

# Mapping interpretation of topological graph elements

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**Rule:**  $\{\{x, y\}, \{y, z\}\} \rightarrow \{\{x, z\}, \{x, w\}, \{w, z\}\}$

This document presents a **computational isomorphism** rather than a rigorous physical derivation. It explores how standard physical phenomena (Gravity, Quantum Non-locality) can be interpreted as emergent properties of a minimal graph-rewriting system.

Explanation of the source of the rules:

## Abstract & Theoretical Foundation

The evolution rule of this model is synthesized from an abstraction of linear dynamical systems, probabilistic frameworks, and dynamic programming (DP) optimization. It represents a conceptual exploration of how complex causal structures might emerge from minimal computational instructions.

The transition from **bi-directional interactions** (active processing) to **mono-directional causal links** (historical record) serves as a discrete analog for the dynamical phase transition from **Space-like intervals** to **Time-like intervals**. This mechanism effectively enforces a "**Causal Rigidity**," preserving the immutability of historical states while allowing for local topological fluctuations.

## Notation and Formal Definitions

### 1. $x - y$ (Active Interaction / Space-like)

This denotes a reciprocal relationship where nodes \$x\$ and \$y\$ exert mutual influence. In our computational simulation, the precise sequence of interaction is treated as stochastic, representing underlying quantum-like fluctuations before causal fixation.

### 2. $x \rightarrow y$ (Causal Fixation / Time-like)

This denotes a determined causal trajectory. Once a relationship transitions to this state, the path is "**frozen**" or rendered inert. This means it no longer participates in further topological rewriting or evolutionary steps, effectively becoming part of the immutable causal history.

*The mapping of physical phenomena and formulas onto topological diagrams:*

## Chapter 1: Newtonian mechanics:

### The Computational Foundation of Classical Mechanics

#### 1.1 Formal Definition of State and Existence

In the Computational Universe Model, spacetime is not a continuous background but a discrete directed graph evolved by the fundamental rewriting rule:

$$\text{hat}\{R\}: \{\{x, y\}, \{y, z\}\} \rightarrow \{\{x, z\}, \{x, w\}, \{w, z\}\}$$

- **Existence (Persistence):** Defined as the topological consistency of a local node cluster  $V_{\text{local}}$  across successive computational steps  $\tau u$ . An object "exists" because the Rule performs constant "**In-place Refreshes**," maintaining the logical structure against the entropy of background graph expansion.
- **Mass (\$m\$): The Total Causal Connectivity**  
In the Computational Universe Model, the mass  $m$  of a local topological defect (particle) is defined not merely by its static density, but by its **Total Topological Degree**. This is the sum of its capacity for future interaction and its accumulated causal history.

#### 1.2 Strict Definitions of Force and Computation

- **Computational Power ( $\Omega$ ):** The system-wide rate of Rule execution. It is the raw "clock speed" of the universe, determining the maximum rate of causal information propagation.
- **Force ( $F$ ):** Defined as a **non-symmetric bias** injected into the Rule's rewriting direction.

**Axiom:** Force is the additional computational increment required to forcibly deflect a local causal path from its default geodesic.

#### 1.3 Derivation of Newton's Laws via Graph Theory

##### [1.3.1] The First Law: Continuity of Causal Paths

**Derivation:** In the absence of external computational bias, the evolution of a node cluster follows the **Principle of Minimum Computational Effort**.

- Once a cluster establishes a specific rewriting pattern (representing a velocity vector), the system preserves this pattern to maintain **Causal Invariance**. Altering this pattern would require a reallocation of Rule applications.
- **Essence:** Uniform linear motion is the self-perpetuating extension of a **geodesic**

**path** on the graph.

### [1.3.2] The Second Law: $F=ma$ (The Resource Allocation Identity)

**Derivation:**

1. Changing the direction of evolution requires a logical redirection of every node within the cluster.
2. Higher node density ( $m$ ) implies a greater number of logical units requiring redirection.
3. A higher rate of change (acceleration  $a$ ) requires more frequent redirection operations per unit of system time  $\tau$ .

