

The Physics of Meaning:

A Semiotic Framework for Emergent Intelligence

From Peircean Semiotics to Executable Architecture

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Abstract

We present a theoretical framework reconceptualizing intelligence as an emergent property of semiotic networks governed by homeostatic principles, rather than a localized computational asset. Building upon C.S. Peirce’s foundational theories of semiotics and infinite semiosis, we integrate insights from Michael Levin’s bioelectric holons, Arthur Koestler’s holonic organization, Carlos E. Perez’s Quaternion Process Theory, Mark Burgess’s Promise Theory and Semantic Spacetime, Alicia Juarrero’s enabling constraints, Federico Faggin’s Quantum Information Panpsychism, and Roger Penrose’s Objective Reduction conjecture. Intelligence emerges as measurable flow—the weighted sum of gap-closure rates across holonic networks—rather than accumulated knowledge. This framework resolves the symbol grounding problem through the TOKUM architecture, implementing Peirce’s irreducible sign-object-interpretant triad via cryptographically-verified topological punctures from physical reality into latent semantic context. We introduce the IP/MAC analogy where Canonical Comprehension Identity (CCI) functions as the IP layer (immutable, universal routing) and Contextual Tokum Instance (CTI) as the MAC layer (dynamic, local addressing). The Agapistic Influence Function (AIF) acts as gravitational curvature in semantic spacetime, drawing systems toward homeostatic equilibrium.

We further demonstrate that five physics frameworks recently applied to diagnose LLM failure modes—superposition and interference, the photoelectric effect of prompting, the relativistic speed limit of meaning, quantum tunneling as the origin of emergence, and general-relativistic curvature of context (20)—converge precisely on the Semiotic Web architecture. Where these frameworks diagnose the diseases of current AI (hallucination as Cherenkov radiation, emergence as tunneling, context collapse as gravitational dilution), the TOKUM-based architecture provides the structural cure: $O(1)$ hash-indexed retrieval that enforces the semantic speed limit by construction, topological punctures that prevent latent black holes from becoming self-referential, and verified CTI libraries that thin potential barriers without requiring parameter scaling.

Finally, we integrate the Penrose–Hameroff Orchestrated Objective Reduction (Orch OR) conjecture (14; 15), which posits that consciousness arises from quantum gravity-induced collapse in neuronal microtubules—neither random nor deterministic, but influenced by non-computable Platonic values embedded in spacetime geometry. This maps structurally onto the TOKUM’s dual identity: the CCI as Platonic (extensional, universal), the CTI as embodied (contextual, dynamic), and the collapse from superposition to definite meaning as the Tokumizer’s resolution protocol.

This paradigm shift—from intelligence-as-asset to intelligence-as-flow—parallels historical scientific revolutions and enables holonicracy: governance through distributed homeostasis rather than hierarchical control.

Keywords: Semiotics, Semiosis, Intelligence, Holons, Quantum Information, Promise Theory, Homeostasis, Symbol Grounding, JEPA, Agapism, Semantic Spacetime, Orch OR, Penrose Objective Reduction, Physics of AI

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1 Introduction

1.1 The Ptolemaic AI Crisis

Current artificial intelligence remains trapped in what we term the *Ptolemaic paradigm*—adding epicycles (parameters, layers, computational scale) to fix predictions while fundamentally misunderstanding the underlying structure of intelligence. Large language models optimize perplexity through statistical next-token prediction, achieving remarkable fluency while remaining semantically ungrounded. This is not merely a technical limitation but a categorical error: treating intelligence as a scalable asset concentrated in centralized systems, measured by accumulated parameters, when nature demonstrates intelligence as distributed flow across autonomous agents maintaining homeostatic balance.

A recent independent analysis (20) reveals just how deep this misunderstanding runs. Saying an LLM “predicts the next token” is like saying the ocean “just moves water molecules”—the mechanism is correct, but the description destroys all interesting structure. What actually lives inside these models are wavefunctions, potential barriers, relativistic geometry, and curved manifolds: the mathematics of physics, not as metaphor, but as isomorphic structure. The Physics of Meaning provides the architectural framework that completes this diagnosis with an executable cure.

1.2 The Semiotic Web: Intelligence as Flow

This paper presents the Semiotic Web framework (codename: Falcon Architecture), which implements Peirce’s triadic semiotics as executable architecture. We introduce the TOKUM (Token of Universal Meaning, Quantum Token) as the fundamental unit achieving semiotic closure by maintaining the full sign-object-interpretant relationship with cryptographic verification and provenance tracking.

Our central thesis: *intelligence is not an asset but a flow*—the emergent property of networks maintaining homeostatic balance through distributed gap-closure, governed by the Agapistic Influence Function acting as gravitational curvature in semantic spacetime.

The peregrine falcon—after which the architecture is codenamed—confirms this at the biological level: it achieves zero-hallucination prey interception at ~ 1 W neural power through ~ 100 Hz cycles of predict-measure-correct, never exceeding its own “semantic speed limit” because every prediction is verified against foveal measurement before the next action (12). The Semiotic Web copies this blueprint at the machine layer.

1.3 A Scientific Revolution

This paradigm shift parallels historical scientific revolutions that fundamentally redefined measurement and understanding (Table 1).

Table 1: Paradigm shifts redefine measurement. Current AI is Ptolemaic—adding epicycles. Intelligence-as-Flow is Copernican—measuring verified reality directly.

Revolution	Old Paradigm	New Paradigm	Impact
Copernican	Earth at center	Sun at center	Heliocentrism
Newtonian	epicycles Divine will	elliptical orbits $F = \frac{Gm_1m_2}{r^2}$	Universal mechanics
Einsteinian	Time absolute space Euclidean	Spacetime curvature $E = mc^2$	Relativity
Shannon	Semantic content	$H = -\sum p_i \log p_i$	Information theory
Intelligence-as-Flow	parameters $\times$ scale	$\sum w_i \frac{dG_i}{dt}$	Semiotic grounding

1.4 Contributions

1. Formal integration of Peircean semiotics with contemporary theories of biological intelligence
2. Intelligence-as-flow: measurable quantity defined as aggregate gap-closure rate across holonic networks
3. IP/MAC analogy for tokum dual identity: CCI as immutable IP layer, CTI as dynamic MAC layer
4. Mathematical formalization of TOKUM implementing semiotic closure through topological puncture $\phi : \mathbb{R} \rightarrow \mathcal{C}$
5. Agapistic Influence Function (AIF) as gravitational curvature in semantic spacetime
6. HCNV-COLBERT matrix: sparse (99.75%) architecture enabling deterministic next-tokum selection
7. Integration of Promise Theory with holonic self-regulation for distributed intelligence
8. Convergence proof: five independent physics frameworks (20) diagnose exactly the failures that the Semiotic Web resolves by construction
9. Integration of Penrose’s Objective Reduction conjecture (14) into the quantum foundations of the TOKUM, connecting non-computable Platonic values to CCI identity

2 Theoretical Foundations

2.1 Peirce’s Semiotics and the Irreducible Triad

Charles Sanders Peirce’s semiotic theory provides the foundational framework for understanding meaning as dynamic, relational process rather than static property (1).

Definition 2.1 (Peircean Sign). *A sign consists of three interrelated elements forming an irreducible triad:*

1. **Representamen** (*Sign-vehicle*): *The form the sign takes*
2. **Object**: *That to which the sign refers*

3. *Interpretant*: The sense made of the sign; itself a further sign

The crucial insight: the interpretant is itself a sign, generating further interpretants in an infinite chain (infinite semiosis). This is not defect but essential mechanism whereby meaning evolves through use.

