The Discrete Dynamics of Relational Mathematical Realism

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January 13, 2026

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1 Introduction

In Relational Mathematical Realism (RMR), physical reality is formalized as a discrete **Relational Network** $\mathcal{G}$, where spacetime and matter emerge from the sequential state updates of a global directed graph. Rather than a continuous manifold, the universe is a self-referential network of **Nodes** and **Edges**, where particles and fields are interpreted as **Persistent Subgraphs**—localized configurations of phase-locked information that maintain structural identity across successive Planck-scale updates.

This chapter develops the scattering theory emergent from this network topology. Familiar quantum phenomena—wave-particle duality, the speed of light, and characteristic scattering angles—arise as necessary consequences of the network's discrete update rules and the **Inter-layer Coupling Tension** [cite: 5, 72, 97, 242] required to project 4-dimensional relational persistence from an underlying 5-dimensional structural substrate.

2 The Network Node: Fundamental Relational Unit

2.1 The 5-Dimensional Adjacency Vector

Each network node v_i is defined by a 5-component **Relational State Vector**:

$$v_i = [r_i, t_i, \gamma_i] \tag{1}$$

where:

- $r_i = (x_i, y_i, z_i)$ represents the **Spatial Adjacency Triplet**, defining local connectivity in the 3D grid.
- t_i is the **Temporal State Index**, tracking the sequential update cycle or "Proper Clock" of the node[cite: 45, 336, 342, 381].
- γ_i is the **Gauge Edge**, representing the fourth tetrahedral connection that anchors the node to the 5D structural substrate responsible for mass and gauge phase[cite: 5, 83, 194, 254].

The spatial and temporal indices describe the node's participation in the emergent 4D spacetime manifold, while the gauge edge γ_i represents the internal phase degree of freedom—or "Relational Tension"—that couples the local node to the global gravitational field.

2.2 Ternary Relational Logic

The information state of any edge connected to a node is governed by a **Ternary Logic** system, essential for managing state-transition overhead:

1. **Persistent** (r_i, t_i, γ_i): The relation is phase-locked and determinate. This represents a "rendered" or collapsed state within a persistent subgraph.
2. **Stochastic** $(\sigma_{r_i}, \sigma_{t_i}, \sigma_{\gamma_i})$: The relation exists as a variance σ, representing a "Vacuum Node" or a state of relational superposition.

3. **Transitional** $(\tilde{r}_i, \tilde{t}_i, \tilde{\gamma}_i)$: The node is undergoing a **Relational Reconfiguration**. This acts as a computational "Time Buffer" during network updates.

This ternary architecture is a structural necessity; the network requires a transitional state to satisfy the 1.25 (5/4) update latency [cite: 377, 381] required to move complex persistent subgraphs across the discrete tetrahedral topology.

2.3 The 137-Bit Node Capacity (Ω)

The total information bandwidth of a single node is constrained by a hardware limit of 137 bits, partitioned across three functional sectors:

$$\text{Spatial Adjacency Bits:} \quad 81 = 3^4 \tag{2}$$

$$\text{Inter-layer Coupling Bits:} \quad 40 \tag{3}$$

$$\text{Structural/Gauge Bits:} \quad 16 = 2^4 \tag{4}$$

$$\text{Total Capacity } (\Omega)\text{:} \quad 137 \tag{5}$$

This capacity $\Omega = 137$ suggests that the inverse fine structure constant α^{-1} is an emergent measure of the network's maximum relational density[cite: 137, 241].

2.3.1 Topological Origin of Bit Distribution

The 81 Spatial bits represent the address space required to resolve 3D connectivity through 4D temporal frames. The network must compute three logic states (Persistent, Stochastic, Transitional) across the four axes of the emergent manifold (x, y, z, t):

$$\text{Spatial Bits} = 3^4 = 81 \tag{6}$$

The 16 Structural bits define the node's **Gauge Core**, a binary 4D seed at the 5th-dimensional vertex:

$$\text{Structural Bits} = 2^4 = 16 \tag{7}$$

This core maintains the fundamental "137-lock" that allows localized resonances to persist as matter.

The 40 Inter-layer Coupling bits represent the **Relational Boundary** or "Surface Area" between the spatial adjacency edges and the gauge core. This sector manages the "coupling tension" [cite: 72, 242, 388] required to synchronize the node's internal phases with the global network state updates.

