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Article

The Dynamic Zeros Under Closure: Irreducible Core of a Discrete Physical Computational Framework

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Abstract

We present a self-contained treatment of the *dynamic zero principle*—the assertion that the element $0 \in S = \{-1, 0, +1\}$ is not an absorbing terminal state but a compression boundary through which the system transitions without annihilation. Beginning from three pre-numeric modal states and four interaction constraints (closure, totality, boundedness, nontriviality), we derive the unique minimal algebra S, prove that cancellation is forced rather than postulated, and show that Euler's identity $e^{i\pi} + 1 = 0$ emerges as the algebraic *termination certificate* of the forced completion sequence $S \to \mathbb{Z} \to \mathbb{Q} \to \mathbb{R} \to \mathbb{C}$. We prove that the primordial states are symmetric under permutation; triadic completion alone admits a symmetric (S_3-equivariant) law, but imposing orientation (order sensitivity) forces symmetry breaking. We discuss how this naturally aligns with the Cayley–Dickson hierarchy through octonions. Modern quantum field theory already rejects the notion of a trivial vacuum: zero-point energy, vacuum polarization, and renormalization reveal that "empty space" is a structured ground state rather than an absence of structure. However, the algebraic status of this structured vacuum is typically introduced through subtraction schemes and regularization procedures that are formally consistent but conceptually layered atop the theory. The dynamic zero principle provides a minimal algebraic model of a non-absorbing ground state in which compression, cancellation, and holonomy arise from closure itself rather than from external adjustment. In this sense, the present work offers a foundational template for thinking about vacuum structure without ad hoc null-state assumptions. We then formalize the dynamic zero as a $\mathbb{Z}_2$ holonomy on the spinor cover: the minimal nontrivial loop that returns observables to themselves while inverting the internal state. The paper is organized into three epistemic tiers: **Established** (results with complete proofs from first principles), **Derivable** (results contingent on the full Kosmoplex axiom set whose proofs are sketched or referenced), and **Open** (precisely stated questions whose resolution would strengthen or falsify the framework). No free parameters appear. The dynamic zero is not a number; it is the engine of non-termination.

Keywords: dynamic zero; non-absorbing ground state; triadic closure; minimal algebra; forced completion sequence; spinorial holonomy; Euler identity; normed division algebras; vacuum structure; algebraic closure

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1. Introduction

Every formal system rests on primitives. Peano arithmetic begins with zero and successor. Set theory begins with the empty set and membership. Quantum mechanics begins with a Hilbert space and self-adjoint operators.

We ask a different question: *What is the minimal algebraic structure from which all subsequent mathematical architecture is forced?* The answer we develop is not an object but a *triad of modal states* and a single structural demand—closure—whose consequences cascade through number theory, algebra, analysis, and geometry, terminating at $\mathbb{C}$ with Euler's identity as the formal seal. The ternary algebraic viewpoint has antecedents in Noether's program of studying abstract algebraic structures through their symmetries and composition laws [10], and in Łukasiewicz's three-valued logic [9]; our contribution is to show that the specific triad $\{-1, 0, +1\}$ is uniquely forced by closure axioms.

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The central object of this paper is *zero*, but zero reconceived. In classical arithmetic, 0 is inert: additive identity, multiplicative annihilator, the origin of the number line. We demonstrate that when 0 is embedded in the minimal closed algebra $S = \{-1, 0, +1\}$, it acquires a dynamic character: it is the state through which transitions pass but at which the system *cannot terminate*. Collapse to a permanent zero state is structurally forbidden by the same axioms that force the algebra into existence. More precisely, the dynamic zero functions as a *compression boundary*—a boundary state reached as the limit of a convergent process (cancellation, summation-to-integral residue, or holonomy) without becoming absorbing—the structural locus where opposing contributions resolve into finite coherence without annihilation, in the same sense that a limit point compresses an infinite sequence into a definite value.