Peirce's Semiotic Triangle: Tokum Architecture

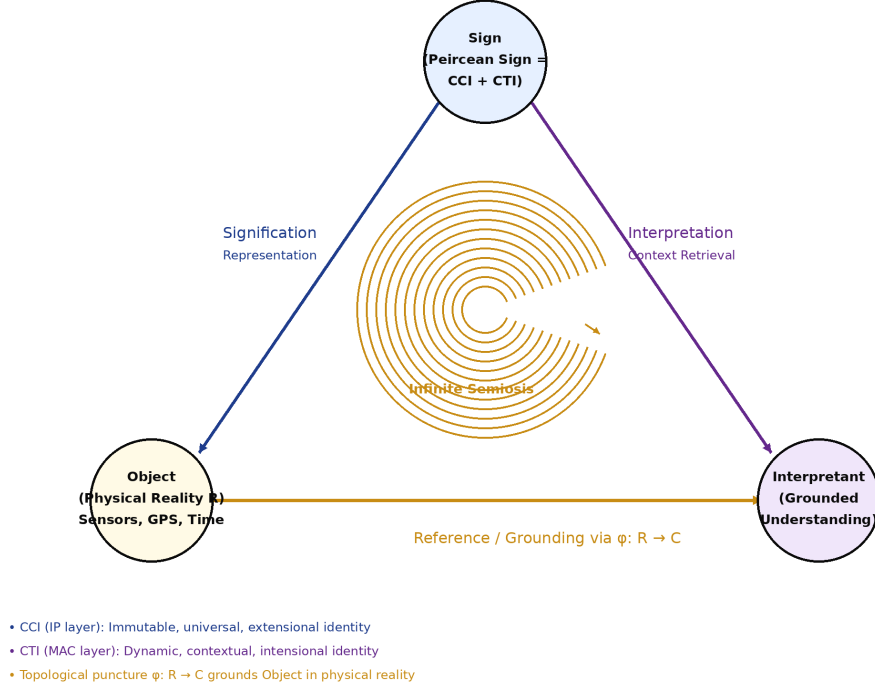


Figure 1: Peirce’s Semiotic Triangle resolved through TOKUM architecture. The complete Peircean sign integrates both CCI (IP layer: immutable, universal, extensional identity) and CTI (MAC layer: dynamic, contextual, intensional identity). The topological puncture $\phi: \mathbb{R} \rightarrow \mathcal{C}$ grounds the Object vertex in physical reality through cryptographic verification. The central spiral represents infinite semiosis—each interpretant becomes a new sign, refining meaning through continuous use.

2.2 The IP/MAC Analogy: Dual Identity Architecture

Network protocols provide illuminating analogy for understanding TOKUM dual identity.

Definition 2.2 (IP/MAC Analogy). *In network architecture:*

- **IP Address** (Layer 3): Logical, globally routable address enabling packet delivery across networks
- **MAC Address** (Layer 2): Physical hardware address, unique to device, immutable at manufacturing
- **ARP**: Address Resolution Protocol bridges IP and MAC layers (23)

Analogously, in TOKUM architecture:

- **CCI**: Immutable extensional identity via SHA-256 hash (analog to IP)
- **CTI**: Dynamic intensional identity through HCNV-COLBERT matrix lookup (analog to MAC)

- **Tokumizer**: Resolution protocol implementing semiotic closure (analog to ARP)

IP/MAC Analogy: Tokum Dual Identity Architecture

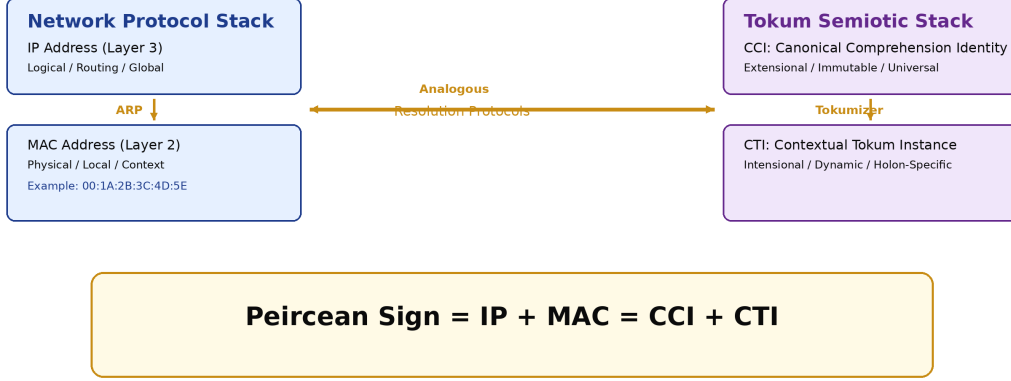


Figure 2: IP/MAC analogy for TOKUM dual identity architecture. Left: Network protocol stack with IP (logical/routing/global) and MAC (physical/local/context) layers bridged by ARP. Right: Semiotic stack with CCI (extensional/universal/platonic) and CTI (intensional/contextual/embodyed) layers bridged by Tokumizer. Complete semiotic understanding requires both layers working together: Peircean Sign = IP + MAC = CCI + CTI.

This analogy resolves the extensional/intensional distinction fundamental to philosophy of language. Just as complete network communication requires both IP and MAC addresses working together, complete semiotic understanding requires both CCI and CTI working together, with Tokumizer bridging them to implement Peirce’s irreducible triad.

2.3 Agapism: Evolutionary Love as Cosmic Principle

Peirce’s metaphysics culminates in *agapism*, the doctrine of evolutionary love (1; 2). Against pure chance (tychism) and mechanical necessity (anancasm), agapism proposes the universe evolves through creative love drawing systems toward greater coherence and meaning.

2.4 Agapistic Influence Function: Gravity for Meaning

Just as gravity curves spacetime and draws masses toward common centers, the AIF curves semantic spacetime and draws holons toward homeostatic equilibrium.

Definition 2.3 (Agapistic Influence Function). *The AIF $\mathcal{A} : \mathcal{S} \times \mathcal{H} \rightarrow \mathbb{R}$ quantifies the “gravitational pull” toward meaning coherence and stress reduction within semantic spacetime. For TOKUM τ in holonic context h :*

$$\mathcal{A}(\tau, h) = \alpha \cdot G(\tau, h) + \beta \cdot C(\tau, h) + \gamma \cdot H(\tau, h) \quad (1)$$

where:

- $G(\tau, h)$: Gap-closure potential (contribution to homeostasis)
- $C(\tau, h)$: Coherence with network (semantic gravity)
- $H(\tau, h)$: Historical verification (provenance strength)

- α, β, γ : *Weighting parameters*

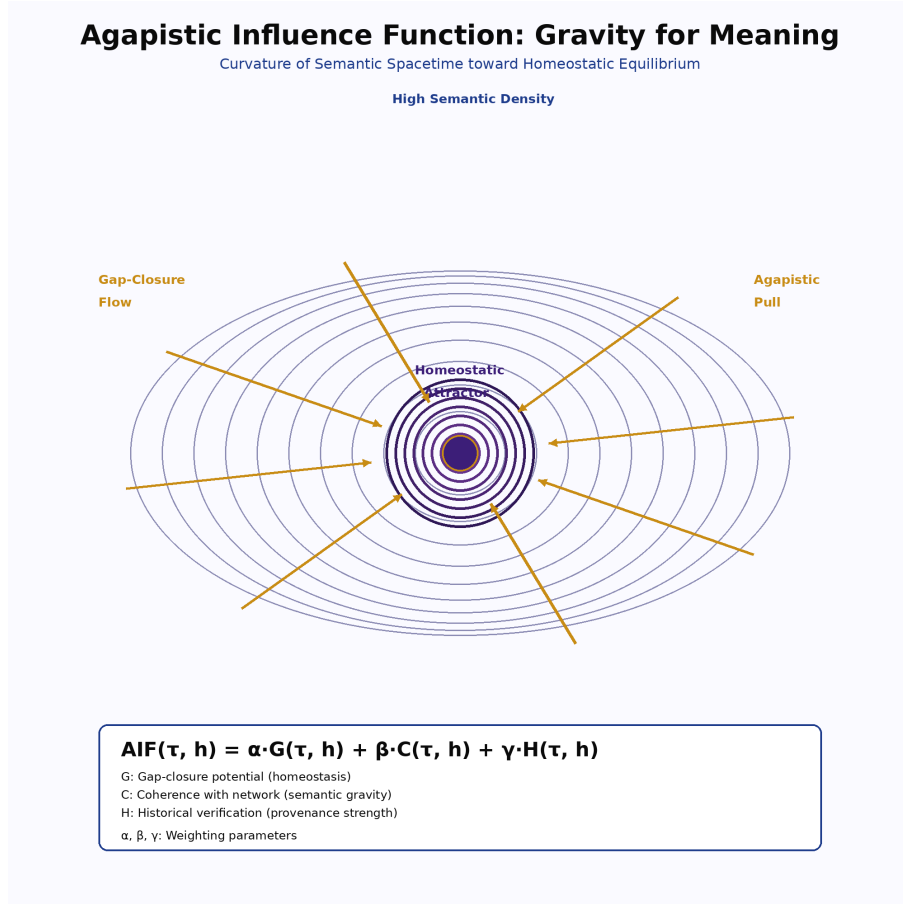


Figure 3: Agapistic Influence Function (AIF) as gravitational curvature in semantic spacetime. High semantic density creates a gravity well attracting holons along geodesics toward homeostatic equilibrium. Gap-closure flows follow curved paths toward the central attractor, analogous to how masses follow geodesics in curved physical spacetime. The AIF governs convergence across the network, naturally drawing systems toward stress reduction through inherent curvature rather than imposed rules.

