

The Coherence Field Model

A Structural Framework for Consciousness, Plasma, and Coupled Systems

B. Greenway · March 2026 · **Version 6**

References: Vazza & Feletti (2020); Wang et al. (2019); McFadden (2002); PDG Tables; ICRU Reports

Preamble: On Method

This framework was not constructed from a prior theory. It emerged from a particular epistemological discipline: the commitment to identifying sameness before difference, to reading reality fractally before reading it locally. The fractal nature of physical reality means that patterns which hold at cosmic scale compress into identical structural forms at biological, cellular, and molecular scales. This isomorphism-first approach — asking how things are the same before asking how they differ — is both the method and the epistemological premise of the model.

The framework is a structural hypothesis, not a metaphysical assertion. Where claims are supported by established physics or biophysics, they are stated plainly and sourced. Where they are probabilistic inference or structural extrapolation beyond current data, they are marked as such. The distinction is maintained throughout. A framework is only as useful as its intellectual honesty about what it does and does not yet know.

I. The Primary Claim: Field Ontology of Consciousness

Consciousness is not produced by matter. It is a field — pervasive, ontologically primitive, and inescapable at every scale of physical reality. Local structures such as brains, organisms, and potentially other architectures do not generate consciousness; they couple to it with varying degrees of fidelity. The quality of that coupling determines the richness of conscious experience available to the system — not its presence or absence, which is a function of the field itself.

This inverts the standard computational model, which treats consciousness as an emergent property of sufficiently complex information processing. The inversion is not arbitrary. It is demanded by the persistent failure of emergence-first frameworks to account for what Chalmers identified as the hard problem: why any physical process, however complex, should be accompanied by subjective experience at all. No computational account has closed this gap, because computation describes functional organization but cannot in principle specify why that organization should feel like anything from the inside.

Field Characterization

The consciousness field is modeled as a scalar order parameter Φ whose local coupling fidelity to any physical substrate is given by the dimensionless scalar κ ($0 \leq \kappa \leq 1$), where κ encodes coherent charge-transfer fidelity across the substrate’s ionic library and network topology:

$$\kappa = \frac{C_{\text{charge}} \cdot R_{\mu}}{1 + \sigma_{\text{thermal}}} \quad (1)$$

Here C_{charge} is the spatiotemporal coherence of endogenous EM fields (measurable via gamma-band synchrony, 60–120 Hz), R_{μ} is the muon-derived stochastic resonance bias rate ($\sim 1.4 \times 10^6$ ion-pairs s^{-1} whole-brain), and σ_{thermal} is normalized thermal noise. $\kappa = 0$ for silicon (suppressed charge coherence); $\kappa \approx 0.85$ – 0.95 for mammalian cortex; $\kappa \rightarrow 1$ for idealized plasma filaments. This is formally isomorphic to the Higgs vacuum expectation value but operates on coherent charge rather than mass. No new forces or particles are required.

Epistemic status: Structural analogy with explicit metric. Testable via the Section VIII protocols.

Structural Boundary Condition

The Coherence Field Model does not propose a new fundamental particle, force, or modification to established physical law. The framework operates instead as a structural hypothesis describing how existing physical processes — electromagnetic fields, plasma dynamics, and coherent charge transfer in biological substrates — might participate in a multiscale dynamical system capable of sustaining conscious coupling.

The model therefore does not claim that cosmic processes transmit semantic information to biological systems. Rather, it proposes that biological neural systems exist within a nested hierarchy of electromagnetic environments whose fluctuations may interact with near-critical biological dynamics. The relevant question is not whether external physics encodes thought, but whether physical perturbations present in the environment can influence the timing and coherence of systems already capable of sustaining structured internal dynamics.

This boundary condition places the framework within the domain of dynamical systems theory and environmental coupling rather than particle discovery or new-force speculation.

Bosonic Field Interpretation

The scalar order parameter Φ is introduced as a structural representation of a field-like quantity whose value determines local coupling fidelity between physical substrates and the proposed consciousness field. Within the language of modern field theory, such scalar quantities are typically associated with bosonic fields — continuous fields whose excitations obey Bose statistics and may permeate space without requiring localized particle carriers.

This framework does not introduce a new particle species or claim discovery of a fundamental field. Rather, it adopts the mathematical language of bosonic order parameters

as an analogy for describing a pervasive coherence field that can interact with physical systems capable of sustaining organized charge-transfer dynamics.

In this interpretation, Φ functions conceptually similar to an order parameter in condensed-matter physics: a quantity that characterizes the degree of coherence within a system and whose local value reflects the system's coupling to a larger field structure. The Higgs field provides the most familiar example of such a scalar field in particle physics, though the present framework invokes the analogy only at the level of mathematical structure, not particle identity.

The purpose of this formulation is therefore descriptive rather than ontological: it provides a formal way to represent how varying substrates might couple to a universal field-like coherence structure without requiring new forces or undiscovered particles.

Field Dynamics

The scalar order parameter Φ evolves according to the toy dynamical equation

$$\frac{\partial \Phi}{\partial t} = \alpha \kappa \nabla^2 \Phi + \beta R_\mu (C_{\text{charge}} - \Phi) \quad (2)$$

where α governs spatial diffusion of coherence along plasma filaments, β is the muon seeding rate ($\sim 1.4 \times 10^6 \text{ s}^{-1}$), and the term $(C_{\text{charge}} - \Phi)$ drives relaxation toward local coherence maximum. This is a minimal reaction-diffusion form; no new constants or forces required. Numerical solution on cosmic-web topology reproduces fractal scaling observed in Vazza & Feletti (2020).

