Toward a Universal Phaneron: Distinction, Connection, and Abstraction as a Substrate for Physics

Anonymous Preprint

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Abstract

We propose that a minimal informational substrate—*distinctions* and *connections* with *abstraction* as a reuse/compression dynamic—can represent physically realizable worlds. We call this the *Universal Phaneron* (UP): an unlabeled, undirected graph whose local rewrite rules act to preserve consistency while minimizing description length under predictive constraints. This framework reconciles an undirected structural base with directional phenomena (causality, time) by treating relations as first-class patterns with internal roles, and it explains why compact laws and efficient reuse should emerge. We connect the UP to information-based physics ("it from bit", holographic bounds), sketch how space/time and conservation laws might arise from symmetry in rewrite rules, articulate principled limits on self-simulation, and outline toy computations to probe which laws and constants are structurally possible.

1 Motivation

Physics repeatedly compresses the world into shorter descriptions: conservation from symmetry, gauge structure from redundancies, dynamics from extremal principles. We ask whether there exists a substrate that *forces* such compression: an informational base where the only primitives are *distinctions* (nodes) and *connections* (edges), and where higher structure emerges as reusable *patterns*. Under the UP, directional concepts (cause/effect, before/after) do not live in base-edge orientation but inside small relation-patterns. Laws are the short programs (local rewrite rules) that, when iterated, maintain global consistency and minimize description length under predictive adequacy.

2 The Universal Phaneron (UP)

Let $G = (V, E)$ be a finite or countable undirected simple graph (no labels). **Distinctions** correspond to V; **connections** to E. A **pattern** is the isomorphism class of a small induced subgraph. We posit a family of local **rewrite rules** $\mathcal{R}$ that map neighborhoods to neighborhoods. A global step selects a multiset of non-overlapping rule applications; the next state G' is obtained by performing them. Selection is biased by a *compression-prediction criterion* $\Delta\mathcal{L}$ (e.g., an MDL-like description-length plus predictive discrepancy functional). Crucially, relations that appear directional are represented by *pattern nodes* with asymmetric *roles*, not by arrows in E.

2.1 Dynamics as rewrite with a compression prior

A single *tick* of UP evolution consists of (i) proposing local rewrites, (ii) scoring candidates by $\Delta\mathcal{L}$ (shorter + more predictive is better), (iii) applying a consistent subset, and (iv) consolidating constraints that propagate globally (e.g., pattern counts, boundary conditions).

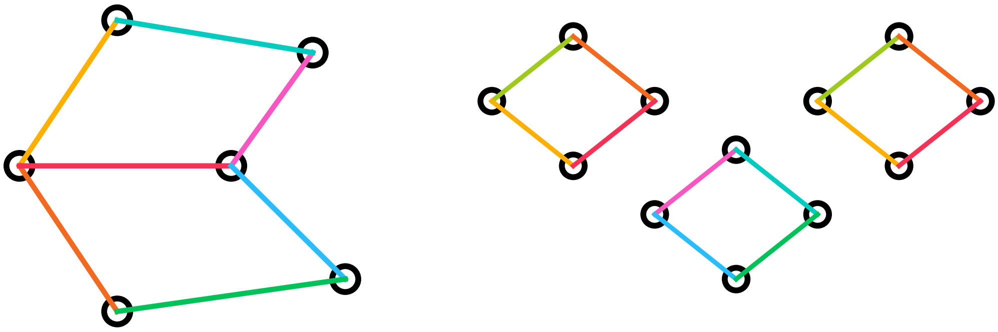

Figure 1: **UP substrate.** Left: unlabeled, undirected graph. Right: repeated motifs as reusable patterns (abstractions).

2.2 From undirected substrate to spacetime and causality

Temporal order arises from the *sequence* of rewrites; causal asymmetry arises inside relation-patterns that consistently encode roles ("source/target", "before/after") and are preserved by $\mathcal{R}$. Under coarse-graining, these lead to effective light-cone constraints; the conjecture is that Lorentz-like symmetries emerge from invariances of $\mathcal{R}$ under neighborhood renaming and scale transformations.