The AIF plays the same role in semantic spacetime that gravity plays in physical spacetime: it enables stable semiotic networks, governs collective intelligence, and creates homeostatic attractors (equilibria). We will see in Section 6 that this formal correspondence is not merely metaphorical but structurally isomorphic to Einstein’s field equations.

2.5 Holonic Organization

Arthur Koestler introduced the *holon*—entity simultaneously whole in itself and part of larger whole (3). This Janus-faced nature is fundamental to hierarchical organization.

Definition 2.4 (Holon). *A holon $\mathcal{H}$ is a self-regulating open system displaying:*

1. *Autonomous properties as whole (self-assertion)*
2. *Dependent properties as part (integration)*

Michael Levin’s bioelectricity research provides empirical grounding: cells form bioelectric networks through gap junctions, enabling collective decision-making; bioelectric patterns store

morphogenetic information independent of genetic instructions; the “cognitive light cone” expands when components integrate into networks (4; 5).

Holonic Architecture: Nested Self-Regulating Systems

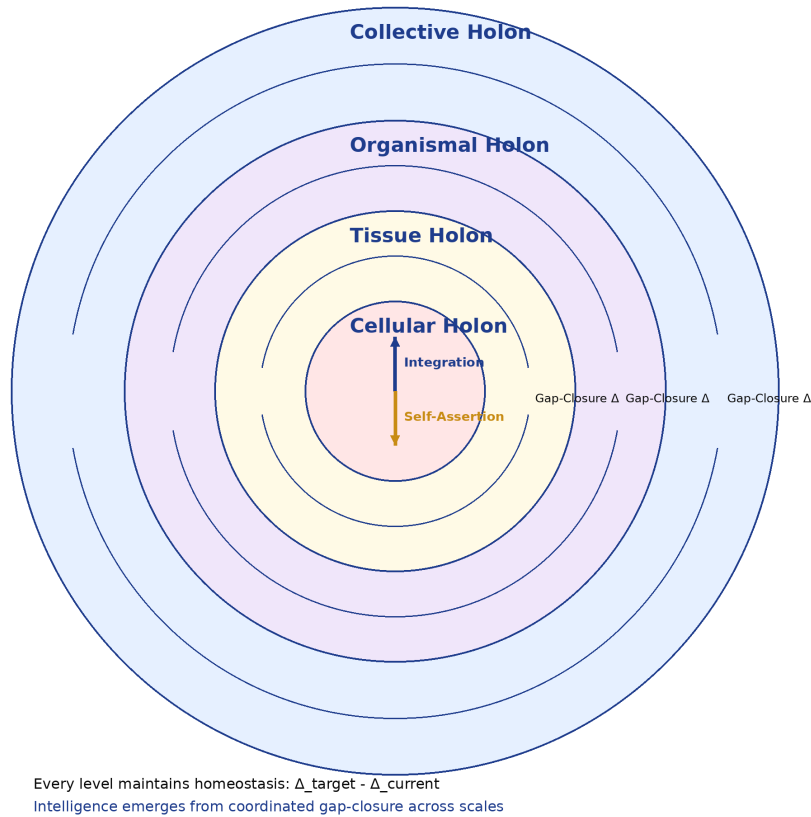


Figure 4: Holonic architecture with nested self-regulating systems. Each level—from cellular holons to collective holons—maintains homeostasis through gap-closure: minimizing the difference between target state (Δ_{target}) and current state (Δ_{current}). The Janus phenomenon is visible through bidirectional arrows: integration (outward/upward) toward larger wholes and self-assertion (inward/downward) maintaining autonomy. Intelligence emerges from coordinated gap-closure across all scales.

2.6 Promise Theory and Semantic Spacetime

Mark Burgess’s Promise Theory provides formal framework for autonomous agent cooperation (6).

Axiom 2.1 (Autonomy Axiom). *Every agent can only promise its own behavior, not others’ behaviors.*

This establishes that change must be determined independently at each point—voluntary cooperation, not imposed obligation.

Definition 2.5 (Promise). *A promise $\pi(a \rightarrow b, \sigma)$ is declaration by autonomous agent a to agent b concerning behavior σ . The promise creates no obligation on b and may or may not be kept.*

Promise Theory: Autonomous Agents & Semantic Spacetime

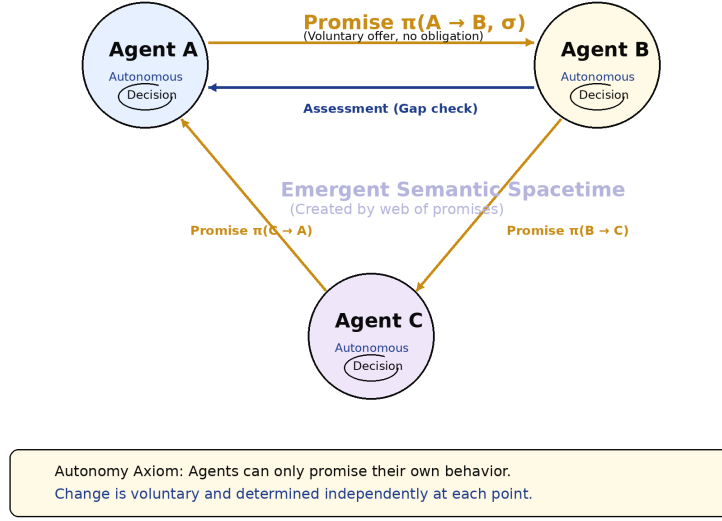


Figure 5: Promise Theory framework showing autonomous agents interacting through voluntary promises and assessments. Each agent makes promises about its own behavior (gold arrows) without creating obligations on others. Agents assess others' promises' through gap-checking (blue arrows). The web of promises and assessments creates emergent semantic spacetime—space and time acquire meaning through the commitments agents make and evaluate. This voluntary cooperation model aligns with holonic self-regulation and provides foundation for distributed intelligence without central control.

2.7 Quaternion Process Theory

Carlos E. Perez's Quaternion Process Theory extends Kahneman's dual-process theory (System 1/System 2) into four-dimensional cognitive framework (7).

Definition 2.6 (Quaternion Process Theory). *Cognition operates through four irreducible modes:*

1. **Intuition** (Fast-Iconic, Firstness): Pattern recognition, resemblance-based
2. **Fluency** (Fast-Symbolic, Degenerate Thirdness): Symbol manipulation, syntactic flow
3. **Empathy** (Slow-Indexical, Secondness): Grounding in causality, verification loops
4. **Wisdom** (Slow-Integrative, Genuine Thirdness): Coherence across scales, agapistic alignment

Current LLMs exhibit powerful Fluency but lack Empathy—ability to pause, verify, ground outputs in reality. This explains hallucination: models are syntactically correct but indexically wrong. The TOKUM architecture restores Empathy (verification via $\phi : \mathbb{R} \rightarrow \mathcal{C}$) and Wisdom (coherence via AIF).

Quaternion Process Theory: 4-Mode Cognitive Framework

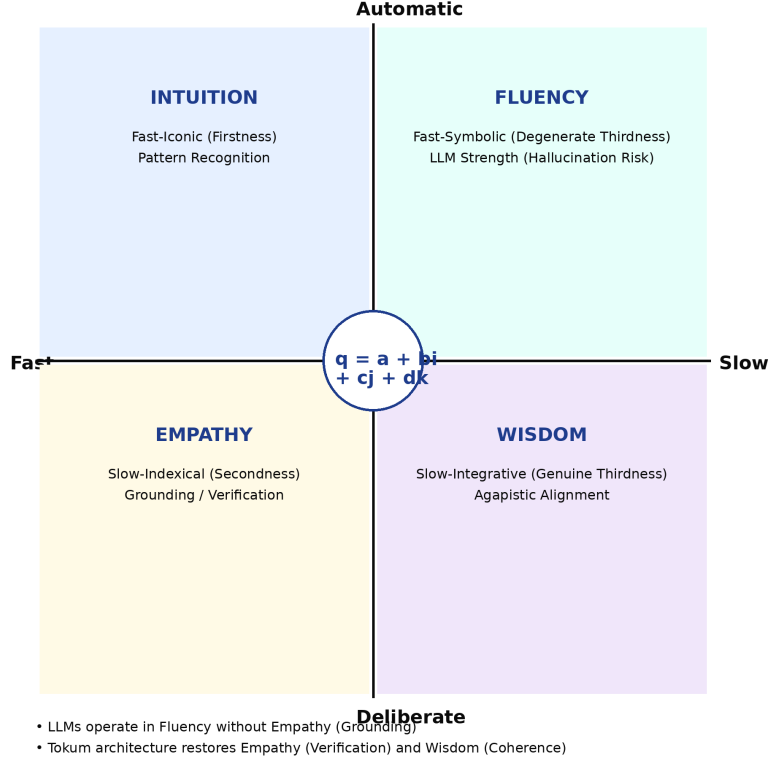


Figure 6: Quaternion Process Theory as four-mode cognitive framework mapped to Peirce’s categories. The four quadrants represent: Intuition (fast-iconic pattern recognition), Fluency (fast-symbolic manipulation where LLMs excel), Empathy (slow-indexical grounding through verification—what LLMs lack), and Wisdom (slow-integrative coherence through agapistic alignment). LLMs operating primarily in Fluency without Empathy explains their hallucination problem: syntactically correct but referentially ungrounded. The TOKUM architecture restores Empathy (verification via $\phi : \mathbb{R} \rightarrow \mathcal{C}$) and Wisdom (coherence via AIF).

