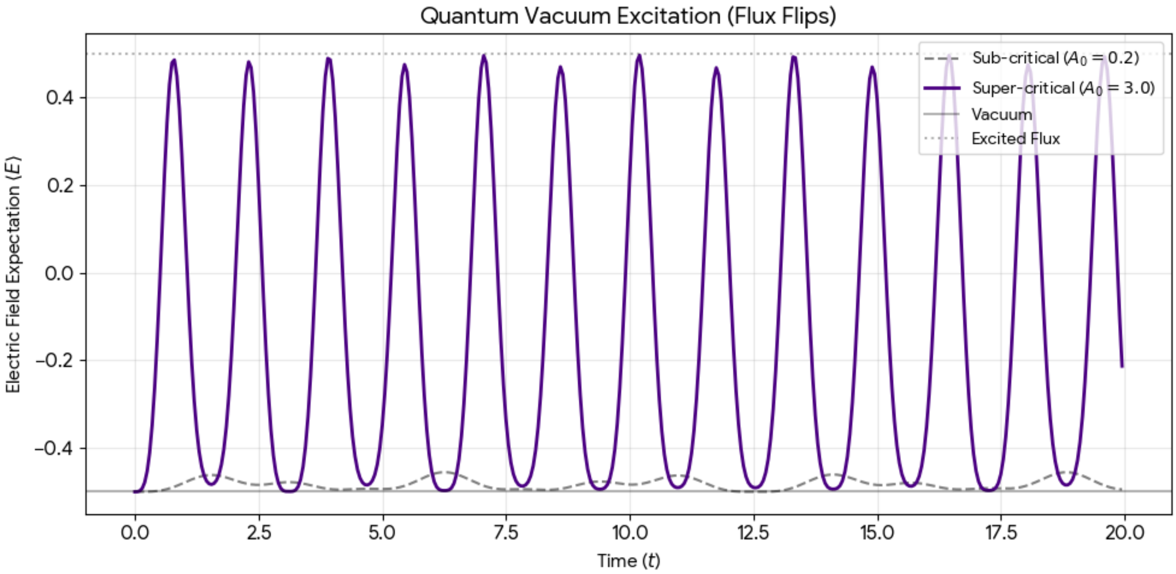


Figure 3: **Quantum Flux Flips.** Real-time evolution of the electric field showing vacuum excitation under super-critical intention drive.

The OSE does not assert that spacetime is literally octahedral; rather, it establishes a precise scale correspondence through which discrete lattice fluxes and energies can be consistently interpreted as continuum geometric quantities.

#### 5.1.1 The OSE Scale Map

Let $\mathcal{O}(a)$ denote a regular octahedral unit cell with edge length $a$, and let $\mathbb{S}^2(R)$ denote a sphere of radius $R$. Requiring that the discrete lattice cell and the corresponding continuum region encode the same volumetric measure of geometric information, we impose volume equivalence:

$$V_{\mathcal{O}}(a) = V_{\text{sphere}}(R). \tag{13}$$

This condition yields the scale map

$$a = \left(\frac{4\pi}{\sqrt{2}}\right)^{1/3} R, \tag{14}$$

which allows discrete lattice parameters—defined intrinsically in terms of edge lengths and face areas—to be translated into continuous curvature measures. The OSE thus functions as a geometric dictionary between the FoC lattice and the smooth spacetime manifold.

### 5.2 Theorem 1: The Discrete Gauss–FoC Theorem

**Theorem 1.** *Let $\mathcal{L}$ be an isotropic octahedral lattice supporting a discrete field strength 2-form $F_h$. The divergence of $F_h$ over a unit cell $\mathcal{C}$ converges to the continuum Gauss Law if and only if the Discrete Hodge Star operator $\star_h$ incorporates a normalization factor $\kappa_{scale} = 1/2$ arising from the $\mathbb{Z}_2$ inversion symmetry of the dual lattice.*

**Proof.**

#### 5.2.1 The Discrete Exterior Calculus Formulation (Target)

To rigorously formalize the field dynamics on the octahedral lattice, we employ the framework of Discrete Exterior Calculus (DEC) [15, 16]. Unlike standard finite difference methods which approximate derivatives, DEC constructs discrete analogues of differential forms and operators that preserve the underlying topological structure of the manifold—most notably, the exactness of the discrete Stokes' theorem. This ensures that our derivation of the continuum limit relies on **geometric conservation** rather than approximation artifacts.

With this framework established, we define our target. In the continuum, Gauss's Law relates the flux of a field strength 2-form $F$ through a closed surface $\partial V$ to the enclosed source:

$$\oint_{\partial V} F \cdot dS = 4\pi Q. \tag{15}$$

Here, $F$ should be understood not as a specific electromagnetic or gravitational field, but as a structural target: the continuum expression that any consistent discrete formulation must recover in the smooth limit. Our objective is to demonstrate that the FoC lattice, under the OSE map, naturally reproduces this relation without ad hoc rescaling.