3 Fundamental Network Chronology

3.1 The Planck Update and Transition Overhead

In RMR, the Planck time t_p represents the fundamental **Network Refresh Rate**—the single clock cycle required for a state update of the global graph $\mathcal{G}$. However, the flow of information is constrained by topological asymmetries:

- **Relational Adjacency Shift** (pure information transfer): $1 \cdot t_p$
- **Sub-graph Reconfiguration** (dimensional projection/coupling): $\frac{5}{4} \cdot t_p$

3.2 Origin of the 5/4 Coupling Factor

The 5/4 ratio is the **Inter-layer Coupling Tension** coefficient. When a persistent subgraph (matter) reconfigures its adjacency, the network must reconcile the 5-dimensional gauge core (γ_i) with the emergent 4-dimensional spacetime representation (r_i, t_i). This reconciliation creates a "Temporal Buffer":

1. Access the 5D structural state via the Gauge Edge.
2. Project the configuration to the 4D spatial adjacency.
3. Update the 4D relational indices.
4. Synchronize and phase-lock with the 5D core.

The additional $1/4 \cdot t_p$ represents the **Projection Latency**. The factor of 5/4 specifically reflects the ratio of available structural dimensions (5) to the dimensions updated per cycle in the observable manifold (4). This is the energetic cost of maintaining a phase-locked configuration across layers.

3.3 Topological Constraints on Causality

This network chronology dictates the causal structure of the universe:

1. **Information advance** occurs at the theoretical maximum rate ($1 \cdot t_p$ per node) because it involves simple adjacency shifts without layer reconfiguration.
2. **Physical interactions** require the extended cycle ($\frac{5}{4} \cdot t_p$) because they necessitate active reconfiguration of the inter-layer coupling tension.
3. **Causal ordering** is topologically protected because localized reconfigurations (cause-effect events) always possess higher latency than pure information transfer (light).

The speed of light c is therefore defined as the **Zero-Tension Limit**—the velocity of an excitation that propagates without inducing inter-layer coupling overhead.

4 Representations of Persistent Subgraphs

We now define the specific network configurations for fundamental excitations, contrasting pure directional shifts with anchored resonances.

4.1 The Photon: Non-Persistent Adjacency Shift

A photon is formalized as a transient **Instruction Vector** with no persistent localization in the network:

$$\gamma = [\Delta r, \sigma_t, 0] \tag{8}$$

where:

- Δr is a **Directional Adjacency Shift**—the instruction to relocate a phase-pulse by one node per update.
- σ_t is **Temporal Superposition**—the photon lacks an internal clock and does not accumulate proper time.
- 0 represents **Null Gauge Coupling**—the photon lacks a 5th-dimensional footprint, resulting in zero rest mass.

Because the photon possesses no structural core ($g = 0$), it never triggers an inter-layer reconfiguration. It advances at exactly $1 \cdot t_p$ per node—the absolute minimum latency of the network topology.

4.2 The Electron: The Anchored 137-Resonance

An electron is a stable, localized resonance we call a **137-Resonance**—a phase-locked subgraph that persists across updates:

$$e^- = [v_i, t_{1.25}, \gamma_\alpha] \tag{9}$$

where:

- v_i is a **Localized Node Cluster**—the resonance is anchored to specific coordinates.
- $t_{1.25} = \frac{5}{4} \cdot t_p$ is the **Phase-Lock Cycle**—each update incurs the full inter-layer coupling tension.
- γ_α is the **Gauge Tension**—the coupling strength to the 5th-dimensional substrate, defining the rest mass.

4.2.1 The 137-Resonance as a Phase-Locked Subgraph

The "137-Resonance" refers to the saturation of the node's 137-bit capacity Ω. Unlike the photon, which utilizes only spatial bits, the electron utilizes the *defined* bit-state of all 137 degrees of freedom simultaneously. This full utilization generates:

- **Rest Mass:** Derived from the internal tension required to synchronize 137 bits across layers.
- **Discrete Charge:** Emerges from the specific tetrahedral phase-locking pattern of the 137 bits.

- **Inertial Persistence:** The configuration maintains topological coherence across state updates.

The Gauge sector γ_α represents the electron's allocation of the 16 structural bits. This specific ratio ($\approx 16/137$) identifies the electromagnetic fine structure constant as a measure of the network's **Coupling Density**.

4.2.2 Relational Latency and Propagation Limits

Because the electron is a phase-locked **137-Resonance** with a defined adjacency cluster v_i and gauge coupling γ_α, any reconfiguration of its position constitutes an **Inter-layer State Transition**. To relocate a persistent subgraph, the network must:

1. Unlock the 137-bit phase configuration from node cluster v_i.
2. Pass through the **Transitional State** $\tilde{r}$ (the "Time Buffer").
3. Re-lock the phase configuration at the adjacent node cluster v_{i+1}.
4. Maintain the inter-layer gauge tension γ_α throughout the refresh cycle.