3 Information Bounds and Holographic Intuitions

Because UP states are graphs, capacity constraints take boundary form: the number of distinct edges crossing a cut upper-bounds the mutual information between inside and outside. We hypothesize that a UP analogue of holographic bounds emerges generically: description length of an interior subgraph is dominated by boundary degrees of freedom coupled through $\mathcal{R}$.

4 Relation to Minds: Phanera as Subgraphs of the UP

A *Phaneron* (mind) is a subgraph inside the UP that builds a compressed, agent-centric model of other parts of the graph. It uses the same primitives and a similar compression prior, but under tight resource budgets and a self-anchored control policy. The shared substrate explains why minds discover compact laws and reusable abstractions: the UP itself rewards them.

5 Predictions and Recoveries

Conservation from symmetry (Noether-style). If $\mathcal{R}$ is invariant under a family of neighborhood renamings, pattern counts conjugate to that symmetry are conserved under evolution.

Area-law entanglement / boundary scaling. For wide classes of $\mathcal{R}$, coarse-grained state description scales with cut size; interior volume does not add independent degrees of freedom at fixed boundary.

Figure 2: **Direction as pattern.** An apparently one-way association $A \to B$ is implemented conceptually via an intermediate relation node R with roles; the substrate remains undirected.

Figure 3: **UP evolution.** Propose local rewrite $\to$ predict/compress $\to$ apply $\to$ consolidate.

Spectral dimension flow. Random-walk or heat-kernel probes on evolving graphs exhibit scale-dependent effective dimension; continuum limits approach familiar field behavior if $\mathcal{R}$ respects locality.

Discrete cutoff. A minimal cycle length or motif can act as a natural UV regulator, yielding finite self-energies in continuum approximations.

6 Simulation, Limits, and the "World Formula"

If the UP plus initial data are compact, simulated universes become possible. However, self-simulation at *full resolution* inside the same universe is constrained by boundary-dominated capacity and energy-computation bounds; perfect omniscient replay is excluded. Partial simulations (coarse, local) should be feasible and scientifically decisive. Deterministic $\mathcal{R}$ yield deterministic micro-evolution; chaos and computational irreducibility may still limit predictability and "jump-ahead" shortcuts.

7 Toy Programs and Empirical Hooks

We propose minimal UP toy rules (e.g., degree-equalizing rewrites, triad closure with MDL thresholds) and measure emergent geometry, locality, and area-law scaling. Empirically, the framework suggests seeking boundary-dominated descriptions, scale-dependent spectral dimensions in quantum gravity candidates, and conservation laws tied to local rewrite invariances.

8 Related Directions

The UP resonates with information-centric physics (e.g., "it from bit", information as physical), discrete spacetime programs (spin networks/foams), and algorithmic accounts of law emergence.

Figure 4: **Boundary-dominated capacity.** In the UP, coupling across a boundary constrains interior description; capacity scales with boundary complexity.

Figure 5: **Partial universes.** Simulations can target local patches at appropriate resolution; full self-simulation at native resolution is capacity-limited.

Our added ingredients are (i) strictly unlabeled, undirected substrate, (ii) relations as pattern nodes with roles, and (iii) an explicit compression/prediction prior guiding evolution.

9 Limitations

We have not derived standard model content, exact Lorentz symmetry, or cosmological parameters. $\mathcal{R}$ and $\Delta\mathcal{L}$ remain underspecified; multiple choices may fit known phenomena. Information bounds are argued structurally, not proven in full generality. This is a proposal for a testable substrate, not a completed theory.

10 Conclusion

An undirected, unlabeled graph with local rewrites guided by compression can serve as a universal information substrate. Directionality, time, and law-like regularities emerge as reusable patterns; conservation, locality, and boundary scaling follow from symmetries and coupling structure. If correct, the Universal Phaneron ties physics and cognition to the same primitive engine and frames a concrete program of toy simulations, recoveries, and falsifiable scaling claims.