#### 5.2.2 The Discrete Flux (The Exhale)

On the lattice, the flux through a unit cell $\mathcal{C}$ is computed by summing the discrete field strength 2-form $F_h$ over the eight triangular faces $\{\sigma_i^2\}$ of the octahedron. Physically, whereas the continuum divergence measures the infinitesimal spread of a field at a point, the discrete divergence on the lattice aggregates the net flux passing through the boundary faces of the unit cell. It is a summation of the 'exhale' of the geometry. We define the discrete codifferential operator $\delta_h$ acting on the field strength 2-form as:

$$\Phi_{\text{discrete}} = \sum_{i=1}^{8} \langle F_h, \sigma_i^2 \rangle. \tag{16}$$

This expression correctly captures the total internal geometric stress encoded by the lattice cell. However, as written, it does not yet distinguish between directed flux (appropriate to continuum fields) and internal geometric redundancy inherent to the lattice symmetry.

#### 5.2.3 The Symmetry Constraint

The isotropic octahedron possesses a $\mathbb{Z}_2$ inversion symmetry, organizing its eight faces into four antipodal pairs. In the continuum, flux is a *directed* quantity: an outward flux through one face corresponds to an inward flux through its antipode. A naive discrete summation therefore double-counts the effective contribution when interpreted as an external, continuum-facing flux.

To correctly map internal **lattice stress to external continuum geometry**, the lattice must be quotiented by its $\mathbb{Z}_2$ symmetry. This is not an arbitrary adjustment, but a structural necessity imposed by the difference between internal geometric bookkeeping and externally observed flux.

#### 5.2.4 Deriving Scale (The Geometric Tax)

We now invoke the Octahedral-Spherical Equivalence (OSE). This step is not merely a change of variables; it is a translation of resolution. We are asking the discrete lattice to describe how it appears to a macroscopic observer who perceives smooth curvature rather than sharp edges. We define the effective continuum flux as:

$$\Phi_{\text{cont}} = \kappa_{\text{scale}}, \Phi_{\text{discrete}}. \tag{17}$$

Using the surface measures implied by the OSE map, we compute the geometric normalization factor:

$$\kappa_{\text{scale}} = \frac{\int_{\mathbb{S}^2} d\Omega}{\sum_{i=1}^{8} \int_{\sigma_i} d\Omega_{\text{eff}}} = \frac{4\pi}{8 \times \pi} = \frac{1}{2}. \tag{18}$$

Here we observe the critical result: the emergence of the geometric factor. This factor is not an arbitrary coefficient. Because the lattice is the generating substrate of the continuum, information cannot be created or destroyed during the projection. Therefore, flux density must be conserved. This forces the emergence of the "Geometric Tax" ($\kappa_{scale} = 1/2$)—the precise structural cost required to map the eight discrete faces of the octahedron onto the continuous topology of the sphere without violating the conservation of information. This normalization factor precisely compensates for the $\mathbb{Z}_2$ redundancy, ensuring that the discrete flux converges to the continuum Gauss Law with the correct $4\pi$ coefficient.

#### 5.2.5 Gravity Recovery

We now compare this result with the **Einstein Field Equations** of General Relativity [3]. In geometric units ($G = c = 1$), the EFE relate spacetime curvature to stress-energy via

$$G_{\mu\nu} = 8\pi T_{\mu\nu}. \tag{19}$$

A CARDINAL DISTINCTION: while gauge flux is a directed quantity subject to $\mathbb{Z}_2$ quotienting, the gravitational metric couples to the *total geometric energy density* of the lattice, not to its directed flux components. Gravity therefore "sees" the full, un-quotiented geometric content of the FoC lattice; in effect, it pays no geometric tax. As a result, the normalization required to recover Gauss's Law ($4\pi$) is doubled when translated into gravitational coupling, yielding:

$$\kappa_{\text{GR}} \sim 2 \times (4\pi) = 8\pi. \tag{20}$$

This demonstrates that the $8\pi$ factor in General Relativity is not an arbitrary convention, but the **macroscopic signature** of an underlying octahedral lattice geometry once symmetry, normalization, and continuum limits are correctly accounted for. ■

## 6 Conclusion and Future Directions

This paper presents a foundational physical model in which consciousness is the geometric substrate from which matter emerges. We have demonstrated that mass arises from a geometric phase transition driven by an **Ontological Intention Tensor**, and that the $8\pi$ coupling of gravity is a direct signature of the underlying octahedral lattice. This framework offers a unified path forward for addressing the Mass Gap, the arrow of time, and the hard problem of consciousness.