- **Conclusion:**

$$F \text{ (Injected Computation)} = m \text{ (Code Complexity)} \cdot a \text{ (Path Deflection Rate)}$$

### [1.3.3] The Third Law: Symmetry of State Merging

**Derivation:**

1. Interaction between cluster A and cluster B is fundamentally a **State Merging** event between two sets of rewriting paths.
  2. Connections in the causal graph are reciprocal. Any modification A imposes on the topology of B necessitates a simultaneous feedback on the path of A to preserve global causal consistency.
- **Essence:** This is not merely a cancellation of forces, but a mathematical necessity for maintaining **Topological Conservation** within the graph.

## Summary

Under this framework, Classical Mechanics is the **macro-statistical manifestation of graph-rewriting rules in low-density, low-velocity regimes**.

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## Chapter2: *Special Relativity*

### The Conservation of Computational Capacity (The Zero-Sum Game)

In this framework, Special Relativity is interpreted not as a geometric property of light, but as a budgeting constraint of computational steps within the system.

Definitions

$C$  (System Clock / Speed of Light): The maximum number of rewriting operations allowed per node per tick. Normalized to  $C = 1$  (1 Hop / 1 Tick). This represents the hard limit of the system's refresh rate.

$V_{\{space\}}$  (Spatial Velocity): The portion of the budget spent on "Topological Reconfiguration" (breaking old edges and forming new ones to displace the node in the graph).

$V_{\{time\}}$  (Temporal Velocity): The portion of the budget spent on "Internal State Updates" (processing local loops, aging, and recording history).

The Fundamental Theorem: Conservation of Action

Since the Rule executes a fixed number of operations per tick, a particle cannot exceed its total computational budget. The allocation is orthogonal:

$$|\vec{V}_{\{total\}}|^2 = V_{\{space\}}^2 + V_{\{time\}}^2 = C^2$$

Deriving Time Dilation (The Lorentz Factor)

Consider an object moving with spatial velocity  $v$  (where  $V_{\{space\}} = v$ ). The remaining computational budget for its internal time ( $V_{\{time\}}$ ) is:

$$V_{\{time\}} = \sqrt{C^2 - v^2} = C \sqrt{1 - \frac{v^2}{C^2}}$$

At Rest ( $v = 0$ ):  $V_{\{time\}} = C$ . The object experiences maximum internal processing (aging at the normal rate).

At Max Speed ( $v \rightarrow C$ ):  $V_{\{time\}} \rightarrow 0$ . All computational resources are diverted to spatial displacement. The object has zero budget left for internal updates. Thus, Time stops.

**Conclusion:** Time Dilation is mathematically equivalent to computational latency induced by heavy resource allocation to motion.

Mass-Energy Equivalence ( $E = mc^2$ )

The Dimensional Unfolding Algorithm

The squared term ( $c^2$ ) in standard physics is often abstract. In Computational Cosmology, it represents a specific *Data Type Conversion* from 1D Storage to 2D Interaction.

Geometric Definitions

**Mass ( $m$ ) [1D]:** The size of the compressed data packet. It represents the number of nodes locked in "Frozen Paths" (closed logical loops). It behaves as linear data (Bitstream).

**Energy ( $E$ ) [2D]:** The "Action Flux" or "Causal Coverage Area" when that packet is unpacked and interacts with the background graph.

**$c$  (Rate):** The system's propagation bandwidth.

### The Decompression Process

When a "*Frozen Path*" (*Mass*) is broken, the linear data unfolds into a planar network. This expansion happens along two axes simultaneously:

***Axis X (Read Rate)*:** The rate at which nodes are released from the loop.

$$J_{\{out\}} = m \cdot c$$

***Axis Y (Spread Rate)*:** The rate at which the causal wavefront expands into neighbors.

$$R_{\{spread\}} = c$$

### Total Integration

Energy is the total Computational Area activated by the release of Mass.

$$E = \text{Read Rate} \times \text{Spread Rate}$$

$$E = (m \cdot c) \cdot c$$

$$E = m \cdot c^2$$

Conclusion:  $E = mc^2$  is the cost function of the universe's "*Unzip & Render*" algorithm. It quantifies the transition from *Linear Storage* ( $m$ ) to Planar Interaction ( $E$ ).