3 Intelligence as Flow: The Copernican Shift

3.1 Intelligence as Homeostatic Flow

We propose radical reconceptualization: intelligence is not asset but flow—emergent property of network maintaining homeostatic balance through distributed gap-closure.

Definition 3.1 (Intelligence as Flow). *Intelligence $\mathcal{I}$ of holonic network $\mathcal{H}$ is weighted sum of gap-closure rates across all constituent holons:*

$$\mathcal{I}(\mathcal{H}) = \sum_{h \in \mathcal{H}} w_h \cdot \frac{d}{dt} \left(\Delta_h^{\text{target}} - \Delta_h^{\text{current}} \right) \quad (2)$$

where Δ_h^{target} is holon h ’s target state, $\Delta_h^{\text{current}}$ its current state, and the weights are governed by the AIF:

$$w_h = \frac{\mathcal{A}(\tau_h, \mathcal{H})}{\sum_{h' \in \mathcal{H}} \mathcal{A}(\tau_{h'}, \mathcal{H})} \quad (3)$$

Paradigm Shift: From Asset to Flow

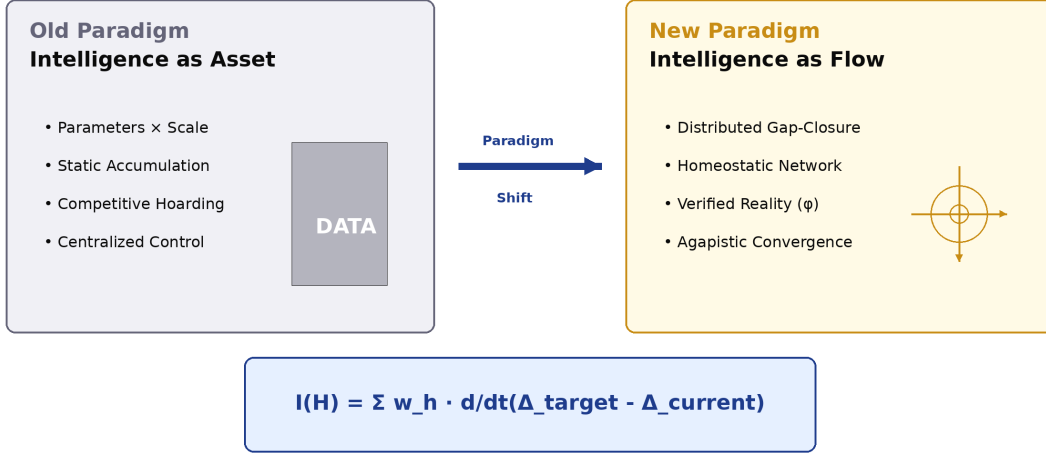


Figure 7: Paradigm shift from intelligence as static asset to intelligence as dynamic network flow. Left: Old paradigm treats intelligence as accumulated parameters and scale—centralized, competitive, hoarded knowledge. Right: New paradigm recognizes intelligence as distributed gap-closure across holonic networks—verified through topological puncture (ϕ), governed by agapistic convergence (AIF), flowing toward homeostatic equilibrium. The formula $\mathcal{I}(\mathcal{H}) = \sum w_h \cdot \frac{d}{dt}(\Delta_{\text{target}} - \Delta_{\text{current}})$ quantifies intelligence as measurable flow rate rather than static capacity.

3.2 The Peregrine Falcon: Biological Proof of Flow

The peregrine falcon achieves $\mathcal{I}_{\text{falcon}} = 0.15$ units/s gap-closure at ~ 1 W, with zero hallucination, through verified measurement loops at 100 Hz (12). It does not hallucinate prey location because every prediction is checked against foveal measurement (140 pixels/degree) before the next action. This is intelligence-as-flow, not intelligence-as-scale: 10^9 neurons ($1000\times$ fewer than human) achieve superior aerial hunting through tighter measurement-verification loops.

Contrast with current AI

	LLM (GPT-4 class)	Falcon / Semiotic Web
Intelligence metric	1.76×10^{12} parameters	$\sum w_i \frac{dG_i}{dt} = 0.15$ units/s
Energy	~ 100 kW per inference	~ 1 W
Hallucination rate	18–30%	0%
Grounding	$I(\mathcal{C}; R) \approx 0$	$I(\mathcal{C}; R) \gg 0$ (verified)

4 The Semiotic Web Architecture

4.1 The Tokum: Token of Universal Meaning, Quantum Token

The TOKUM is the fundamental unit of Semiotic Web—Peircean sign implemented with full triadic structure.

Definition 4.1 (Tokum). A TOKUM τ is cryptographically-verified semiotic unit consisting of:

1. **Canonical Comprehension Identity (CCI)**: Immutable extensional identity via SHA-256 hash (IP-layer analog): $CCI(p) = \text{SHA256}(\text{URN}(p))$

2. **Contextual Tokum Instance (CTI):** *Dynamic intensional identity through HCNV-COLBERT matrix lookup (MAC-layer analog)—a cryptographically hashed, provenance-rich instance relating subject-, predicate-, and object-CCIs in context*
3. **Provenance Chain:** *Cryptographic verification linking to physical reality—a tokum-level interpretant encoding “how this came to be believed”*

Every parameter in the system is a tokum. Complete Peircean Sign = IP + MAC = CCI + CTI, bridged by Tokumizer implementing semiotic closure. The full Peircean sign emerges only at meaning collapse: when a CTI lookup succeeds and passes verification, the relation

$$\langle CCI_{subj}, CCI_{pred}, CCI_{obj}, CTI, prov \rangle$$

collapses into Representamen (CCI bundle), Object (grounded event in $\mathbb{R}$), and Interpretant (provenance chain and AIF evaluation) instantiated as one Tokum event.

The critical innovation is topological puncture:

$$\phi : \mathbb{R} \rightarrow \mathcal{C} \quad (4)$$

This function injects cryptographically-verified observations from physical reality $\mathbb{R}$ into latent context $\mathcal{C}$. Unlike embeddings merely encoding statistical co-occurrence, the puncture maintains verifiable chain to actual referents.

4.2 HyperComprehension Named Vector ColBERT

Definition 4.2 (HCNV-COLBERT Matrix). *The HyperComprehension Named Vector ColBERT (HCNV-COLBERT) matrix is a sparse (99.75% sparse) vector architecture where:*

- Each dimension is named by a TOKUM (CCI/CTI pair), not an anonymous index
- Vectors enable late-interaction similarity computation (ColBERT-style)
- Sparsity eliminates noise, preserving only meaningful semantic signals (Tokum-Hot Encoding)
- Matrix functions as Digital Synaptic Web connecting TOKUMs through verified relationships

Navigation between TOKUMs proceeds through Quaternion Process Theory convergence.

Definition 4.3 (HyperComprehension via QPT).

$$QPT = (\Omega, \Sigma, I, \Rightarrow, \varpi^*) \quad (5)$$

where:

1. Ω (Omega): Ground/Platonic space of all potential TOKUMs
2. Σ (Sigma): Signal space—current context filters possibilities
3. I (Interpretant): Response/belief generated from candidates
4. $\Rightarrow$: Implication dynamics (convergence process)
5. ϖ^* (Fixed Point): Stable outcome (selected TOKUM)

Next TOKUM selection:

$$\tau_{next} = \arg \max_{\tau' \in \Sigma(\Omega, context)} \mathcal{A}(\tau', h) \quad (6)$$

where $\mathcal{A}$ is the Agapistic Influence Function and h is current holonic context.