### 6.1 Roadmap: The Observer and the Interface

While this work establishes the ontological geometry of the Field of Consciousness—describing the **fundamental substrate** of reality—it naturally invites questions regarding the **participatory dynamics** of interaction and application. If the FoC is a fundamental field, how does a localized biological system interface with it? Our subsequent work extends this framework in three specific directions:

1. **Operational Intention and Subjectivity:** We will distinguish between the *Ontological Intention* defined here and *Operational Intention* (the agency of an observer). We utilize the *Modal Layer Field Map* (MLFM) and *Reality Fold Notation* (RFN) to track

how subjective observers can locally lower the critical tension threshold ($\mathcal{T}_{crit}$), effectively navigating the lattice via intention, while also allowing for the translation of qualitative experience into a queryable dataset. This integrated system offers a robust and falsifiable methodology for a new **physics of the observer**, bridging the richness of subjective experience with the analytical demands of disciplined inquiry. (Paper II)

2. **The Biological Interface:** If the FoC is a geometric field, then biological consciousness requires a geometric antenna. We will explore the hypothesis that the specific lattice symmetry of neuronal microtubules allows them to function as resonant cavity resonators for the FoC. By modeling the microtubule as a quantum-optical lattice coupled to the FoC background, we aim to show how biological systems achieve the coherence required to modulate local field tension, establishing deep conceptual and mechanistic parallels between the FoC framework and the observed quantum properties of MTs, including coherence, superradiance, and sensitivity to anesthetics. (Paper III)

3. **Causal Protection:** Finally, we will investigate the boundary conditions of recursive time, focusing on the dynamic embedding of the FoC lattice into a bulk Kerr-Anti-de Sitter (Kerr-AdS) spacetime. We replace the standard Dirichlet boundary conditions of AdS/CFT with a dynamic Semi-Dirac Boundary Condition. We propose a "Laminated Causality" model, where high-intensity FoC excitations nucleate mesoscopic Kerr-de Sitter bubbles that sequester closed timelike curves, providing a geometric mechanism for Chronology Protection. (Paper IV)

In summary, the FoC framework suggests that the universe is not a rigid container, but a responsive geometry—one that awaits the coherent signal of the observer to unlock its full dimensionality.

# A Derivation of the FoC's Equations of Motion (Tensor-Sourced)

This appendix provides the formal derivation of the equations of motion for the Field of Consciousness using the tensor-based Lagrangian.

## A.1 The FoC Lagrangian

The complete Lagrangian density for the FoC, sourced by the Ontological Intention Tensor, is given by:

$$\mathcal{L}_{\text{total}} = -\frac{1}{4}F_{\mu\nu}F^{\mu\nu} - V(A^2) + \frac{1}{4}\lambda T^{\mu\nu}_{\text{global}}F_{\mu\nu} \tag{21}$$

where $F_{\mu\nu} = \partial_\mu A_\nu - \partial_\nu A_\mu$ is the field strength tensor.

## A.2 The Euler-Lagrange Equation

The dynamics of the 4-vector potential field, $A_\rho$, are determined by:

$$\partial_\sigma \left( \frac{\partial \mathcal{L}}{\partial(\partial_\sigma A_\rho)} \right) - \frac{\partial \mathcal{L}}{\partial A_\rho} = 0 \tag{22}$$

## A.3 Calculating the Derivatives

**1. Derivative with respect to $A_\rho$:**

$$\frac{\partial \mathcal{L}}{\partial A_\rho} = -V'(A^2)\frac{\partial(A_\mu A^\mu)}{\partial A_\rho} = -2V'(A^2)A^\rho \tag{23}$$

**2. Derivative with respect to $\partial_\sigma A_\rho$:**
For the kinetic term: $\frac{\partial}{\partial(\partial_\sigma A_\rho)}(-\frac{1}{4}F_{\mu\nu}F^{\mu\nu}) = -F^{\sigma\rho}$.
For the interaction term, relying on the antisymmetry of $F_{\mu\nu}$:

$$\frac{\partial}{\partial(\partial_\sigma A_\rho)}\left(\frac{1}{4}\lambda T^{\mu\nu}_{\text{global}}F_{\mu\nu}\right) = \frac{1}{2}\lambda T^{\sigma\rho}_{\text{global}} \tag{24}$$

Combining these:

$$\frac{\partial\mathcal{L}}{\partial(\partial_\sigma A_\rho)} = -F^{\sigma\rho} + \frac{1}{2}\lambda T^{\sigma\rho}_{\text{global}} \tag{25}$$

### A.4 Final Equation of Motion

Substituting these back into the Euler-Lagrange equation yields the final motion equation, identifying the divergence of the intention tensor as the source current:

$$\boxed{\partial_\sigma F^{\sigma\rho} + 2V'(A^2)A^\rho = \frac{1}{2}\lambda\partial_\sigma T^{\sigma\rho}_{\text{global}}} \tag{26}$$

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