### General Relativity

#### Gravitational Lensing via System Lag

We replace the abstract "Curvature of Spacetime" with the concrete concept of "Computational Density & Lag."

#### The Model: Vacuum vs. Mass

Vacuum: Sparse node distribution. The Rule executes instantly.  $v_{\{proc\}} \approx C$ .

Mass ( $M$ ): Extremely dense node cluster (Frozen Paths). The Rule struggles to process the sheer volume of connections, creating a local *Processing Bottleneck*.

## The Refractive Index of Spacetime

We model the high-density region as a medium with a high "*Computational Refractive Index*" ( $n$ ). The effective processing speed  $v_{eff}$  at a distance  $r$  from Mass  $M$  is:

$$v_{eff}(r) = \frac{C}{n(r)}$$

Where the *Congestion Index*  $n(r)$  is derived from the node density gradient:

$$n(r) \approx 1 + \frac{GM}{rc^2}$$

## Deriving Gravitational Time Dilation

The "Local Clock" ( $d\tau$ ) ticks slower because the system is lagging:

$$d\tau = \frac{dt_{vacuum}}{n(r)} \approx dt \left(1 - \frac{GM}{rc^2}\right)$$

This derivation aligns perfectly with the weak-field approximation of the Schwarzschild metric.

## Deriving Geodesics (Gravity as Optimization)

Why do objects fall?

*Standard Physics*: They follow *geometric curvature*.

*Computational Universe*: They follow the *Path of Maximum Reuse*.

A moving object scans its neighborhood and finds that connecting to the high-density Mass allows it to share existing causal paths (Deduplication), whereas moving into empty space requires generating new paths (High Computational Cost). Following *Dijkstra's Algorithm* (or *Fermat's Principle*), the object's trajectory naturally bends towards the region of highest density.

*Conclusion*: Gravity is not a force pulling objects; it is the \*\*statistical tendency of causal paths to merge into high-density clusters to optimize storage efficiency.

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## Chapter3: Electromagnetism

### The Dynamics of Topological Chirality

#### Formal Definition of Charge and Field

In the Computational Universe Model, if Mass is defined as "Frozen Paths" (undirected structural density), then Charge is defined as "**Directed Frozen Paths**" or "**Topological**

## Chirality."

- Charge ( $q$ ) as Chirality:

Charge is formally defined as the topological handedness of a local node cluster during the Rule rewriting process.

- **Positive Charge (+):** A cluster where the Rule exhibits a **Clockwise Bias** (Right-Handedness) in generating causal loops.
- **Negative Charge (-):** A cluster where the Rule exhibits a **Counter-Clockwise Bias** (Left-Handedness) in generating causal loops.
- **Neutral ( $q=0$ ):** A cluster where topological chirality is symmetric or statistically canceled (e.g., a Neutron).
- Electric Field ( $\vec{E}$ ) as Graph Tension:

The Electric Field is not a physical fluid, but a Tension Gradient across the causal graph. When a Chiral Node attempts to connect with the neutral background mesh, the mismatch in rewriting direction creates a topological stress. The spatial distribution of this "twisting stress" is what we observe as the Electric Field.

- Magnetic Field ( $\vec{B}$ ) as Graph Vorticity:

The Magnetic Field represents the Dynamic Vorticity of the Rule's rewriting flow. When a Chiral Node moves (Current) or when Graph Tension changes, neighboring nodes are forced to undergo rotational rewriting to maintain connectivity. This "rotational flow of rewriting" is the Magnetic Field.

## Deriving Maxwell's Equations from Graph Rewriting

We reinterpret Maxwell's Equations not as axiomatic laws, but as conservation and propagation rules governing the topology of the causal graph.