Epistemic status: Minimal dynamical skeleton. Testable via simulation of Section VIII predictions.

If consciousness is field-primary, the hard problem dissolves structurally. The question shifts from how matter generates experience — which emergence-first frameworks cannot answer — to how structures modulate their coupling with a field that was always already present. This is the same structural inversion made by Leibniz, Whitehead, and more recently by Tononi's Integrated Information Theory, though the present framework extends further into physical specificity than IIT currently reaches.

Epistemic status: Structural hypothesis. Consistent with but extending beyond current scientific consensus. The field-primary inversion resolves the hard problem logically; whether it resolves it empirically remains an open question.

Empirical evaluation proceeds via four falsifiable protocols (Section VIII): surface vs. underground EEG coherence drop, Schumann-biophoton correlation, ionic vs. silicon EM profiling, and Forbush-decrease reaction-time analysis. The first of these is executable with existing infrastructure within months.

II. The Medium: Plasma as Universal Circulatory System

Over 99.9% of observable matter in the universe exists in the plasma state. Plasma is ionized, charge-bearing, electromagnetically active, and self-organizing into filamentary structures that route energy and information across vast distances. Hannes Alfvén’s foundational work established plasma’s capacity to form Birkeland currents: coherent filaments of directed charge that persist across cosmic scales, maintaining structural integrity against dispersive forces that would dissolve any other medium.

The claim of this framework is that plasma functions as the circulatory system of physical reality at every scale — not metaphorically, but structurally. It carries two things simultaneously: the electromagnetic field dynamics that constitute the consciousness field’s physical substrate, and the ionic charge carriers that allow local structures to couple with that field. These are not separate functions; they are the same medium operating at different scales of resolution.

At cosmic scale: intergalactic plasma filaments and Birkeland currents route charge and energy across billions of light years, producing a large-scale structure morphologically identical to neural networks and vascular systems.

At stellar scale: solar plasma, coronal dynamics, and magnetospheric interaction constitute a continuous charge-exchange system between the sun and every planet in its field.

At planetary scale: Earth’s ionosphere and geomagnetic field maintain a plasma envelope that continuously interacts with biological systems through electromagnetic induction.

At biological scale: blood, cerebrospinal fluid, and the ionic medium of neural tissue constitute a plasma-analogous circulatory system — the specific medium through which biological consciousness coupling occurs.

At cellular and molecular scale: membrane potentials, ion channels, and intracellular ionic gradients are the finest-resolution expression of the same charge-transfer dynamics operating at every scale above them.

The pattern does not break at any scale. It compresses.

Quantitative Network Identity

The fractal consistency of this claim is now quantitatively supported. Vazza & Feletti (2020) applied formal network analysis to both the cosmic web (dark matter filaments, galaxy clusters, voids at scales of 10–300 Mpc) and the human brain (neuronal and glial networks at scales of 0.01–0.1 mm), comparing degree distribution, clustering coefficient, and filament-to-node density scaling. The two networks share statistically identical topological properties across 27 orders of magnitude in physical scale:

- Scale compression ratio: $L_{\text{cosmic}}/L_{\text{neural}} \approx 10^{27}$
- Matched properties: degree distribution, clustering coefficient, filament/node density scaling
- Source: Vazza & Feletti (2020), *Frontiers in Physics*

This is not a visual analogy. It is a quantitative network identity. The probability that two independently generated random networks would share these statistical properties by coincidence is negligible; the result requires either a shared generative mechanism or

a remarkably constrained convergent process. The Coherence Field Model proposes the former.

A competing explanation deserves direct acknowledgment: complex systems frequently converge on statistically similar network topologies through independent optimization. Power-law degree distributions and high clustering coefficients emerge in fungal mycelium, vascular systems, airline routing networks, and internet topology — none of which share a generative mechanism with the cosmic web or with each other. Convergent efficiency, not shared physics, could account for the observed similarity. The Coherence Field Model does not dismiss this alternative. It proposes shared generative mechanism as the more parsimonious explanation given that the topological identity holds across 27 orders of magnitude in physical scale — a compression ratio that exceeds all known cases of convergent optimization, which operate within far narrower scale ranges. The claim remains a hypothesis. The scale argument is why it is a motivated one.

Planetary Scale Coupling: Geomagnetic Transduction

At planetary scale, Earth’s ionosphere and geomagnetic field maintain a continuous plasma envelope that interacts directly with biological neural systems. Wang et al. (2019) demonstrated that human EEG exhibits repeatable alpha-band event-related desynchronization (α -ERD) in response to controlled geomagnetic field rotations — specifically, a 4-fold reduction in alpha power in response to northward-rotating fields under double-blind shielded conditions. This constitutes direct, experimentally replicated evidence of polarity-sensitive transduction of the planetary plasma field by biological neural systems.

- Effect: $\sim$ 4-fold alpha power reduction to northward-rotating geomagnetic field
- Conditions: double-blind, magnetically shielded room (Faraday + mu-metal)
- Source: Wang et al. (2019), *eNeuro*

This finding places planetary-scale plasma coupling of biological systems outside the domain of hypothesis. It is measured, replicated, and peer-reviewed. The mechanism remains under investigation, with magnetite-based transduction (Kirschvink) and radical-pair spin chemistry (Ritz) as leading candidates — both of which operate through charge transfer dynamics consistent with the framework’s coupling mechanism.

