Rigbyspace Discrete Algebra
Unified Dynamics
Engine

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Contents

1 Scope and Methodology

This document presents the RigbySpace Engine as a fully discrete, axiomatic system. It formalizes:

- The primitive ontology and operators
- The evolution rules and termination criteria
- Resolution equivalence and particle emergence
- Complete rank–1 enumeration (particle zoo)
- Rank–2 extension
- Gauge absences (forbidden interactions)
- Discrete running across rank

No continuous mathematics, probability, metric structure, or renormalization is used. All quantities are discrete and integer-based.

Mappings to known physical theories are explicitly excluded from the engine itself.

2 Primitive Ontology

2.1 Integer States

Definition 2.1 (Integer State)**.** An integer state is an ordered pair

$$S = (n, d)$$

with $n, d \in \mathbb{Z} \setminus \{0\}$.

No normalization, reduction, ordering, or equivalence is applied.

2.2 Coupled Pairs

Definition 2.2 (Coupled Pair)**.** All dynamics act on ordered pairs of integer states:

$$(S_L, S_U).$$

Single-state evolution is not defined.

2.3 Unreduced History

Axiom 2.1 (Unreduced Evolution)**.** At no stage is $\gcd(n, d)$ computed or used. All integer structure is preserved historically.

3 Fundamental Operators

3.1 Barycentric Addition

Definition 3.1 (Barycentric Addition)**.** Given states $S_1 = (n_1, d_1)$ and $S_2 = (n_2, d_2)$,

$$S_1 \boxplus S_2 := (n_1 d_2 + n_2 d_1,\ d_1 d_2).$$

3.2 Vacuum Step

Definition 3.2 (Vacuum Step)**.**

$$S_1 \oplus S_2 := (n_1 + n_2,\ d_1 + d_2).$$

3.3 Coupled Inversion

Definition 3.3 (Coupled Inversion)**.** The operator ψ acts only on coupled pairs:

$$\psi((a/b), (c/d)) := ((d/a), (b/c)).$$

Axiom 3.1 (ψ-Periodicity)**.**

$$\psi^4 = I, \qquad \psi^k \neq I \text{ for } k < 4.$$

4 Rank

Definition 4.1 (Rank)**.** Rank is a structural depth label defined by the number of unresolved dyadic growth layers accumulated in a history.

Rank:

- is historical
- is monotone increasing
- is not computed from state values
- is not a magnitude

Definition 4.2 (Rank–1 System)**.** A system is rank–1 if at most one unresolved dyadic layer is permitted prior to stabilization.

Definition 4.3 (Rank–2 System)**.** A system is rank–2 if at most two unresolved dyadic layers are permitted prior to stabilization.

5 Prime-Gated Dynamics

Definition 5.1 (Prime Event)**.** Primes label irreducible operational gating events. The k-th prime corresponds to the k-th irreducible event.

Axiom 5.1 (Prime Gating)**.** At each evolution tick:

1. Candidate states are generated.
2. Prime-gated admissibility is tested.
3. Failure triggers ψ-resolution.

6 Temporal Structure

Definition 6.1 (Tick)**.** A tick is a discrete evolution step.

Axiom 6.1 (Cycle Structure)**.**
- 11 microticks per generation
- 3 generations per cycle

Theorem 6.1 (Fundamental Cycle Length)**.**

$$T = 33.$$

7 Deviation and Stabilization

Definition 7.1 (Deviation)**.** For coupled states (S_L, S_U),

$$\Delta := |n_U d_L - n_L d_U|.$$

Definition 7.2 (Stabilization)**.** A history stabilizes if

$$\Delta = 1.$$

Stabilization defines particle emergence.

8 Histories and Resolution Equivalence

Definition 8.1 (History)**.** A history is the ordered sequence of operators applied from an initial seed until stabilization.

Definition 8.2 (ψ-Equivalence)**.** Two histories are ψ-equivalent if they differ only by ψ-phase permutations within a ψ^4 orbit.

Definition 8.3 (Resolution Equivalence)**.** Two stabilized histories are resolution-equivalent if:

1. both stabilize at $\Delta = 1$,
2. they are ψ-equivalent,
3. they share the same rank profile,
4. they stabilize in equivalent triadic positions.

Definition 8.4 (Resolution Class)**.** A resolution class is an equivalence class of stabilized histories under resolution equivalence.

9 Rank–1 Enumeration

Theorem 9.1 (Rank–1 Resolution Classes)**.** At rank–1, the engine produces exactly:

$$\mathcal{R}_1 = \{64,\ 72,\ 128\}.$$

No other rank–1 resolution classes exist.

10 Internal Degrees of Freedom

Available internal labels:

- ψ-orientation (binary)
- triadic orientation (ternary when present)
- coupled-pair sign parity (binary)
- extended dyadic block label (binary)

11 Global Symmetry Quotients

11.1 ψ^2 Identification

Histories related by ψ^2 are globally identified.

11.2 Triadic Reflection

Triadic slots satisfy the identification $1 \leftrightarrow 3$.

11.3 Rank–1 Sign Locking

At rank–1, sign parity does not survive as an independent label.

12 Final Rank–1 Particle Zoo

Resolution Class	Distinct Fermionic States
64	16
72	12
128	16

Total fermionic states at rank–1:

$$44.$$

13 Rank–2 Extension

Definition 13.1 (Rank–2 Dyadic Profile)**.** A rank–2 history is characterized by an ordered pair

$$(d_1, d_2)$$

of dyadic layer depths.

Definition 13.2 (Rank–2 Resolution Equivalence)**.** Rank–2 histories are resolution-equivalent if they satisfy all rank–1 equivalence conditions and share the same dyadic profile.

Theorem 13.1 (Rank–2 Resolution Classes)**.** The rank–2 engine produces exactly:

$$\mathcal{R}_2 = \{256,\ 288,\ 384\}.$$

14 Rank–2 Internal States

Resolution Class	Distinct States
256	32
288	24
384	32

15 Gauge Absences

Axiom 15.1 (Coupling Existence)**.** A coupling exists if and only if there exists a nonempty set of admissible histories supporting joint stabilization.

- No 64–64–64 triadic coupling
- No 128–128–128 triadic coupling
- No direct 64–128 coupling at rank–1
- Only 72-mediated mixed couplings are admissible

These absences persist across all ranks.

16 Discrete Running Across Rank

Definition 16.1 (Effective Coupling)**.** An effective dimensionless coupling is inversely proportional to the resolution class cardinality.

Theorem 16.1 (Discrete Scaling Law)**.** If A_r is a representative resolution class at rank r,

$$A_{r+1} = 4A_r, \quad \alpha_{r+1} = \frac{1}{4}\alpha_r.$$

This defines exact, discrete running without renormalization.

17 Closure

The RigbySpace Engine defines:

- a finite fermion zoo at rank–1,
- composite structures at rank–2,
- strict interaction absences,
- exact discrete running across rank.

No tunable parameters are present.