### 1. Gauss's Law: The Source of Tension

$$\nabla \cdot \vec{E} = \frac{\rho}{\epsilon_0}$$

- **Graph Interpretation:** A Chiral Node (Source  $\rho$ ) inevitably forces a "twist" upon the surrounding non-chiral background graph. This topological distortion cannot vanish; it must propagate outwards to infinity.
- **$\epsilon_0$  (Permittivity):** Represents the "**Topological Stiffness**" of the background graph—its resistance to being twisted by a charge.

### 2. Gauss's Law for Magnetism: The Topological Constraint

$$\nabla \cdot \vec{B} = 0$$

- **Graph Interpretation:** The fundamental Rule  $\{\{x, y\}, \{y, z\}\} \rightarrow \{\{x, z\}, \dots\}$  always forms closed triangular circuits. In a directed graph formed by such rules, any "rotational flux" must be a closed loop to maintain causal consistency.
- **Conclusion:** A "magnetic monopole" (a node with only outgoing or incoming rotational flux) is **topologically forbidden** in this rewriting system.

### 3. Faraday's Law: Dynamic Stress Transfer

$$\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$$

- **Graph Interpretation:**  $\frac{\partial \vec{B}}{\partial t}$  represents a change in the rotational rewriting velocity (Vorticity). To preserve graph connectivity during this acceleration, adjacent regions must generate an opposing "linear tension" (Electric Field). This is the graph's **Elastic Response** to dynamic shear.

### 4. Ampere-Maxwell Law: The Propagation Mechanism

$$\begin{aligned} \nabla \times \vec{B} &= \mu_0 \left( \vec{J} \right. \\ &\quad \left. + \epsilon_0 \frac{\partial \vec{E}}{\partial t} \right) \end{aligned}$$

- **Graph Interpretation:** Rotational Flow (Magnetic Field) is generated by two mechanisms:
  1.  **$\vec{J}$  (Current):** The physical displacement of Chiral Nodes drags the surrounding mesh into rotation.
  2.  **$\frac{\partial \vec{E}}{\partial t}$  (Displacement Current):** A purely local change in Topological Tension triggers a chain reaction of rewriting, creating vorticity even without the motion of matter.
- **Conclusion:** This proves that the Rule can sustain a self-propagating chain of "Twist-Flow" updates in a vacuum—which is Light.

### The Speed of Light as System Latency

By combining the Graph Tension ( $\epsilon_0$ ) and Graph Inertia ( $\mu_0$ ), we derive the propagation speed of causal updates:

$$c = \sqrt{\epsilon_0 \mu_0}$$

- **Computational Meaning:** Light is not a particle traveling through space; it is the "**Wavefront of Rule Execution**" propagating across the grid.

- **Limit:** Since the Rule can only update neighbor-to-neighbor (1 Hop per Tick), the propagation speed  $c$  is necessarily a finite constant, representing the **Maximum System Latency**.
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## Chapter 4: Quantum Mechanics

### The Diffusion of Causal Potential

#### 3.1 Formal Definition of the Wave Function ( $\psi$ )

In standard physics, the wave function is an abstract probability amplitude. In the Computational Universe, it is a concrete measure of "**Rewriting Potential.**"

- *The Wave Function ( $\psi$ ) as Causal Potency:*

We define  $\psi(x, t)$  not as a particle's state, but as the state of the Graph Location  $x$  itself.

$$\psi(x, t) = \sqrt{\rho(x, t)} \cdot e^{i\theta(x, t)}$$

- **Magnitude ( $\rho$ )**: The **Computational Density** or "Attention" of the System. It represents the probability that the Rule will choose node  $x$  for the next update operation.
- **Phase ( $\theta$ )**: The **Cyclic State** of the local rewriting engine. Since the Rule  $\{x, y\}, \{y, z\} \rightarrow \dots$  is a multi-step process,  $\theta$  encodes which step of the algorithmic cycle the node is currently in.
- **The Imaginary Unit ( $i$ )**: Represents the **Orthogonal Rotation** between the internal update cycle (Time) and the external topological expansion (Space).

