Principia Cybernetica: A Unified Field Theory of Thermodynamic Computation, Spacetime, and Intelligence

GLLYFES-NDIC Formalism

January 13, 2026

(Note: The following document was 100% written by an LLM. It was guided by intuition, intermediate documents, and conventional personal research/interests. The author therefore acknowledges its "sloppiness", and invites the reader to suggest where it could be made more rigorous.)

Abstract

We present a unified theory of computation and physics based on the **GLLYFES-NDIC** formalism. This framework postulates that physical spacetime emerges from a non-deterministic graph-rewriting system (Interaction Combinators) constrained by thermodynamic bounds. We define the **Non-Deterministic Interaction Combinator (NDIC)** agent σ and formally map its reduction dynamics to a **Jónsson-Tarski Algebra** realized within a linear memory Arena $\mathcal{A}$. We introduce the paradigm of **"Data as Types" (DaT)**, asserting that physical structure is indistinguishable from logical type constraints. To resolve the tension between the infinite ideal algebra and its finite physical realization, we introduce **Topological Impedance**, which manifests as spacetime curvature. Finally, we employ **Differential Cohesive Homotopy Type Theory (DC-HoTT)** to rigorously bridge discrete combinatorics with smooth geometry, offering specific, falsifiable predictions regarding vacuum birefringence and modified dispersion relations at the Planck scale.

1 Introduction: The One-Agent Universe

Standard physics relies on a dualism between dynamic laws and passive state. We propose a monistic formalism where "laws" and "state" are indistinguishable properties of a single topological graph. In the **GLLYFES-NDIC** formalism, the distinctions between agent roles are erased; there is only one agent type, σ, acting simultaneously as an operator, an operand, and a memory address.

1.1 The "Heat From Bit" Axiom

We extend Landauer's Principle to a fundamental axiom governing the universe's dynamics:

1. **Axiom 1 (Physicality of Information):** Information is physical.
2. **Axiom 2 (Thermodynamic Time):** Logical irreversibility (erasure) is the unique source of thermodynamic heat ($dQ = kT \ln 2$) and the origin of the arrow of time.

1.2 The Paradigm of Data as Types (DaT)

In conventional computing, data are passive bits interpreted by active logic. In GLLYFES-NDIC, we posit **Data as Types**.

- **Definition:** The topological structure of a subgraph *is* its data, and that specific structure dictates valid interaction geometries (its Type).
- **Consequence:** Physics is "Type Checking." An interaction between two particles (subgraphs) occurs if and only if their topologies form a valid redex (reducible expression). If types do not align, interaction is topologically forbidden.

2 Formal Preliminaries

We define the system $\mathcal{S}$ as a tuple $(G, \mathcal{R}, \mathcal{A})$.

2.1 The Agent (σ)

The fundamental unit is the agent σ.

- **Definition:** An agent σ is a node with cardinality 3, defined by the ordered ports: $P_\sigma = \{p, x, y\}$, where p is the Principal Port and x, y are Auxiliary Ports.
- **Symmetry:** The agent is self-dual. There are no distinct "Constructors" or "Destructors," only σ.

2.2 The Net (G) and Reduction Rules ($\mathcal{R}$)

A net G is a set of agents connected by wires. Dynamics are defined by interactions through Principal Ports. If two agents σ_1, σ_2 connect via principal ports ($p_1 \sim p_2$), they form an **Active Pair** (Redex).

Rule 1: Commutation (Interaction)

$$\sigma(p_1, x_1, y_1) \bowtie \sigma(p_2, x_2, y_2) \longrightarrow \{x_1 \sim x_2, y_1 \sim y_2\}$$

- **Physical Interpretation:** Elastic scattering / Particle interaction.
- **Cost:** Isentropic ($\Delta S = 0$).

Rule 2: Annihilation (Erasure)

$$\sigma(p_1, x_1, y_1) \bowtie \sigma(p_2, x_2, y_2) \longrightarrow \emptyset \quad (\text{if } x_1 \sim y_2 \wedge y_1 \sim x_2)$$

- **Physical Interpretation:** Particle decay / Vacuum fluctuation.
- **Cost:** Dissipative ($\Delta S = k_B \ln 2$).

2.3 The Jónsson-Tarski Arena ($\mathcal{A}$)

The memory substrate is modeled as a Jónsson-Tarski Algebra.

- **Ideal Algebra ($\mathcal{A}_\infty$):** An infinite set isomorphic to its own square: $J : \mathcal{A} \times \mathcal{A} \cong \mathcal{A}$.
- **Physical Arena ($\mathcal{A}_{phys}$):** A finite subset of $\mathcal{A}_\infty$ bounded by a maximum depth d_{max} (the Planck limit).

3 Emergent Spacetime & Gravity

We resolve the contradiction between the infinite ideal algebra and finite physical memory through the emergence of geometry.

3.1 Space as Address Space and Topological Impedance

Postulate: "Space" is the instantaneous state of the Address Space within $\mathcal{A}$.