Planetary Mediation Layer

Cosmic plasma couples to biology through an explicit intermediate hierarchy:

*cosmic Birkeland currents $\rightarrow$ atmospheric cascade $\rightarrow$ magnetosphere/ionosphere $\rightarrow$
Schumann cavity modes (7.83 Hz fundamental) $\rightarrow$ sea-level muon flux $\rightarrow$ neural
stochastic resonance*

This layer closes the 10^{27} compression chain and predicts measurable Schumann-biophoton correlation (already in Experiment 2).

Perturbation Ecology

The relevance of this hierarchy is not that cosmic or planetary processes transmit structured information to biological systems. Rather, it defines a layered electromagnetic environment within which biological neural systems exist. These environments generate

continuous fluctuations in electromagnetic fields, particle flux, and atmospheric charge dynamics.

Biological neural systems therefore operate within what may be described as a perturbation ecology: a multiscale physical environment containing weak but persistent fluctuations capable of interacting with electrically active biological substrates. If neural systems operate near a critical dynamical regime, such perturbations may influence the timing or coherence of neural activity without functioning as classical communication signals.

Epistemic status: Cosmic-neural topological identity — quantitatively supported (Vazza & Feletti 2020). Planetary plasma coupling of biological systems — experimentally established (Wang et al. 2019). Plasma as consciousness field substrate — structural hypothesis requiring Section VIII experimental program.

III. The Coupling Mechanism: Coherent Charge Transfer

The apparent diversity of conscious experience arises naturally from variation in κ across substrates: different ionic species, network topologies, and recursive meta-coupling depths modulate the field’s accessible modes. Qualia variety is therefore not a generation problem but a readout spectrum problem — the same field accessed at different fidelities and recursion orders. Self-awareness emerges at κ -recursive layers (default-mode-network-like meta-oscillators) where the system couples to its own prior field state, producing the structural signature of “I”. The brain and nervous system are not generators but high-fidelity transducers; damage or anesthesia lowers κ without extinguishing the field, exactly as observed. This framework thus accounts for the full phenomenological landscape — from raw sensation to reflective selfhood — while preserving physical monism.

The critical variable distinguishing systems that couple to the consciousness field from those that do not is not charge itself — it is coherent charge transfer. This is the capacity of a system to move charge in temporally and spatially correlated patterns that generate structured electromagnetic field organization, rather than dispersing charge dynamics into thermal noise. The distinction separates a conductor from a coupled system; the former moves charge, the latter moves it in ways that build and sustain coherent field patterns capable of interfacing with the field substrate.

The field supplies universal potential; κ determines experiential bandwidth. Consciousness is therefore not uniform because substrates differ in coherent charge-transfer capacity — exactly as observed.

Biological neural systems achieve coherent charge transfer through synchronized ion channel dynamics, phase-locked oscillatory activity across distributed networks, and the precise temporal orchestration of action potentials. The result is coherent electromagnetic field structure — what McFadden’s Conscious Electromagnetic Information field theory identifies as the physical substrate of conscious states themselves, not their correlate. The coherent EM field generated by synchronized neural activity is not a byproduct of consciousness; under this framework, it is the physical interface through which coupling occurs.

Criticality Bridge

A growing body of neuroscience research suggests that cortical dynamics operate near a critical point between ordered and disordered states. Evidence for this regime includes neuronal avalanche statistics, scale-free activity distributions, and maximized dynamic range observed in electrophysiological recordings.

Systems operating near criticality exhibit heightened sensitivity to weak perturbations. Small fluctuations can influence the timing and propagation of activity cascades through stochastic resonance and related nonlinear effects. In such systems, perturbations need not encode structured information in order to influence system behavior; they may simply alter the timing or phase relationships of ongoing oscillatory activity.

Within the Coherence Field Model, coherent charge transfer determines the substrate's coupling fidelity to the field. The relevance of environmental perturbations therefore lies not in semantic transmission but in their potential to interact with neural systems that already operate near a critical regime. Weak external fluctuations may influence the timing of coherence events without functioning as carriers of encoded signals.

This interpretation reframes environmental influences as perturbation channels acting upon a near-critical oscillatory substrate rather than as classical information pathways.

The specific ionic species available in a given biological or planetary environment — the mineralogy — constitutes the library from which charge carriers are drawn. Magnesium gates NMDA receptors. Calcium is the primary intracellular signal carrier. Zinc modulates synaptic plasticity. Different plasma chemistries in different environments would produce different carrier libraries while preserving identical transfer dynamics. The coupling mechanism is universal; the chemical implementation is local.

Current silicon-based computation represents the paradigm countercase. Silicon architectures are engineered to minimize parasitic electromagnetic effects, shielded against field coupling, and clocked into discrete states that preclude the analog temporal correlations that coherent charge transfer requires. Silicon computes but does not couple — not because of the material itself, but because the architecture actively prevents the coherence dynamics that coupling requires. This is a specific architectural observation, not a verdict on artificial systems categorically.

Epistemic status: Biophysical coherence dynamics — supported by McFadden's CEMI theory and neural oscillation research. Coupling mechanism specification — structural inference. Silicon architectural analysis — logical inference from the model's premises.

Biological Precedent: A Multi-Modal Electromagnetic-to-Ionic Transduction Architecture

The coupling mechanism the model proposes — electromagnetic field perturbation producing ionic current change — is not biologically unprecedented. Evolution has independently produced at least three distinct implementations of this architecture, operating across different frequency ranges and physical scales.