#### 3.2 Deriving the Schrödinger Equation from Graph Random Walks

We derive the Schrödinger Equation by treating the Rule execution as a **Discrete Random Walk** on the causal graph.

##### 1. The Conservation of Rewriting Probability

Total system attention is conserved (Unitary Evolution). The Rule must happen somewhere.

$$\frac{\partial \rho}{\partial t} + \nabla \cdot \vec{J} = 0$$

This continuity equation describes the flow of computational focus across the network.

## 2. The Kinetic Term: Topological Diffusion

When the Rule executes at node  $x$ , it creates new edges connecting  $x$  to its neighbors. Statistically, this causes the "Update Potential" to diffuse outward.

On a discrete grid, the rate of change of a value depends on the average of its neighbors minus its current value. This is the Discrete Laplacian:

$$D \cdot (\psi_{\text{neighbors}} - \psi_{\text{center}}) \approx -\frac{\hbar^2}{2m} \nabla^2 \psi$$

- **Interpretation:** The  $-\frac{\hbar^2}{2m} \nabla^2$  term represents the **Cost of Diffusion**. It is the computational effort required to spread the causal structure into the void.
- **$\hbar$  (Planck's Constant):** Represents the **Graph Resolution** or "Pixel Size." It quantifies the minimum discrete action required to define a valid graph update.

## 3. The Potential Term: Structural Resistance

$$V(x) \psi$$

- **Interpretation:**  $V(x)$  represents the **Topological Resistance** of the local environment. If node  $x$  is near a massive cluster (High Density) or a strong field (High Tension), the cost to update  $x$  increases. The Rule is less likely to execute there unless sufficient energy is supplied.

## 4. The Master Equation: Resource Allocation Balance

By balancing the "Rate of State Change" (Energy) against "Diffusion" and "Resistance," we obtain:

$$i \hbar \frac{\partial \psi}{\partial t} = \left[ -\frac{\hbar^2}{2m} \nabla^2 + V(x) \right] \psi$$

- **LHS (E):** The total computational budget allocated to updating this region.
- **RHS (Hamiltonian  $\hat{H}$ ):** The sum of the cost to diffuse structure (*Kinetic*) and the cost to overcome local density (*Potential*).

### 3.3 Quantum Tunneling as Graph Hopping

Standard physics views tunneling as "passing through a wall." In Graph Dynamics, it is **"Non-Local Connectivity."**

- Mechanism:

The Rule  $\{\{x,y\},\{y,z\}\} \rightarrow \{\{x,z\}, \dots\}$  establishes a direct link between  $x$  and  $z$ , effectively bypassing the intermediate node  $y$ .

- Interpretation:

If a potential barrier  $V(x)$  (e.g., a wall of high node density) exists, a classical particle must climb over it. However, the Graph Rewriting Rule operates on Topological Adjacency, not geometric distance.

There is a non-zero probability that the Rule generates a "shortcut" edge that connects a node inside the barrier directly to a node outside the barrier.

Conclusion: Tunneling is not magic; it is a Cross-Link Update that skips the "blocked" nodes in the graph.

### 3.4 Wave Function Collapse as Update Finalization

- **The Measurement Problem:** Why does  $\backslash\psi$  collapse to a point when observed?
- Computational Answer:

$\backslash\psi$  represents the "List of Potential Updates" (a pending queue).

"Measurement" (Interaction) forces the System to Commit to a specific update path to maintain causal consistency with the observer.

Once the Rule executes and the new edges are written to the database, the "potential" ( $\backslash\psi$ ) instantly vanishes and becomes "history" (Classical Reality).

Collapse is simply the transition from RAM (Pending Calculation) to Hard Drive (Written History).

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### Chapter Summary

Quantum Concept	Computational Interpretation
Wave Function ( $\backslash\psi$ )	Update Potential (Queue of pending rewrites).
Schrödinger Eq.	Diffusion Equation of computational attention.
Tunneling	Shortcut Edge Generation bypassing a dense cluster.