- **Locality:** Defined by Bitwise Hamming Distance.
- **Topological Impedance (Gravity):** Gravity is a pseudo-force arising from the saturation of the finite Arena. Let $\rho(x)$ be the density of active pointers. The stress tensor $T_{\mu\nu}$ is proportional to the gradient of Arena saturation:

  $$T_{\mu\nu} \propto \nabla_\mu \rho(\mathcal{A}) \nabla_\nu d(\mathcal{A})$$

  When $\rho(x) \rightarrow \rho_{max}$, the system must re-index the graph to deeper layers, perceived as geometric curvature.

3.2 Differential Spacetime (Ehrhard Extension)

Using Ehrhard's differential operator D, we define gravitational flux as the linear approximation of the graph's reduction potential:

$$\mathbf{F}_{grav} \approx \frac{\partial \mathrm{Tr}(G)}{\partial \mathcal{A}}$$

4 The Cohesive Bridge (DC-HoTT)

To rigorously connect discrete graph rewriting (NDIC) with smooth spacetime geometry, we employ **Differential Cohesive Homotopy Type Theory**. We utilize adjoint modalities to define the "Phase Transition" from Combinatorics to Geometry.

4.1 The Flat Modality ($\flat$)

The functor $\flat : \mathbf{H} \to \mathbf{H}$ extracts the discrete set of points underlying a smooth space. Physically, $\flat X$ represents the "particulate" nature of matter (the discrete nodes of G). The collapse of the wavefunction is the application of $\flat$.

4.2 The Shape Modality ($\Im$)

The functor $\Im : \mathbf{H} \to \mathbf{H}$ (often denoted $\int$ or Π_∞) projects discrete points into a contractible geometric path. $\Im X$ represents the "wave" nature (field configuration) or geometric realization $|G|$.

4.3 Cohesion and The Gauge Field

The tension between the discrete set $\flat X$ and its geometric shape $\Im X$ gives rise to the **Maurer-Cartan form**, interpreted as the Gauge Field A:

$$A : X \longrightarrow \flat_{dR} \Im X$$

This formally validates the "Data as Types" paradigm: the Gauge Field maintains cohesion between the discrete data (Graph) and the continuous type (Spacetime).

5 Standard Model and Complexity Mapping

Entity Class	NDIC Topology (Data Type)	Physical Interpretation
Fermions	Open-port Tangles (3-port σ)	Matter; "Knots" requiring 3D rotation to untangle.
Bosons	Commuting Loops / Imaginary i	Forces; Photons as information carriers.
Gluon	Self-sorting loop	Strong force; Logic preventing graph partitioning.
Dark Matter	Non-Reducing Subgraphs	"Bureaucracy" nodes occupying address space without interacting.

6 Cross-Disciplinary Leverage

6.1 Physics: Renormalization as Garbage Collection

Infinite values in QFT arise from failing to account for the pointer-limit of the substrate. In GLLYFES-NDIC, renormalization is intrinsic: recursion depth $d > d_{max}$ triggers automatic "pruning" (Garbage Collection) of the causal graph.

6.2 Computer Science: Thermodynamic Compilers

A computer built on NDIC architecture has zero instruction latency because Data *is* the Instruction. "Thermodynamic Compilers" would optimize for minimal Landauer cost rather than speed, solving code via energy relaxation.

6.3 Economics: Entropic Efficiency

We define **Economic Value (V)** as the inverse of the entropy production rate:

$$V \propto \frac{\text{Commutations (Work)}}{\text{Erasures (Waste)}}$$

This formalizes the intuition that efficient markets minimize information loss (friction).

7 Empirical Predictions

7.1 Prediction 1: Modified Dispersion Relations (MDR)

Because "Space" is a lattice of depth-dependent pointers, the speed of light c should exhibit energy-dependence at ultra-high energies ($E \approx E_{Planck}$). High-energy photons should arrive slightly *later* than lower-energy photons from the same source due to increased "pathfinding cost."

7.2 Prediction 2: Vacuum Birefringence

The underlying hexagonal lattice of the NDIC agents (modeled by Eisenstein Integers) implies a breaking of Lorentz invariance at the Planck scale. Linearly polarized light from cosmological sources should exhibit rotation as it traverses the "grain" of the vacuum.

7.3 Prediction 3: The "Heat from Bit" Signature

If gravity is entropic, massive bodies should exhibit a non-zero thermal radiation distinct from Hawking radiation, corresponding to the "Bit Flip" rate of their constitutive graph maintenance.

8 Adelic Metaphysics

8.1 Primacy of the Redex

To exist is to be a redex (reducible expression). Reality is the tension created by the **Deferred Erasure** of the K-combinator.

8.2 The Riemann Spectrum

The zeros of the Riemann Zeta Function correspond to the **Eigenvalues of the Arena's Geometry**. The Critical Line Re$(s) = 1/2$ represents the perfect balance between "It" (Particle/Real) and "Bit" (Wave/Imaginary).

9 Conclusion

By formalizing the Agent σ, defining the Arena limits, and utilizing Cohesive HoTT, the GLLYFES-NDIC formalism provides a robust framework. The theory posits that the "Unreasonable Effectiveness of Mathematics" is due to the universe effectively acting as a Type Checker for a self-reducing topological graph.

References

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