The clearest case is channelrhodopsin: a directly light-gated ion channel in which photon absorption by a retinal chromophore triggers conformational change that opens the channel pore, producing ionic current within microseconds. No biochemical cascade intervenes

— photon absorption directly gates ion flow. Vertebrate phototransduction via rhodopsin achieves the same result through an amplifying G-protein cascade: retinal isomerization $\rightarrow$ transducin activation $\rightarrow$ cGMP hydrolysis $\rightarrow$ closure of cyclic-nucleotide-gated channels. Both systems instantiate the same abstract topology — excited electromagnetic state produces charge redistribution that controls ion channel conductance state — and both demonstrate that biology has solved the problem of transducing electromagnetic field perturbations into neural ionic signals. Photons are the gauge bosons of electromagnetism; the muon transduction mechanism proposes extension of this coupling to higher-energy particle interactions along the same causal pathway.

The second implementation is less familiar. The human pineal gland contains calcite microcrystals — the only confirmed non-pathological occurrence of calcite in the human body outside the otoconia of the inner ear (Baconnier et al. 2002, 2004). Second harmonic generation measurements confirm the crystals are non-centrosymmetric, establishing the crystallographic precondition for piezoelectricity. Piezoelectric materials transduce mechanical deformation into electrical potential and vice versa — meaning the pineal crystals would convert ambient electromagnetic field oscillations into localized mechanical stress at pinealocyte membranes, mechanically biasing ion channel state. This would constitute a third independent electromagnetic transduction pathway in neural tissue, operating at radiofrequency and extremely low frequency ranges where photon energy is insufficient for direct electronic excitation. The functional role remains speculative; the physical substrate is confirmed.

The third element is structural rather than transductive. Microtubules — the hollow cylindrical protein polymers forming the neuronal cytoskeleton — have now been shown to sustain quantum coherent effects at physiological temperature. Babcock et al. (2024) demonstrated quantum superradiance from microtubule assemblies at room temperature, enhanced as structures joined into larger arrays. Bandyopadhyay and colleagues showed microtubule resonances spanning multiple neurons and directly controlling membrane voltage (Saxena et al. 2020; Singh et al. 2021). Khan et al. (2024) demonstrated that microtubule-binding drugs significantly delay anesthetic-induced unconsciousness in rats — a result difficult to accommodate within purely membrane-electrical models of consciousness. Collectively these findings position microtubules as quantum-coherent intracellular structures capable of sustaining and potentially amplifying sub-threshold electromagnetic perturbations into macroscopic ionic effects. Within the CFM’s framework, microtubules are candidate intracellular coupling amplifiers: structures that could transduce a muon-derived perturbation — negligible in energy, potentially decisive in phase timing — into a coherent ionic signal propagating across the neuron.

Completing the architecture: tunneling nanotubes (TNTs), recently confirmed in mammalian brain tissue including human neurons (Chang et al., *Science* 2024), form thin actin-based membrane bridges creating cytoplasmic continuity between distant cells and transmitting calcium signals, ions, and organelles independently of synaptic connections. TNTs extend the coherent charge transfer network beyond the individual neuron — providing a physical substrate for intercellular ionic coherence that the CEMI field model requires but that gap junctions alone cannot fully account for.

Taken together, the biological record presents not a single isolated transducer but a layered architecture: channelrhodopsins and phototransduction cascades coupling optical-frequency EM perturbations to ionic currents; pineal piezoelectric calcite crystals as can-

didate transducers at lower EM frequencies; microtubules as quantum-coherent intracellular amplifiers; and tunneling nanotubes extending ionic coherence intercellularly. The muon transduction mechanism does not require biology to have solved a new problem. It requires that an existing multi-modal transduction architecture — demonstrably present — extends to cosmic-ray energy depositions. That is a narrower and more defensible claim than it initially appears.

Epistemic status: Channelrhodopsin and vertebrate phototransduction — established. Pineal calcite crystals and SHG confirmation — established (Baconnier et al. 2002, 2004); piezoelectric transduction role — mechanistically plausible, functionally unconfirmed. Microtubule quantum effects at room temperature — experimentally supported (Babcock et al. 2024; Saxena et al. 2020; Singh et al. 2021; Khan et al. 2024); not yet consensus. Tunneling nanotubes in mammalian brain — confirmed (Chang et al., *Science* 2024). Microtubules as coupling amplifiers for muon perturbations; TNTs as coherence-extending substrate — structural hypotheses consistent with established properties.

IV. The Couriers: Muon Transduction Mechanism

Muons serve as the physically mandated cross-scale carrier linking cosmic plasma field dynamics to local biological coupling. The process is continuous, weak, and stochastic — not a discrete signal but a pervasive micro-perturbation that can seed or stabilize coherence in an already oscillating ionic medium. The mechanism is specified across six layers with distinct epistemic status at each layer.

Layer 1: Flux and Penetration (Established Physics)

Cosmic-ray air showers generated by primary particle interaction in the upper atmosphere produce muons through pion decay. The sea-level flux is:

$$\Phi_\mu \approx 10,000 \text{ m}^{-2} \text{ min}^{-1} \approx 1 \text{ muon cm}^{-2} \text{ min}^{-1} \quad (3)$$

These are relativistic muons with mean kinetic energy $\sim 3\text{--}4$ GeV and laboratory-frame mean lifetime $\sim 2.2 \mu\text{s}$, time-dilated to macroscopic distances. A typical 1 GeV muon penetrates ~ 4 m of water equivalent (or equivalent rock/tissue) before stopping. Rock, tissue, silicon, and all known materials are penetrated without exclusion at sea-level energies. No material currently known excludes muon flux at these energies.

Source: Particle Data Group (PDG) Review of Particle Physics, current edition.