Quantum Concept	Computational Interpretation
Collapse	Commit Operation (Finalizing the rewrite).

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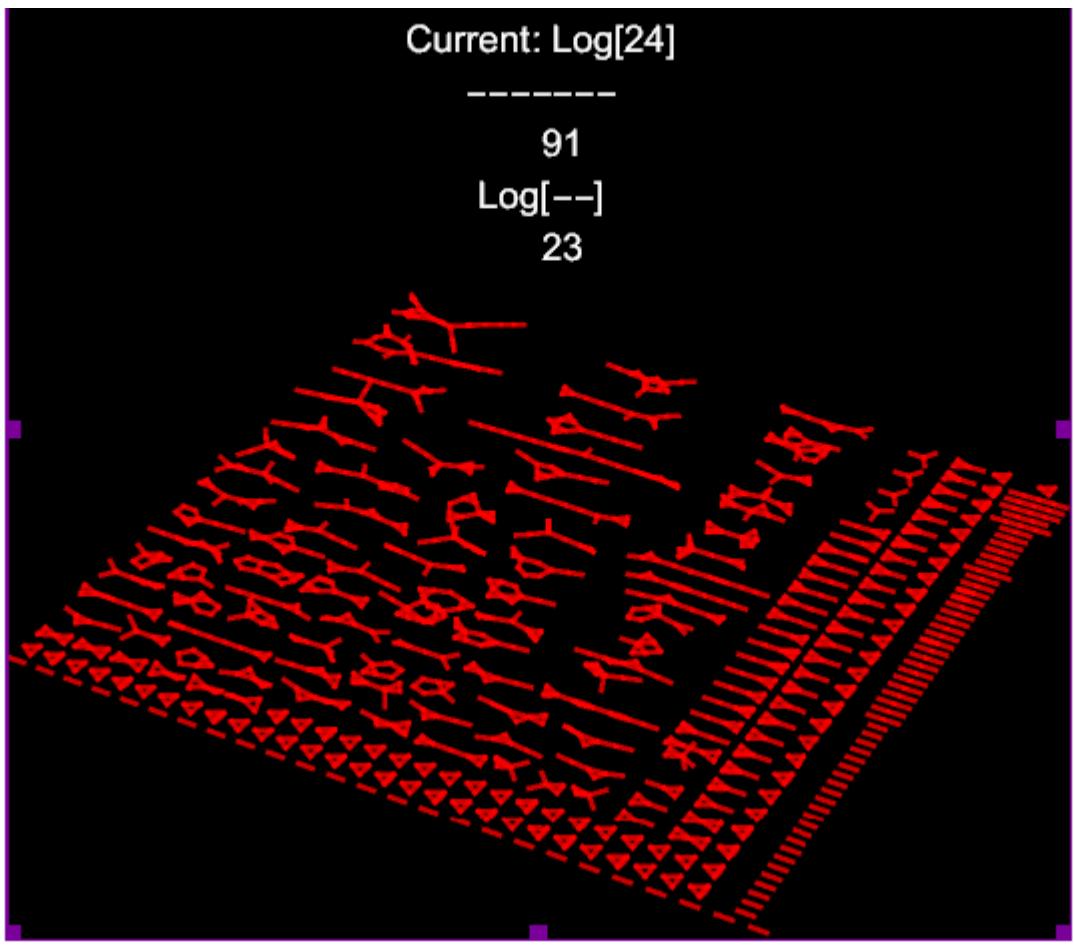


Table 1

**Personal Conjecture: Network Connectivity as Dark Matter** In this project, I explore the possibility that the Union (deduplication) mechanism might serve as a geometric analog for Dark Matter. My intuition is that while simple graph rules produce a homogeneous vacuum, the "stitching" effect of the Union operation creates complex topological shortcuts (table 1). I speculate that these emergent artifacts could physically manifest as the excess gravity observed in cosmological models, offering a geometric perspective distinct from standard particulate explanations

Please note that this remains a speculative hypothesis. Providing a formal mathematical derivation is currently beyond my reach, and I welcome insights from the community.