This process requires the full $\frac{5}{4} \cdot t_p$ **Coupling Latency**, rendering the electron's maximum propagation speed (the "Hardware Limit") necessarily slower than the zero-tension limit c.

5 Resonance-Pulse Interactions

When a photon-pulse and an electron-resonance occupy the same network node during a transitional window, a **Relational Handshake** must occur. The outcome is governed by the conservation of the 137-bit capacity Ω within the local node cluster.

5.1 The Interaction Constraint

The interaction is formalized as a vector addition of relational states:

$$[v_i, t_{1.25}, \gamma_\alpha] + [\Delta r, \sigma_t, 0] \xrightarrow{\Omega} [\tilde{v}_{i+\Delta}, \tilde{t}, \gamma_\alpha] \tag{10}$$

where $\Omega = 137$ acts as the **Conservation Boundary**. The network cannot exceed its node capacity; total relational information must be conserved during the handshake.

5.2 Absorption: Relational Identity Merge

If the photon's adjacency shift Δr is compatible with the electron's internal degrees of freedom, the pulse is absorbed:

1. The photon instruction is removed from the network: $\gamma \to \emptyset$.
2. The Δr vector is converted into **Internal Harmonic Tension** within the 137-resonance.

3. The resonance persists at node v_i with an excited inter-layer state:

$$e^-_{\text{excited}} = [v_i, t_{1.25}, \gamma_\alpha, E_{\text{int}}] \tag{11}$$

Absorption requires the pulse energy to match an allowed transition within the **81 Spatial Bits**. This quantization of internal reconfiguration is the origin of spectral lines within the relational network.

5.3 Scattering: Phase-Vector Reflection

If the pulse energy is incompatible with the available 137-bit reconfiguration modes, the network must vent excess information to maintain the 137-lock. This results in **Compton-type Scattering**:

1. The resonance absorbs a partial δr vector sufficient to update its nodal adjacency: $v_i \to v_i + \delta r$.
2. The resonance Gains **Recoil Momentum** but remains below the tension required for internal layer reconfiguration.
3. The network generates a secondary pulse with the residual shift: $\gamma_{\text{out}} = [\Delta r', \sigma_t, 0]$, where $\Delta r' = \Delta r - \delta r$.

6 Geometric Scattering Theory

We now derive the characteristic scattering angle emergent from the network's **Tetrahedral Topology**.

6.1 The Gear Ratio Deflection

When a photon impacts an electron-resonance, the interaction enters a **Processing Queue** imposed by the $\frac{5}{4}$ refresh cycle. The "input" (photon) attempts to rotate the resonance's spatial vector by 137 units of angular phase, but the "output" (rendered position) is delayed by the 1.25 inter-layer coupling tension.

The resulting deflection in the 3D manifold is defined by the **Hardware Gear Ratio**:

$$\theta_{\text{RMR}} = \frac{\Omega}{5/4} = \frac{137}{1.25} = 109.6^\circ \tag{12}$$

6.2 The Simplex Constraint and Tetrahedral Packing

This prediction of 109.6° aligns with the **Maraldi Angle** (Tetrahedral Angle), derived from the RHM simplex constraint $\cos\theta = -1/3 \approx 109.47^\circ$.

6.2.1 Why Tetrahedral Connectivity?

In a discrete network, uncertainty volumes σ_r must pack into the 3D spatial adjacency. The most efficient relational packing is tetrahedral.

The **81 Spatial Bits** naturally decompose into a cluster of 20 tetrahedra (Icosahedral symmetry) plus a fractional $\frac{1}{4}$ component representing the $\frac{5}{4}$ temporal lag. This suggests the electron is a **Dynamic Resonance Cluster** of 20 tetrahedra jittering between adjacent states at the Planck frequency.

6.3 The Network Hierarchy

The relationship between the bit-sectors and tetrahedral structure is formalized as a graph:

- **81 Spatial Bits:** The potential adjacency **Vertices** in the local neighborhood.
- **40 Coupling Bits:** The **Edges** defining phase-locking rules between vertices.
- **16 Structural Bits:** The **Central Node** (Gauge Core) anchoring the cluster.

When a pulse attempts a deflection at an arbitrary angle (e.g., 90°), no corresponding edge exists in the 81-bit spatial budget. The network *cannot render* such a trajectory; it must snap the output to the nearest tetrahedral vertex, reinforcing the 109.6° characteristic angle.