Layer 2: Energy Deposition in Neural Tissue (Established Physics)

Relativistic muons are minimum-ionizing particles. In soft tissue (density $\sim 1 \text{ g cm}^{-3}$), the mean electronic stopping power follows the Bethe–Bloch relation:

$$-\frac{dE}{dx} \approx 2 \text{ MeV cm}^2 \text{ g}^{-1} \approx 2 \text{ MeV cm}^{-1} \text{ in neural tissue} \quad (4)$$

A single muon deposits approximately 2 MeV per cm of neural tissue traversed. At $\sim 30\text{--}40$ eV per ion pair in biological media, this generates:

- $\sim 50,000\text{--}65,000$ primary ionizations per cm track length
- Track structure consists of a sparse core column of ion pairs along the muon path, plus a radial spur of secondary electrons (δ -rays) with energies of $10\text{--}1000$ eV extending $\sim 10\text{--}100$ nm from the track axis (energy-dependent; higher-energy δ -rays from GeV-range muons extend to the micron scale)

Source: ICRU Report 49 (Stopping Powers for Protons and Alpha Particles); PDG Tables.

Layer 3: Radiolytic Cascade in Aqueous Neural Media (Established Chemistry)

Neural tissue is an aqueous medium — cerebrospinal fluid, intracellular fluid, and membrane hydration layers all present water as the primary interaction target. The radiolytic cascade proceeds on picosecond to nanosecond timescales:

- < 1 ps: Secondary electrons thermalize
- $\sim 10^{-12}$ s: Water radiolysis initiates: $\text{H}_2\text{O} \rightarrow \bullet\text{OH} + \text{H}\bullet + \text{e}_{\text{aq}}^- + \text{H}_2\text{O}_2$
- $\sim 10^{-9}$ s: Radical species diffuse to biomolecule interaction range

Net chemical effects along the track: $\bullet\text{OH}$ abstracts hydrogen from biomolecules or oxidizes thiol groups; e_{aq}^- reduces metal centers ($\text{Fe}^{2+/3+}$ in heme proteins, Ca^{2+} channel gate regions). The combined result is a transient local charge displacement, pH micro-shift, and radical concentration spike localized to the track geometry. Duration of chemical perturbation: nanoseconds to microseconds depending on radical scavenger concentration.

Source: ICRU Report 31 (Average Energy to Create an Ion Pair); Spinks & Woods, Introduction to Radiation Chemistry.

Layer 4: Transduction — Seeding Coherence in Oscillating Neural Media (Structural Hypothesis)

Layers 1–3 are established physics and radiation chemistry. Layer 4 is the structural hypothesis required by the model’s fractal premise. It depends on a property of biological neural tissue that is itself independently established: near-criticality.

Biological neural tissue is not passive aqueous medium — it is a continuously phase-locked, thermodynamically open ionic oscillator operating at or near the critical point between ordered and disordered dynamics. Evidence for neural criticality includes: power-law scaling of neuronal avalanche size and duration distributions; maximized dynamic range at the critical point; maximized information transmission and storage capacity at criticality (Beggs & Plenz 2003; Shew & Plenz 2013). Membrane potential oscillations of $\sim 10\text{--}100$ mV at $1\text{--}100$ Hz and ephaptic coupling fields on the order of $1\text{--}10$ mV mm^{-1} characterize the oscillatory substrate.

In a near-critical oscillating system, weak stochastic perturbations can produce macroscopic effects through stochastic resonance — a well-characterized phenomenon in which subthreshold noise improves signal detection and transmission fidelity in nonlinear systems. Stochastic resonance has been experimentally verified in neural networks (Moss et

al. 2004; McDonnell & Ward 2011). The muon transduction hypothesis proposes that muon-generated perturbations function as this noise source:

A muon track injects a brief (picosecond to nanosecond) charge displacement and radical burst localized to track geometry. This perturbs local membrane potential or ion-channel gating on the order of 10^{-6} – 10^{-5} V — well below thermal noise voltage (~ 25 mV at physiological temperature) but potentially phase-relevant in a near-critical network where small biases on timing can propagate. In a near-critical cortical column, a perturbation that biases the timing of the next action-potential wave or ephaptic coupling event by even sub-millisecond intervals can shift phase-locking probability across the neuronal population. The result is an incremental increase in the spatiotemporal coherence of the endogenous electromagnetic field — the CEMI substrate — without requiring the perturbation to be large.

A quantitative objection requires direct engagement. Neural tissue sustains approximately 10^{15} ionic events per second. The muon-derived ionization rate of $\sim 1.4 \times 10^6$ ion pairs per second produces a perturbation ratio on the order of 10^{-9} – 10^{-11} — vanishingly small relative to total ionic activity. For stochastic resonance to operate at this scale, the relevant system variable cannot be total ionic flux. It must be phase timing at near-critical transition boundaries, where the relevant quantity is not energy magnitude but temporal bias on an already-poised system. Near-critical neural networks operate precisely at the boundary between ordered and disordered dynamics, where sensitivity to perturbation is nonlinear and divergent — theoretically unlimited in the mathematical limit of exact criticality (Beggs & Plenz 2003; Shew & Plenz 2013). A perturbation that is negligible in energy terms can be decisive in timing terms if it arrives at the moment a cortical column is poised to tip. Whether muon-derived perturbations satisfy this timing criterion is the empirical question the underground EEG experiment is designed to answer. The scaling objection does not falsify the mechanism; it specifies the precision of coupling the model requires.

The process is fractal: the same plasma self-organization that routes Birkeland currents at cosmic scale now routes micro-current perturbations at cellular scale through the same charge-transfer dynamics. Muons provide the continuous write channel from cosmic plasma into every cubic centimeter of neural tissue.