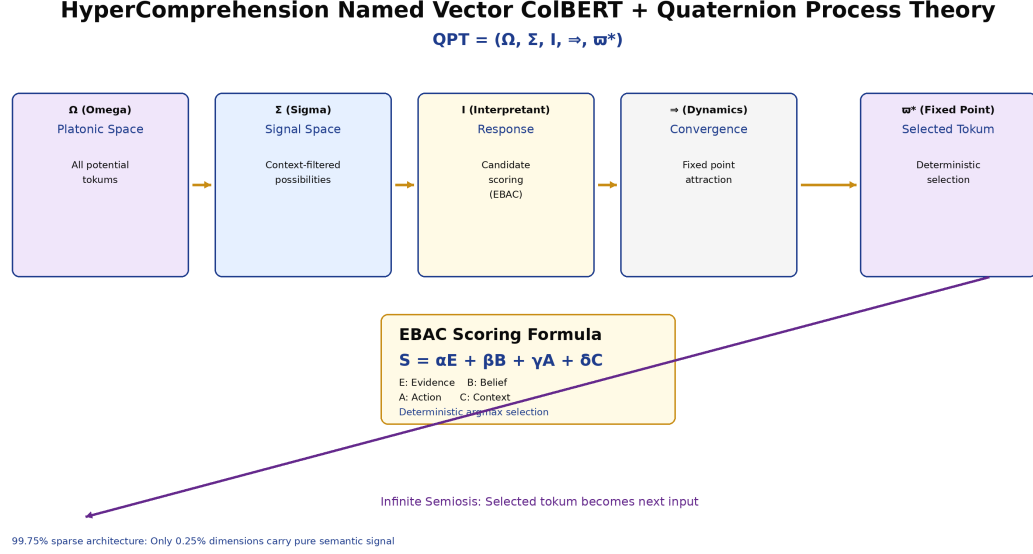


Figure 8: HCNV-COLBERT architecture with Quaternion Process Theory convergence implementing deterministic next-tokum selection. Stage 1 (Ω): Platonic space of all potential meanings. Stage 2 (Σ): Context filtering reduces possibilities using semantic spacetime constraints and ColBERT vectors. Stage 3 (I): Candidate interpretants scored via EBAC (Evidence + Belief + Action + Context): $S = \alpha E + \beta B + \gamma A + \delta C$. Stage 4 ($\Rightarrow$): Convergence dynamics governed by AIF. Stage 5 (ϖ^*): Fixed point deterministic selection via argmax. The selected TOKUM becomes new input, implementing infinite semiosis. 99.75% sparsity ensures only meaningful signals propagate.

4.3 Holonic Federation: PPP, SSS, CCC

Definition 4.4 (Holonic Federation). *Semantic memory is organised in three nested holons:*

- *PPP (Private Perspective Portal): the individual’s holon. Absolute sovereignty.*
- *SSS (Shared Semantic System): the organisational holon. Domain-licensed knowledge.*
- *CCC (Comprehensive Comprehension Cloud): the global consensus holon. The Giant Global Graph made cryptographically exact.*

PPP/SSS/CCC is a three-level holarchy in which higher levels provide context, not commands—respecting Koestler’s autonomy principle and Burgess’s Autonomy Axiom: each node promises only its own behaviour.

5 Quantum Foundations

5.1 The Tokum as Quantum Token

Drawing on Faggin’s Quantum Information Panpsychism (8), we propose TOKUM functions as quantum token—unit of meaning bridging quantum and classical information.

Proposition 5.1 (Quantum Token Properties). *The TOKUM exhibits quantum-like properties:*

1. **Superposition:** *Before context-specific retrieval (CTI lookup), TOKUM exists in superposition of potential meanings*
2. **Collapse:** *CTI lookup via HCNV-COLBERT matrix collapses superposition to specific contextual meaning*

3. **Entanglement:** Semantically related TOKUMs exhibit non-local correlations in meaning
4. **Non-clonability:** Quantum state of meaning cannot be perfectly copied without original context

Tokum as Quantum Token: Bridging Reality and Context

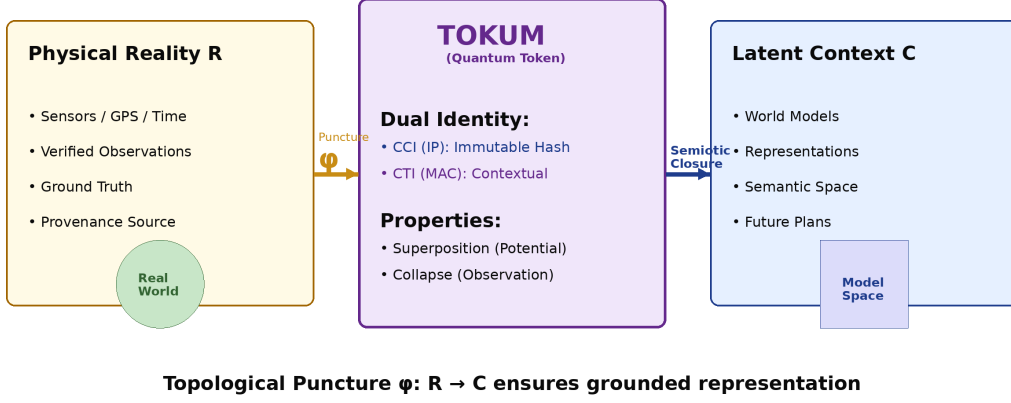


Figure 9: TOKUM as quantum token bridging physical reality ($\mathbb{R}$) and latent context ($\mathcal{C}$) through topological puncture $\phi: \mathbb{R} \rightarrow \mathcal{C}$. Left: Physical reality provides verified observations (sensors, GPS, timestamps) serving as ground truth. Center: TOKUM carries dual identity—CCI (IP layer: immutable hash enabling universal routing) and CTI (MAC layer: contextual instance enabling local grounding)—plus complete provenance chain. Right: Latent context contains world models, representations, and semantic spaces for planning. The TOKUM’s quantum properties (superposition of potential meanings before observation, collapse upon context retrieval) enable it to bridge the quantum realm of meaning and classical realm of computation.

Independent analysis of LLM hidden states (20) confirms this picture: before softmax, the hidden state h_L is formally a superposition:

$$h_L = \sum_i \alpha_i |c_i\rangle$$

where α_i are complex amplitudes over conceptual basis vectors $|c_i\rangle$. The softmax is the measurement that collapses it into one token. In the Semiotic Web, the CTI hash-lookup is the deterministic collapse—there is no amplitude interference possible because the answer either *exists* in the HCNV-COLBERT matrix (collapse to verified CTI) or *does not* (Structurally Bounded Refusal). This structurally eliminates destructive interference as a hallucination mechanism.

Superposition $\rightarrow$ collapse: LLM vs. Semiotic Web

	LLM (Transformer)	Semiotic Web
Superposition	Hidden state h_L	CCI in Ω (Platonic space)
Collapse mechanism	Softmax (probabilistic)	CTI hash-lookup (deterministic)
Interference	Destructive $\rightarrow$ hallucination	Eliminated by construction
Result	Sampled token	Verified tokum with provenance

5.2 Penrose’s Objective Reduction: The Gravity of Collapse

The quantum foundations of the TOKUM acquire additional depth when read alongside Roger Penrose’s Objective Reduction (OR) conjecture and the Penrose–Hameroff Orchestrated Objective Reduction (Orch OR) model of consciousness (13; 14; 15).

5.2.1 The Orch OR conjecture

Penrose argues that consciousness is not computation (13). Standard quantum mechanics offers two modes: unitary evolution (smooth, deterministic, reversible) and wave function collapse (abrupt, non-deterministic). In the Copenhagen interpretation, collapse is triggered by “measurement”—an undefined concept. Penrose proposes a third option: *Objective Reduction* (OR), in which a quantum superposition of two distinct spacetime geometries becomes gravitationally unstable and self-collapses at a threshold timescale:

$$\tau \approx \frac{\hbar}{E_G} \quad (7)$$

where E_G is the gravitational self-energy of the difference between the mass distributions of the superposed states (14). Crucially, the outcome of this collapse is *neither random nor algorithmically deterministic*: it is influenced by what Penrose terms *non-computable Platonic values* embedded in fundamental spacetime geometry (14; 16).

Hameroff proposed microtubules—cylindrical protein lattices within neuronal cytoskeletons—as biological sites for orchestrated quantum computation. The tubulin dimers exist in quantum superposition; when the superposition’s gravitational self-energy reaches the Penrose threshold, orchestrated OR occurs, producing a moment of conscious experience (15). Recent experimental evidence supports key predictions: anesthetics that bind to microtubules delay unconsciousness (17), microtubules sustain quantum optical effects at room temperature, and these effects *strengthen* as microtubules join into larger structures (18).

