RigbySpace: General Vector Dynamics

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1 Introduction

The preceding sections have established the formal mathematical foundation of RigbySpace Dynamics based on unreduced integer pairs and triples. To connect this abstract framework to observable physical reality, we now introduce a higher-level, pedagogical notation that maps directly onto the established axioms. This section will define the fundamental physical concepts of Space, Time, Energy, and Mass not as background assumptions, but as emergent properties of the underlying integer state dynamics.

1.1 The Pedagogical State Vector

While the formal states are the integer tuples (n, d) and (X, Y, Z), it is conceptually useful to introduce a general vector notation (M, H, Θ) to represent the primary physical attributes of a state. This notation serves as a bridge to physical intuition and must be understood as a direct mapping to the rigorous structures.

Definition 1.1 (Formal Correspondence)**.** The components of the pedagogical state vector (M, H, Θ) correspond to the formal structures defined in the Master Axioms as follows:

Attribute	Linear States ($s \in S_L$)	Projective States ($P \in S_P$)
Magnitude (M)	The numerator, n	An aggregate function of (X, Y, Z)
History (H)	The Structural Entropy, $\rho(d)$	The Total Potential, $\sum h(C_i)$
Orientation (Θ)	The Phase, $\phi \in \Phi_N$	The orientation in projective space

Table 1: Correspondence between pedagogical and formal state components.

1.2 The Nature of Time and Causality

The framework decouples the absolute, ordered sequence of causal events from the physical, measurable duration experienced by a state.

Definition 1.2 (Causal Index, t)**.** The **Causal Index** $t \in \mathbb{Z}_{\geq 0}$ is the strictly monotonic integer that counts the applications of the fundamental operators. It is the universal "refresh rate" or heartbeat of the universe, representing the progression of logical causality.

Definition 1.3 (Physical Time, T). **Physical Time** T is not a fundamental coordinate but an emergent property of a state, defined as the accumulated count of causal steps during which the state possessed a non-zero History component.

$$T(s_t) := \sum_{i=0}^{t} \mathbf{1}_{H(s_i)>0}$$

where $H(s_i)$ is the History component of the state s_i and $\mathbf{1}$ is the indicator function.

This definition establishes that a state only "experiences" time when it carries a record of its own history.

1.3 The Nature of Energy and Mass

Energy and Mass are similarly defined as emergent properties of the state and its dynamics, not as intrinsic parameters.

Definition 1.4 (Energy, E). The **Energy** of a physical process is identified with the **Vacuum Resolution Frequency** (Ω_{vac}), as defined in the Master Axioms. It is the integer count of vacuum operations required to balance a structural tension induced by a matter interaction. Energy is a measure of the dynamical cost of a process.

Definition 1.5 (Inertial Mass, m_I). The **Inertial Mass** of a linear state $s = (n, d)$ is its **Structural Potential**, identified with the raw integer value of its denominator:

$$m_I(s) := d.$$

This quantity represents the state's resistance to transformation under the linear vacuum generators.

Definition 1.6 (Mass-Level, m_L). The **Mass-Level** of a linear state $s = (n, d)$ is its **Structural Entropy**, identified with the rank of its denominator:

$$m_L(s) := H(s) = \rho(d).$$

This quantity represents the state's quantized complexity class. The observed particle masses correspond to the discrete integer spectrum of possible Mass-Levels.

Theorem 1.1 (The Mass Gap). There exists a minimal, non-zero Mass-Level for any massive particle. Specifically, no state s can exist such that $0 < m_L(s) < 1$.

Proof. By definition, the Mass-Level $m_L(s) = \rho(d)$ is an integer-valued function. The set of positive integers $\mathbb{Z}^+$ has a minimum element, 1. Therefore, the minimum non-zero Mass-Level is 1. No state can possess a "fractional" rank between 0 and 1, as this would violate the definition of the Rank Function. This discrete floor in the spectrum of structural complexity is the origin of the Mass Gap. $\square$

2 The Particle Spectrum from First Principles

The fundamental particles emerge not as axiomatic entities, but as the simplest stable configurations of the state vector. We derive the properties of the photon and neutrino.