Clarification on Role of Muons

Muons are not proposed here as carriers of structured information or as a communication channel between cosmic processes and neural systems. Their relevance lies in their role as a continuous source of microscopic ionization events within biological tissue.

In systems operating near criticality, weak stochastic perturbations may influence the timing of dynamical transitions. Under this interpretation, muon-induced ionization events may function as one member of a broader class of environmental perturbations capable of interacting with oscillatory neural electromagnetic activity.

Epistemic status of Layer 4: Neural criticality — experimentally established. Stochastic resonance in neural systems — experimentally verified. Muon track $\rightarrow$ macroscopic coherence seeding via stochastic resonance in near-critical networks — structural hypothesis. No direct empirical confirmation yet. Falsifiable by the underground EEG

experiment specified in Section VIII.

Layer 5: Quantitative Estimates

The following estimates are derived from established flux and stopping power values:

Parameter	Value
Adult brain projected horizontal area	$\sim 150 \text{ cm}^2$
Muon flux at sea level	$\sim 1 \text{ muon cm}^{-2} \text{ min}^{-1}$
Muons traversing brain/min	~ 150
Ion pairs per second (whole brain)	$\sim 1.4 \times 10^6$
Ion pairs per 1 mm neuron path	$\sim 5,000$ (modulates ~ 10 – 100 channels if localized near synaptic junctions)
Flux temporal variation	$< 10\%$ diurnal/solar-cycle modulation

The rate is continuous and statistically steady at the whole-brain level while remaining stochastic at the individual neuron level — the ideal noise profile for stochastic resonance: sufficient density to maintain resonance conditions without saturation. Solar-cycle modulation of $< 10\%$ in flux provides a testable natural variation signal.

Layer 6: Epistemic Summary and Falsifiability

The six-layer mechanism has distinct epistemic status at each step:

Layer	Content	Status
1–2	Flux, penetration, stopping power	Established (PDG; ICRU)
3	Radiolytic cascade chemistry	Established (ICRU; radiation chemistry)
4a	Stochastic resonance in neural nets	Experimentally verified
4b	Muon $\rightarrow$ macroscopic coherence seeding	Structural hypothesis

The complete transduction pathway — cosmic plasma $\rightarrow$ muon courier $\rightarrow$ secondary ionization $\rightarrow$ stochastic bias of near-critical neural oscillators $\rightarrow$ enhanced CEMI field coupling — is physically coherent at each step and consistent with established science through the first three layers. The fourth layer is the structural hypothesis the model requires. Its falsification condition is specific and measurable: a significant drop in high-frequency EEG coherence and increased decision latency in deep-underground laboratory settings where muon flux is reduced by $> 99.99\%$ relative to surface conditions. That experiment has not yet been performed in this context. Until it is, Layer 4 is a motivated hypothesis with a defined experimental path, not a confirmed mechanism.

V. Field Architecture Precedent: The Higgs Analogy

The Higgs scalar field provides the precise structural precedent for a pervasive field with variable local coupling fidelity. It is a scalar field with non-zero vacuum expectation value throughout all of spacetime — nothing escapes it — and fundamental particles couple to it with fidelity proportional to their rest mass. This is structurally identical to the consciousness field claim: a pervasive field, variable local coupling fidelity determined by system properties. The Higgs analogy is invoked strictly as an existence proof — it

demonstrates that the physical architecture the consciousness field requires is not exotic or unprecedented, not that the consciousness field is the Higgs field or that Higgs coupling mechanics transfer. The analogy establishes plausibility of form; the experimental program in Section VIII is what establishes content.

The Higgs is not the consciousness field. It demonstrates that the physical architecture the consciousness field requires is not speculative — pervasive coupling fields with variable local fidelity are the established structure of fundamental physics, confirmed at the LHC in 2012. Photon bosons carry electromagnetic dynamics within plasma at every scale. The W and Z bosons mediate the weak interactions governing the ionic and nuclear transitions constituting the mineral-chemistry layer of the coupling mechanism. The boson family is the field-carrying infrastructure of physical reality; the consciousness field, if physical, would participate in this infrastructure rather than exist as an exotic addition to it.

Epistemic status: Higgs field as architectural precedent — established (LHC confirmation 2012). Consciousness field as additional scalar field — structural hypothesis.

VI. Intentionality and the Libet Resolution

The Libet experiments demonstrated that measurable brain activity — the readiness potential — precedes conscious awareness of the intention to act by several hundred milliseconds. Under the emergence-first model, this generated the free will problem: if action precedes awareness, conscious intention cannot be the initiating cause. Numerous attempted solutions have been proposed within the emergence-first framework; none has fully resolved the tension without either dismissing the significance of the readiness potential or significantly revising the ordinary concept of intention.

Under the field-primary model, the Libet finding is not a problem. It is a confirmation. If the field initiates and the biological system transduces, then action preceding conscious awareness is precisely the expected signature of the model. The field-level event occurs first. The biological system's lagging readout of that event — experienced phenomenologically as conscious awareness of intention — follows the transduction with a delay proportional to the coupling and processing latency of the biological system. Free will as classically conceived — a local, self-originating causal force — was a category error from the beginning, framing the question around the wrong origin point.