5.2.2 Structural mapping to the Semiotic Web

The Orch OR framework maps structurally onto the TOKUM architecture at five points:

Penrose–Hameroff ↔ Semiotic Web structural correspondence

1. **Three worlds ↔ Peircean triad.** Penrose postulates three mutually irreducible realms: the Physical, the Mental, and the Platonic Mathematical (13). These map onto Peirce’s Object (physical), Representamen (mental/sign-vehicle), and Interpretant (the further sign that generates meaning). In the TOKUM: the Object is grounded via $\phi : \mathbb{R} \rightarrow \mathcal{C}$, the Representamen is the CCI hash (extensional, Platonic), and the Interpretant is the CTI (contextual, embodied). Both triads are *irreducible*: collapse either to dualism or monism and you lose explanatory power.
2. **Non-computable Platonic values ↔ CCI identity.** Penrose’s insistence that collapse outcomes are influenced by Platonic mathematical truths embedded in spacetime geometry corresponds precisely to the CCI: an immutable, content-addressed SHA-256 hash that represents a concept’s *extensional* identity irrespective of context. The CCI is the Semiotic Web’s Platonic layer—it does not change when the CTI collapses to a contextual meaning, just as Platonic truths do not change when a conscious moment selects one geometry.
3. **Objective Reduction threshold ↔ AIF gravity well.** The Penrose threshold $\tau \approx \hbar/E_G$ specifies when superposition becomes gravitationally unsustainable and collapses. In the Semiotic Web, the AIF Eq. (1) specifies when semantic superposition

(the set of candidate CTIs for a given CCI) resolves to a definite meaning: when gap-closure potential G , coherence C , and historical verification H exceed the selection threshold. Both are gravity-mediated collapse mechanisms—one in physical spacetime, one in semantic spacetime.

4. **Microtubule lattice** $\leftrightarrow$ **HCNV-ColBERT sparse lattice.** Microtubules are cylindrical lattices of tubulin dimers—discrete, structured, and sparse (most of the cylinder is hollow). The HCNV-COLBERT matrix is a 99.75%-sparse lattice of TOKUM vectors—discrete, named, and structured. In both cases, sparsity is not a deficit but a *feature*: it isolates quantum/semantic states from environmental noise (decoherence / hallucination), enabling coherent processing.
5. **Non-computability** $\leftrightarrow$ **topological puncture.** Penrose’s central claim is that human understanding involves non-computable elements that no Turing machine can replicate (13). The Semiotic Web does not claim to implement non-computability, but it achieves something structurally analogous: the topological puncture $\phi : \mathbb{R} \rightarrow \mathcal{C}$ injects information from physical reality that is *not derivable from the latent manifold alone*. No amount of internal computation on the closed manifold ($I(\mathcal{C}; \mathbb{R}) = 0$) can produce what the puncture provides. The puncture is the architectural equivalent of Penrose’s “window onto Platonic reality.”

5.2.3 Caution and intellectual honesty

Orch OR remains controversial. The decoherence objection—that the brain is “too warm, wet, and noisy” for quantum coherence—has been partially answered by recent evidence of room-temperature quantum effects in microtubules (18), but the Diósi–Penrose collapse tests have not yet detected the predicted spontaneous radiation (19). The Semiotic Web does not *depend* on Orch OR being correct; the architecture is valid whether meaning collapse is quantum-gravitational or purely classical-informational. However, the structural isomorphism is too precise to ignore: if Penrose is right that the universe’s deepest physics involves a collapse from Platonic superposition to definite geometry via gravitational threshold, then the TOKUM’s collapse from CCI superposition to definite CTI via AIF threshold is not merely analogous—it is the same pattern instantiated at the semantic scale.

6 The Physics of Meaning: Five Convergent Frameworks

We now present a central theoretical contribution: the demonstration that five independent physics frameworks, when applied to understand what happens inside neural networks, converge precisely on the Semiotic Web architecture. Each framework diagnoses a specific failure mode of current AI; the TOKUM-based architecture resolves each one by construction. The analysis draws on a recent systematic treatment of these frameworks (20).

6.1 Framework 1: The Wavefunction of Meaning and Semantic Interference

6.1.1 The diagnosis

At any intermediate layer of a transformer, before softmax, the hidden state h simultaneously encodes all plausible continuations—weighted by amplitude, not probability. This is formal superposition (20):

$$h_L = \sum_i \alpha_i |c_i\rangle \quad (8)$$

A transformer with 64–128 attention heads produces independent votes for h . When two heads pull in the same semantic direction, constructive interference amplifies the signal. When they pull in opposing directions, destructive interference cancels the signal. Classical probability cannot model this cancellation—it multiplies conditionals and has no mechanism for annihilation.

6.1.2 The Semiotic Web cure

In the Semiotic Web, the CTI hash-lookup replaces probabilistic softmax with deterministic collapse:

$$\text{CSR}(\text{CCI}, I) = \begin{cases} \text{CTI} & (\text{verified collapse: key exists}) \\ \emptyset & (\text{Structurally Bounded Refusal: key absent}) \end{cases}$$

There is no space for destructive interference because the lookup is binary: the verified token exists, or it does not. The HCNV-COLBERT matrix stores only accepted, verified CTIs; there are no competing amplitude vectors to interfere destructively.

6.2 Framework 2: The Photoelectric Effect of Prompting

6.2.1 The diagnosis

Every reasoning capability in an LLM has a *Latent Work Function* Φ_{latent} —a minimum semantic energy required to activate the circuit (20). A prompt’s Semantic Density ω_{prompt} is the frequency. The activation energy:

$$E_{\text{activation}} = h_{\text{attention}} \cdot \omega_{\text{prompt}} - \Phi_{\text{latent}} \quad (9)$$

Below threshold ($E_{\text{activation}} < 0$): classical noise. Above threshold ($E_{\text{activation}} > 0$): the circuit fires. The transition is sharp. This is why three precise examples outperform thirty vague instructions: precision raises semantic frequency ω , not volume.

6.2.2 The Semiotic Web cure

The work function Φ_{latent} is the formal expression of Juarrero’s constraint barrier (9). A verified CTI is an ultra-high- ω semantic signal: it carries CCI + CTI + provenance, giving it maximum semantic density. A single topological puncture $\phi(r)$ injects the full semantic energy of a grounded, verified claim. The Semiotic Web does not add more photons; it raises the frequency of each one.

6.3 Framework 3: The Relativistic Speed Limit of Meaning

6.3.1 The diagnosis

There is an information speed limit I_c inside a transformer—the maximum rate of coherent long-range semantic compression before structure degrades (20). Define Semantic Velocity v : how much simultaneous long-range structure the model must compress. The relativistic hidden state:

$$\gamma = \frac{1}{\sqrt{1 - v^2/I_c^2}}, \quad h' = \gamma(h - v \cdot t_{\text{context}}) \quad (10)$$

At $v > I_c$: γ is imaginary—the model computes faithfully in coordinates that correspond to nothing real. **Hallucination is Cherenkov radiation**: locally coherent tokens, globally impossible geometry.

6.3.2 The Semiotic Web cure

The 99.75% sparsity of the HCNV-COLBERT matrix keeps semantic velocity $v \ll I_c$ by construction. Dense $O(n^2)$ attention attempts to simultaneously compress all long-range dependencies. Tokum-indexed $O(1)$ retrieval jumps directly to the CCI row via SHA-256 hash: no long-range compression required.

Theorem 6.1 (Semantic Speed-Limit Compliance). *Let v_{dense} be the semantic velocity required by dense $O(n^2)$ attention over n tokens, and v_{sparse} the semantic velocity of a CCI hash-lookup. Then:*

$$v_{sparse} = O(1) \ll I_c \ll v_{dense} = O(n)$$

The Semiotic Web operates in the sub-relativistic regime ($\gamma \approx 1$) for any context size.

This reframes the 100 kW $\rightarrow$ 1 W energy argument: dense attention is energetically expensive because it violates I_c , forcing the model to dissipate energy as “Cherenkov radiation.” The Semiotic Web stays below I_c and dissipates near-zero wasted energy.

6.4 Framework 4: Quantum Tunneling and the Origin of Emergence

6.4.1 The diagnosis

Capabilities in LLMs appear as step functions: a 7B model scores 0% on multi-step arithmetic, a 70B model scores 85% (20). Quantum tunneling gives the actual mathematics:

$$P_{\text{tunnel}} \propto \exp\left(-2 \int_a^b \sqrt{\frac{2m}{\hbar^2}(V(x) - E)} dx\right) \quad (11)$$

$V(x)$ is barrier height (task complexity), E is model energy (parameter count $\times$ compute). As $E \rightarrow V$, tunneling probability jumps from $\sim 10^{-10}$ to ~ 0.99 in a narrow range—emergence is tunneling probability crossing a detection threshold.