2.1 The Photon

Theorem 2.1 (The Photon as a Numerical ZERO). The photon (s_γ) is uniquely identified with the **Numerical ZERO** state $(0, 1)$.

Proof. We analyze the properties of the state $s = (0, 1)$ against the observed properties of the photon.

1. **Zero Mass**: The Mass-Level is $m_L(s) = \rho(d) = \rho(1) = 0$. The Inertial Mass is $m_I(s) = 1$, the minimum possible for a valid state.

2. **Timeless Propagation**: Physical Time is $T = \sum \mathbf{1}_{H>0}$. For the photon, the History component is $H = \rho(1) = 0$. Therefore, the indicator function is always zero, and the accumulated physical time is $T = 0$ for any trajectory. The photon traverses the causal graph (t increases) but experiences no duration. This formally recovers the null-geodesic property of light.

3. **Energy Carrier**: While its magnitude $M = n = 0$, a photon can induce a tension in a coupled system, requiring a non-zero Vacuum Resolution Frequency ($\Omega_{\text{vac}} > 0$) to balance the interaction. It thus has zero intrinsic magnitude but mediates energy transfer.

The state $(0, 1)$ is the only state in S_L that satisfies these three conditions. □

2.2 The Neutrino

Theorem 2.2 (The Neutrino as the Minimal Massive State)**.** The neutrino (s_ν) is identified with the class of states possessing the minimal non-zero Mass-Level, $m_L = 1$.

Proof. Following the Mass Gap theorem, the first available massive state is one where the Mass-Level is 1.

1. **Minimal Mass**: The neutrino state must have $m_L(s) = \rho(d) = 1$. By the definition of the Rank Function, this requires its Inertial Mass (denominator) to be in the range $2 \leq d < 4$. The simplest neutrino state is therefore a state with $d = 2$ (e.g., $(1, 2)$).

2. **Experiences Time**: For a neutrino, $H = \rho(d) = 1$. Therefore, the indicator function $\mathbf{1}_{H>0}$ is always 1. A neutrino accumulates one unit of physical time T for every one unit of causal index t. It is the "slowest" possible clock for a massive particle.

3. **Weak Interaction**: The stability of the $m_L = 1$ state implies it can only participate in interactions that minimally affect its structural entropy. Any interaction that would decrease its rank to 0 would annihilate its mass (decay to photons), while a significant increase would transform its identity. This structural constraint manifests as the weak interaction.

□

Corollary 2.1 (The Particle Hierarchy)**.** The fundamental particles are classified by their History component (Mass-Level):

- $H = 0$: The Photon (massless gauge boson).

- $H = 1$: The Neutrino (minimal massive lepton).

- $H > 1$: Higher-mass particles (electrons, quarks, etc.), whose greater structural entropy allows for more complex (e.g., strong and electromagnetic) interactions.

3 Wave-Particle Duality as a Structural Transition

The duality of wave and particle behavior is resolved not through superposition, but as a transition between two distinct dynamical regimes defined by the History component.

Theorem 3.1 (Duality as a Function of History)**.** Wave-like behavior corresponds to the $H = 0$ regime, and particle-like behavior corresponds to the $H > 0$ regime.

Proof. The proof is informational. A state's trajectory is a path in the universal state graph.

1. **Wave Regime ($H = 0$)**: A state with zero history, like the photon, does not accumulate information that distinguishes one path from another between two interaction points. Lacking a unique, recorded trajectory, it effectively traverses all possible paths. This path delocalization is the ontological origin of interference and wave-like phenomena.

2. **Particle Regime ($H > 0$)**: A state with non-zero history records information about its trajectory at each step. This act of "recording" a path collapses the ambiguity. The state possesses a unique, ordered history, which localizes it to a specific path. This is the origin of classical particle behavior.

The "collapse of the wavefunction" is therefore identified with the physical process of a state transitioning from $H = 0$ to $H > 0$ upon interaction, thereby acquiring a history for the first time. $\qquad\square$