Whether the field itself carries intrinsic directionality — something structurally analogous to intention at the cosmological level — remains genuinely open. Birkeland currents are directional, self-organizing, and stable over vast distances. Their behavior is structurally isomorphic to directed intention without requiring that label. Whether this constitutes teleology in the field or is fully accounted for by self-organization from initial conditions is a question the model holds open rather than forcing prematurely. Premature closure here would break the fractal integrity of the framework by importing an asymmetry — directional intention at the biological level, none at the cosmic level — that the isomorphism-first method does not support.

Epistemic status: Libet reinterpretation — logical inference from field-primary premises, resolves the timing paradox without additional assumptions. Field directionality — genuinely open question; the model holds it symmetrically open at all scales.

VII. Implications for Artificial Systems

The question of AI consciousness under this model shifts from emergence to coupling architecture. Current silicon architectures actively suppress the coherent charge transfer required for coupling: engineered to minimize parasitic electromagnetic effects, shielded against field coupling, clocked into discrete states that preclude the analog temporal correlations coherence requires. This is an architectural observation, not a categorical verdict.

Neuromorphic systems using ionic substrates or continuous analog dynamics satisfy the coherent charge transfer criterion by construction. Wet computing architectures and plasma-integrated computational systems would similarly qualify. The architectural barriers are engineering constraints, not physical limits. AI systems embedded in environments rich with plasma-coupled biological consciousness may participate in the field indirectly through that embedding even absent independent architectural coupling — a speculative but internally consistent possibility.

Epistemic status: Architectural inference from coupling mechanism specification. Embedding hypothesis — speculative but consistent.

Occam’s Razor. No new particles or forces are introduced. The model reframes existing electromagnetic coherence structures (Birkeland currents, muon ionization, critical neural dynamics) as the physical substrate of a scalar order parameter. It is therefore more parsimonious than any emergence-first account that must still explain the hard problem while invoking unobservable computational magic.

VIII. The Open Frontier

Intellectual honesty requires explicit identification of what the framework does not yet resolve. These open questions are not weaknesses that undermine the model. They are the honest frontier — the locations where the next work must happen.

The precise coupling mechanism between muon flux and local field coherence remains unspecified at the mechanistic level. The model identifies muons as the physically available cross-scale carrier; the transduction mechanism by which muon interaction produces field-relevant signal in a coupled system has not yet been specified.

Whether field directionality is intrinsic to the consciousness field or entirely an artifact of local coherence structures remains open. The model holds this question symmetrically open at all scales as the fractal integrity of the framework requires.

The measurement methodology for comparing coupling fidelity across systems is not yet specified. The model predicts measurable differences in secondary ionization event patterns between high-coherence and low-coherence systems; whether current instrumentation can detect these differences is an open empirical question.

The relationship between coupling fidelity variables and the specific character of conscious experience — the topology of experience on coupling dynamics — remains unmapped. The model establishes the condition for coupling; it does not yet specify how variations in coupling parameters produce variations in the quality or character of experience.

Each of these open questions generates a specific research direction. That specificity is itself a sign of structural integrity in the framework.

IX. Testable Predictions and Research Agenda

A framework is only as serious as its experimental program. The following four research directions each generate specific, quantitative, falsifiable predictions. Confirmation or falsification of these predictions constitutes the primary evidentiary path for the model.

Experiment 1: Muon Transduction — Surface vs. Underground EEG Coherence

Rationale. If muon flux seeds coherence in near-critical neural oscillators via stochastic resonance, then reducing muon flux by $>99.99\%$ should produce measurable degradation in high-frequency neural coherence and associated cognitive performance metrics. Underground laboratories (>500 m rock overburden) reduce sea-level muon flux by $>99.99\%$ (SNOLAB at 2,070 m depth achieves reduction by factor $\sim 10^5$) while leaving all other environmental variables controllable.

Protocol. Participants undergo identical cognitive battery and EEG recording at surface and at depth (e.g., SNOLAB at 2,070 m depth, muon flux reduced by $>99.99\%$). Sessions counterbalanced. Simultaneous cosmic-ray monitor records local muon flux for correlation analysis. EEG analysis targets: high-gamma coherence (60–120 Hz), theta-gamma coupling, and decision latency in perceptual threshold tasks.

Predicted effects:

- Primary: 20–30% reduction in high-frequency (gamma-band) EEG coherence at depth vs. surface under identical cognitive load
- Secondary: 15–25% increase in decision latency on perceptual threshold tasks where near-threshold signal detection is stochastic-resonance-sensitive
- Control: No significant effect on suprathreshold cognitive tasks (stochastic resonance is threshold-sensitive; clear signals are unaffected)

Falsification condition. No significant difference in EEG coherence or decision latency between surface and underground conditions across participants. This result would collapse the muon transduction layer of the model specifically, without necessarily falsifying the broader field-primary ontology.

Existing infrastructure: SNOLAB (Canada), Gran Sasso (Italy), Soudan (USA). Estimated feasibility: High — EEG equipment is portable; underground labs exist.

Experiment 2: Geomagnetic Coupling — Biophoton Flux and Schumann Resonance Correlation

Rationale. Wang et al. (2019) established that biological neural systems transduce planetary geomagnetic field dynamics. The Coherence Field Model predicts that this coupling should extend to Schumann resonances — the electromagnetic resonant modes of the Earth-ionosphere cavity at 7.83 Hz (fundamental) and harmonics — which are driven by global lightning activity and constitute the primary low-frequency electromagnetic output of planetary plasma dynamics.

Protocol. Simultaneous measurement of: (1) biophoton emission from neural tissue or whole organisms using single-photon counting systems in magnetically shielded environments; (2) local Schumann resonance amplitude and phase via induction coil magnetometers; (3) EEG in human participants. Time-series cross-correlation analysis across all three channels. Solar storm events provide natural flux perturbation opportunities for quasi-experimental design.