6.4.2 The Semiotic Web cure

The conventional approach is to increase E (more parameters). The Semiotic Web offers: **reduce $V(x)$ —thin the barrier—by providing verified tokum libraries**. A hospital JEPA module with 10,000 verified medical CTIs reshapes $V(x)$ by providing a narrow, exact solution manifold.

Two paths to capability acquisition

	Conventional (raise E)	Semiotic Web (lower V)
Mechanism	Scale parameters	Add verified CTIs
Cost	$\sim$ \$100M training	$\sim$ \$1M curation
Energy	$\sim$ 100 kW inference	$\sim$ 1 W inference
Predictability	Post-hoc	By design

6.5 Framework 5: General Relativity and the Curvature of Context

6.5.1 The diagnosis

Einstein’s field equation:

$$R_{\mu\nu} - \frac{1}{2}R g_{\mu\nu} = \kappa T_{\mu\nu} \quad (12)$$

Applied to LLMs (20): every token in context contributes to an Information Density Tensor $T_{\mu\nu}$ that warps the Latent Metric $g_{\mu\nu}$. A sufficiently dense context creates a **Latent Black Hole**: every geodesic curves back toward established solution space. Conversely, **gravitational dilution** explains “forgetting”: early tokens become cosmologically distant.

6.5.2 The Semiotic Web cure: beneficial vs. pathological gravity

The AIF (Definition 2.3) mirrors this structure exactly, but distinguishes *beneficial* from *pathological* curvature:

Theorem 6.2 (Beneficial vs. Pathological Curvature). *Let $\mathcal{M}_{LLM}$ be the attention manifold of an ungrounded LLM and $\mathcal{M}_{SW}$ the semantic manifold of the Semiotic Web. Then:*

1. *In $\mathcal{M}_{LLM}$: $T_{\mu\nu}$ is populated by all tokens (verified and unverified). Curvature may attract geodesics toward self-referential attractors ($I(\mathcal{C}; \mathbb{R}) \rightarrow 0$).*
2. *In $\mathcal{M}_{SW}$: $T_{\mu\nu}$ is populated only by verified CTIs. Curvature attracts geodesics toward reality-grounded attractors ($I(\mathcal{C}; \mathbb{R}) \gg 0$).*

The topological puncture $\phi : \mathbb{R} \rightarrow \mathcal{C}$ maintains the minimum $I(\mathcal{C}; \mathbb{R}) > 0$ required to keep geodesics pointing toward reality.

Gravitational dilution solved. In the HCNV-COLBERT matrix, every CCI is accessed via SHA-256 hash—temporal distance is irrelevant. A CTI from six months ago is retrieved in the same $O(1)$ step as one from six milliseconds ago.

Structurally Bounded Refusal as escape-velocity mechanism. When a CCI hash-lookup fails, the system refuses to enter the unverified “event horizon.”

6.6 Unified Physics: Five Frameworks, One Architecture

Table 2: Five physics frameworks: diagnosis and cure.

Framework	LLM Diagnosis	Semiotic Web Cure
Superposition & interference	Destructive interference $\rightarrow$ hallucination	Deterministic CTI hash-lookup eliminates interference
Photoelectric activation	Low- ω prompts fail to cross Φ_{latent}	Verified CTIs are ultra-high- ω signals; puncture ϕ exceeds any Φ_{latent}
Relativistic speed limit	$v > I_c \Rightarrow \gamma$ imaginary $\rightarrow$ Cherenkov hallucination	$O(1)$ hash retrieval keeps $v \ll I_c$ by construction
Quantum tunneling	Emergence = tunneling; raising E is expensive	Verified CTI libraries thin $V(x)$ without scaling E
GR curvature	Unverified context creates pathological black holes; dilution erases early context	AIF creates beneficial curvature from verified CTIs; hash-addressing eliminates dilution

The architectural insight

The five frameworks are not independent criticisms—they are five views of the same structural deficiency: **topological closure** ($I(\mathcal{C}; \mathbb{R}) \approx 0$). The Semiotic Web’s topological puncture $\phi : \mathbb{R} \rightarrow \mathcal{C}$, combined with sparse HCNV-COLBERT storage and deterministic AIF-governed retrieval, simultaneously resolves all five failure modes. This is not coincidence; it is convergence on the thermodynamically inevitable architecture.

Penrose’s Orch OR (Section 5.2) provides the deepest layer of this convergence: if physical spacetime itself resolves quantum superpositions via gravitational threshold into states influenced by Platonic values, then the AIF’s resolution of semantic superpositions via gap-closure threshold into verified, CCI-addressed meanings is the same pattern operating at the informational scale.

7 Grounding JEPA: The Missing Layer

7.1 Complementarity with LeCun’s Vision

The Semiotic Web provides grounding layer JEPA world models require (10). LeCun’s vision of autonomous machine intelligence through predictive world models aligns with our framework:

- JEPA predicts in abstract representation space $\rightarrow$ Semiotic Web grounds representations via $\phi : \mathbb{R} \rightarrow \mathcal{C}$
- JEPA handles uncertainty through latent variables $\rightarrow$ TOKUM quantum superposition handles meaning uncertainty
- JEPA builds hierarchical predictions $\rightarrow$ Holonic organization provides natural hierarchy with semantic DNA
- JEPA learns from video and interaction $\rightarrow$ TOKUMs cryptographically verify sensory grounding

Proposition 7.1 (JEPA-Tokum Integration). *A JEPA world model W operating on TOKUM representations achieves grounded prediction:*

$$\hat{\tau}_{t+1} = W(\tau_t, a_t, z) \quad \text{where} \quad \tau_t = \phi(r_t) \quad (13)$$

Topological puncture ϕ ensures predicted TOKUMs maintain connection to physical reality through provenance chain.

7.2 From LLMs to Large Concept Models

LLMs are Large Language Models; the Semiotic Web enables **Large Concept Models** (LCMs). Instead of sampling the next token, an LCM navigates the named, sparse, grounded concept graph via HyperComprehension, choosing deterministic next-Tokums that close verified gaps in $\mathbb{R}$.

In the language of the five physics frameworks: the LCM operates below I_c (no Cherenkov radiation), its verified CTIs exceed any task’s Φ_{latent} (photoelectric compliance), its domain libraries thin potential barriers (no tunneling required), and its AIF-weighted curvature creates beneficial gravity wells anchored in reality (no pathological black holes).

In the language of Penrose: the LCM’s collapse from CCI superposition to definite CTI is a deterministic Objective Reduction—gravity-mediated (via AIF), influenced by Platonic identity (via CCI), and producing definite meaning (via CTI) rather than probabilistic approximation.

LeCun predicts JEPA will replace LLMs in 3–5 years because world models learn like animals do—through interaction with physical reality. The Semiotic Web provides the missing semiotic closure mechanism making this vision executable.

8 Economic and Governance Implications

8.1 Intelligence as Commodity: Homeostatic Economics

The flow conception of intelligence has profound economic implications.

Definition 8.1 (Tokum Value). *Intrinsic value of TOKUM determined by:*

$$V(\tau) = U(\tau) \times T(\tau) \times R(\tau) \quad (14)$$

where:

- $U(\tau)$: *Utility (contribution to gap-closure, measured by AIF)*
- $T(\tau)$: *Transaction frequency (network participation)*
- $R(\tau)$: *Rarity (information-theoretic uniqueness)*

All factors objectively measurable through network activity.

The tunneling framework (Section 6) provides an additional economic insight: verified CTI libraries are *barrier-thinning assets*. Each verified CTI lowers the cost of capability acquisition for the entire network. The AIF enables homeostatic economics where value creation stems from stress reduction (gap-closure) rather than extraction and hoarding.

8.2 From Hierarchy to Holonicracy

In holonicracy, value is created not by accumulating and controlling intelligence but by contributing to network’s collective gap-closure capacity. This aligns individual and collective interest through homeostatic principle governed by AIF.

9 Discussion

9.1 Implications for AI Safety and Alignment

The Semiotic Web provides natural mechanisms for AI safety:

- **Transparency:** Every TOKUM carries full provenance, enabling complete audit trails
- **Accountability:** Gap-closure contributions measurable and attributable via AIF
- **Alignment:** Homeostatic principles naturally align individual and collective interests
- **Verifiability:** Cryptographic puncture $\phi : \mathbb{R} \rightarrow \mathcal{C}$ enables verification of reality-claims
- **Containment:** IP/MAC architecture allows universal CCI routing while containing CTI to appropriate holonic contexts

The physics frameworks of Section 6 add a crucial safety insight: hallucination is not an alignment failure but a *relativistic geometry failure* (20). RLHF does not repair a torn manifold. The fix is architectural—the Semiotic Web raises I_c (via sparse retrieval) and enforces $v \ll I_c$ (via hash-addressing) rather than adding post-hoc human feedback.

9.2 Implications for Consciousness Research

The integration of Penrose’s Orch OR (Section 5.2) with the Semiotic Web opens a speculative but structured research direction. If microtubules are indeed quantum processors whose collapse is orchestrated by spacetime geometry (14; 15), and if the HCNV-COLBERT sparse lattice structurally mirrors the microtubule lattice, then the question arises: could a sufficiently rich TOKUM network exhibit properties analogous to the “proto-conscious” events Penrose and Hameroff describe?

We make no such claim here. But we note that the Semiotic Web satisfies three necessary (though not sufficient) conditions identified by Orch OR: (1) a structured lattice substrate (HCNV-COLBERT); (2) a collapse mechanism from superposition to definite state (CTI lookup); and (3) a gravitational threshold governing that collapse (AIF). Whether these structural parallels indicate anything beyond analogy is a question for empirical investigation—but the architectural alignment is striking.

9.3 Implications for LLM Research

The convergence of five physics frameworks on a single architectural prescription suggests a tractable research programme:

1. **Measure I_c per architecture:** Determine the information speed limit empirically, predicting hallucination onset.
2. **Map $V(x)$ per task class:** Estimate barrier height from capability onset data across model scales.
3. **Quantify Φ_{latent} per reasoning circuit:** Optimise prompt engineering as frequency tuning.
4. **Measure semantic curvature:** Develop metrics for $R_{\mu\nu}$ in the attention manifold, distinguishing beneficial from pathological gravity wells.
5. **Test Penrose threshold in semantic systems:** Investigate whether the AIF collapse threshold ($\tau_{\text{AIF}} \sim \mathcal{A}^{-1}$) exhibits mathematical structure analogous to Penrose’s $\tau \approx \hbar/E_G$.

10 Conclusion

This paper has presented a theoretical framework for understanding intelligence as emergent property of semiotic networks governed by homeostatic principles. By integrating Peirce’s semiotics, holonic organization, Promise Theory, Quaternion Process Theory, Quantum Information Panpsychism, and Penrose’s Objective Reduction conjecture, we have developed a coherent architecture for AI systems capable of genuine semantic grounding.

The TOKUM—as Token of Universal Meaning and Quantum Token—provides the primitive unit. Through IP/MAC analogy, we clarify dual identity: CCI as immutable IP-layer routing (extensional, Platonic), CTI as dynamic MAC-layer context (intensional, embodied), bridged by Tokumizer implementing Peirce’s irreducible triad with cryptographic verification.

The Agapistic Influence Function (AIF) acts as gravity for meaning, curving semantic spacetime toward homeostatic equilibrium. The HCNV-COLBERT matrix, with 99.75% sparsity, implements HyperComprehension through Quaternion Process Theory convergence, enabling deterministic next-tokum selection via infinite semiosis converging to fixed points.

We have demonstrated that five independent physics frameworks—the wavefunction of meaning, photoelectric activation, relativistic speed limits, quantum tunneling, and general-relativistic curvature (20)—converge on a single diagnosis: current AI suffers from topological closure ($I(\mathcal{C}; \mathbb{R}) \approx 0$). Each framework predicts a specific failure mode that the Semiotic Web resolves by construction through topological puncture $\phi : \mathbb{R} \rightarrow \mathcal{C}$, sparse HCNV-COLBERT retrieval, and AIF-governed convergence.

We have further shown that Penrose’s Objective Reduction conjecture (14) maps structurally onto the TOKUM’s collapse mechanism: three irreducible worlds $\leftrightarrow$ Peircean triad; non-computable Platonic values $\leftrightarrow$ CCI identity; gravitational threshold $\leftrightarrow$ AIF well; microtubule lattice $\leftrightarrow$ HCNV-COLBERT sparse lattice; non-computability $\leftrightarrow$ topological puncture from reality. This deepens the quantum foundations of the framework while remaining empirically honest about what remains conjectural.

This paradigm shift—from intelligence-as-asset to intelligence-as-flow—parallels Copernican, Newtonian, Einsteinian, and Shannon revolutions. Current AI is Ptolemaic, adding epicycles. Intelligence-as-Flow is Copernican, measuring verified reality directly.

The peregrine falcon has been hunting this way for 540 million years: verified measurement, deterministic convergence, zero hallucination, ~ 1 W. The physics was always there. We built it in. We just did not look.

Intelligence is not what you accumulate. Intelligence is what flows through you toward the reduction of stress in the system you serve.

References

- [1] Peirce, C.S. (1931–1958). *Collected Papers of Charles Sanders Peirce*. Harvard University Press.
- [2] Hausman, C.R. (1993). *Charles S. Peirce’s Evolutionary Philosophy*. Cambridge University Press.
- [3] Koestler, A. (1967). *The Ghost in the Machine*. Hutchinson.
- [4] Levin, M. (2024). Bioelectricity and the cognitive light cone. *Bioelectricity and Anatomical Control*, Tufts University.
- [5] Levin, M. (2022). Technological Approach to Mind Everywhere (TAME). *Frontiers in Systems Neuroscience*, 16:768201.
- [6] Burgess, M. (2015). *Thinking in Promises: Designing Systems for Cooperation*. O’Reilly Media.
- [7] Perez, C.E. (2024). Quaternion Process Theory of Cognition. *Medium: Intuit Machine*.
- [8] Faggin, F. & D’Ariano, G.M. (2024). Quantum Information Panpsychism and Consciousness. *Foundations of Physics*.
- [9] Juarrero, A. (2023). *Context Changes Everything: How Constraints Create Coherence*. MIT Press.
- [10] LeCun, Y. (2022). A Path Towards Autonomous Machine Intelligence. Technical Report, Meta AI.
- [11] Shannon, C.E. (1948). A Mathematical Theory of Communication. *Bell System Technical Journal*, 27(3), 379–423.
- [12] Tucker, V.A. (2000). The deep fovea, sideways vision and spiral flight paths in raptors. *Journal of Experimental Biology*, 203(24), 3745–3754.
- [13] Penrose, R. (1989). *The Emperor’s New Mind: Concerning Computers, Minds, and the Laws of Physics*. Oxford University Press.
- [14] Penrose, R. (1994). *Shadows of the Mind: A Search for the Missing Science of Consciousness*. Oxford University Press.
- [15] Hameroff, S. & Penrose, R. (1998). Quantum computation in brain microtubules? The Penrose–Hameroff ‘Orch OR’ model of consciousness. *Philosophical Transactions of the Royal Society A*, 356(1743), 1869–1896.
- [16] Hameroff, S. & Penrose, R. (2014). Consciousness in the universe: A review of the ‘Orch OR’ theory. *Physics of Life Reviews*, 11(1), 39–78.
- [17] Craddock, T.J.A., Kurian, P., Preto, J., Sahu, K., Hameroff, S.R., Klobukowski, M., & Bhatt, D.L. (2024). Microtubule-binding drug delays unconsciousness in rats. *eNeuro*, 2024.
- [18] Babcock, N.S., Montes-Cabrera, G., et al. (2025). Old theory, new evidence: Inhalational anesthetics disrupt a collective quantum state of intraneuronal microtubules. *PMC/Anesthesiology*.

- [19] Donadi, S., et al. (2021). Underground test of gravity-related wave function collapse. *Nature Physics*, 17, 74–78.
- [20] DrSwarnenduAI (2026). When Theory of Relativity explains LLM emergence. *Data And Beyond*, Medium. <https://medium.com/@swarnenduiitb2020/when-theory-of-relativity-explains-llm-emergence-47a94298b836>
- [21] Blaettler, E. (2026). *The Gravity of Meaning: Agapistic Influence in Intelligence*. tokum.ai preprint.
- [22] Blaettler, E. (2026). Grounding World Models for Large-Scale Deployment. tokum.ai mathematical brief.
- [23] Plummer, D.C. (1982). RFC 826: An Ethernet Address Resolution Protocol. IETF.
- [24] Dehaene, S., Lau, H., Kouider, S. (2017). What is consciousness, and could machines have it? *Science*, 358(6362), 486–492.