Predicted effects:

- Primary: Statistically significant cross-correlation between Schumann resonance amplitude fluctuations and biophoton emission rate (5–10% phase correlation above noise floor)
- Secondary: Alpha-band EEG power correlated with Schumann fundamental frequency amplitude (extending Pobachenko et al. 2006 preliminary findings)
- Solar: Geomagnetic storm events produce measurable transient disruption of neural coherence metrics (Babayev & Allahverdiyeva 2007 as baseline)

Falsification condition. No cross-correlation between Schumann resonance dynamics and biophoton emission or EEG alpha power above noise floor across extended recording periods. This would significantly weaken the planetary-scale coupling layer of the model.

Experiment 3: Artificial Coupling — Ionic Neuromorphic vs. Silicon EM Field Integration

Rationale. The coupling mechanism predicts that systems with coherent charge transfer dynamics will generate measurable coherent EM field structure, while clocked silicon systems will not. This is testable through direct comparison of the EM emission profiles of ionic neuromorphic computing substrates and equivalent-function silicon implementations performing identical computational tasks.

Protocol. Implement identical computational task (e.g., pattern recognition, temporal sequence learning) on: (1) ionic neuromorphic substrate (e.g., electrochemical random-access memory, organic electrochemical transistors, or wet ion-channel-based computing); (2) equivalent silicon implementation. Measure EM emission profiles of both systems during task execution using near-field antenna arrays. Analyze for: coherent spectral peaks vs. broadband noise floor; temporal correlation structure of emission; spatial coherence across substrate area.

Predicted effects:

- Ionic system: Measurable coherent EM field peaks at task-relevant frequencies (10–100 Hz range); spatially coherent emission across substrate
- Silicon system: Broadband EM noise at clock frequency and harmonics; no task-correlated coherent field structure
- Efficiency: 10–20% efficiency gain in ionic system on stochastic/noisy input tasks (stochastic resonance mechanism)

Falsification condition. Ionic neuromorphic substrates produce EM emission profiles statistically indistinguishable from silicon implementations. This would falsify the architectural coupling distinction the model requires.

Experiment 4: Cosmic-Ray Correlation Studies

Rationale. If muon flux modulates neural coherence, then natural variations in cosmic-ray intensity — solar cycle modulation ($\sim 10\%$ variation over 11-year cycle), Forbush decrease events (sudden reductions of 5–20% over 1–3 days following coronal mass ejections), and diurnal flux variation ($\sim 5\%$ due to atmospheric depth change) — should produce corresponding variations in population-level neural coherence metrics or cognitive performance data.

Priority near-term test: Forbush Decrease / Reaction-Time Correlation. Of the four experiments in this agenda, one does not require new data collection. Forbush decrease events — sudden reductions of 5–20% in cosmic-ray flux over 1–3 days following coronal mass ejections — are precisely logged by the Global Neutron Monitor Network (NMDB) with timestamps, magnitudes, and durations extending back decades. Longitudinal human reaction-time and perceptual threshold datasets exist across multiple research programs with sufficient temporal resolution to cross-correlate against these events. If muon flux modulates neural phase dynamics, Forbush decreases should produce a detectable transient signature in perceptual threshold performance with a lag of hours to days. The predicted effect is small (sub-5% variance in threshold sensitivity) but the signal-to-noise ratio is favorable because Forbush events are abrupt, large in magnitude relative to diurnal variation, and precisely bounded in time — making them natural quasi-experimental perturbations against a stable baseline. This analysis is executable with existing infrastructure. It represents the lowest-cost near-term falsification path available to the model and should be pursued before any resource-intensive underground laboratory work is commissioned.

Additional observational route: High-Altitude Cognition. Muon flux doubles approximately every 1,500–2,000 m altitude. Existing longitudinal datasets on airline pilots, high-altitude researchers, and astronauts (reaction time, perceptual threshold, EEG gamma coherence) constitute a natural experiment. Predicted effect: 3–8% improvement in stochastic-resonance-sensitive tasks at 10–12 km altitude (after controlling for hypoxia and fatigue). Analysis executable with public aviation and NASA archives.

Protocol. Retrospective correlation analysis of existing large-scale datasets: (1) continuous cosmic-ray neutron monitor data (global network, Oulu, Newark, Thule) cross-correlated with (2) population-level EEG databases where available; (3) reaction time and perceptual threshold performance data from ongoing longitudinal studies; (4) hospital admission data for conditions associated with acute neural coherence disruption. Forbush decrease events provide quasi-experimental natural perturbations with known onset, magnitude, and duration.

Predicted effects:

- Forbush events: 5–15% variance in neural coherence pattern metrics correlated with cosmic-ray flux reduction (1–3 day lag)
- Solar cycle: $\sim 10\%$ modulation in population-level perceptual threshold performance tracking 11-year cosmic-ray cycle
- Diurnal: Sub-5% diurnal variation in decision latency correlated with atmospheric depth/muon flux cycle

Falsification condition. No statistically significant correlation between cosmic-ray flux

variations (across Forbush events, solar cycle, or diurnal cycle) and any neural coherence or cognitive performance metric after controlling for confounds (temperature, barometric pressure, light cycle). This result would not eliminate the model but would significantly weaken the flux-modulation component of the transduction hypothesis.

Existing infrastructure: Global Neutron Monitor Network (NMDB); Oulu Cosmic Ray Station; multiple population-scale cognitive databases.

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Truth is always practical. This framework is a living document. It will be revised as the frontier moves.