We further show that the three primordial states, though symmetric under permutation at the pre-algebraic level, admit a fully symmetric (commutative) triadic-completion law. However, the moment one demands *orientation*—that the ordered pair (a, b) be distinguishable from (b, a)—this S_3 symmetry must break. The breaking is not spontaneous; it is logically forced by order sensitivity. The resulting oriented incidence structure prefigures the hierarchy of normed division algebras and, ultimately, the octonionic structure that underlies the Kosmoplex framework.

This paper collects and formalizes results that appear across several companion works [1,2] into a single, self-contained document organized by epistemic status.

1.1. Epistemic Tiers

We adopt three tiers throughout:

ESTABLISHED
Complete proofs from the axioms stated herein; no external framework required. Marked with ■.

DERIVABLE
Results that follow from the full Kosmoplex axiom set (11 axioms) with proofs sketched or available in cited references. Marked with ⋄.

OPEN
Precisely formulated questions whose resolution is unknown. Marked with ◦.

1.2. Notation

Throughout, $\circ$ denotes a generic binary interaction on the primordial state set $\{\sigma_+, \sigma_0, \sigma_-\}$. Beginning in Section 3, we map states to the integers $\{-1, 0, +1\}$ and introduce the standard ring operations $+$ (addition) and $\cdot$ (multiplication) as the canonical decomposition of $\circ$ into an additive and a multiplicative structure. This transition is made explicit in Section 3.1. The symbol F always denotes an admissible dynamics (Definition 2).

2. The Primordial States

2.1. Before Number

We begin not with quantities but with *modes of becoming*.

Definition 1 (Primordial states)**.** *The three primordial states are:*

1. σ_+ (Creation)*: the condition of arising.*
2. σ_- (Destruction)*: the condition of passing.*
3. σ_0 (Potential)*: the condition of poise, neither arising nor passing.*

These are not numbers. They are pre-numeric conditions of being that precede quantification. The claim is that all subsequent mathematical structure can be *derived* from the demand that these three states interact consistently.

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2.2. The Interaction Axioms

We impose four constraints on how states interact. The first two are structural; the third and fourth are distinct stability conditions that we separate explicitly to prevent conflation.

Axiom 1 (Closure). *For any two states $\sigma_a, \sigma_b \in \{\sigma_+, \sigma_0, \sigma_-\}$, their interaction produces a state in the set:*

$$\forall \sigma_a, \sigma_b : \quad \sigma_a \circ \sigma_b \in \{\sigma_+, \sigma_0, \sigma_-\}.$$

Axiom 2 (Totality). *Every interaction between states is defined. There are no undefined or forbidden combinations: $\circ$ is a total binary operation on the state set.*

Axiom 3 (Boundedness). *Closure does not force enlargement of the alphabet at the primordial tier. That is, iterated application of $\circ$ to elements of $\{\sigma_+, \sigma_0, \sigma_-\}$ produces no element outside this set.*

Axiom 4 (Nontriviality). *No proper subset of $\{\sigma_+, \sigma_0, \sigma_-\}$ is closed under $\circ$. In particular, the dynamics cannot collapse to a single-state or two-state subsystem.*

Remark 1. *Axioms 1 and 3 together assert that the primordial set is closed. Axiom 4 asserts that the closure is* tight*: no smaller set suffices. The former "Axiom 3 (Stability)" appearing in earlier work [1] is hereby decomposed into Axioms 3 and 4 to prevent equivocation between algebraic boundedness and dynamical nontriviality.*

2.3. Primordial Symmetry and Its Breaking

A foundational observation about the primordial states deserves explicit treatment. The labels σ_+, σ_0, σ_- are *representational choices*, not intrinsic properties. At the primordial tier, the three states are symmetric: each is a dynamic zero within the system—a boundary condition that neither dominates nor disappears. The assignment of "creation," "destruction," and "potential" is a cognitive projection made by an observer embedded in the system's output.

Proposition 1 (ESTABLISHED: Orientation forces symmetry breaking). *Let $Z = \{Z_1, Z_2, Z_3\}$ be a three-element set with the natural S_3 action by permutation. Let $C : Z \times Z \to Z$ be a total binary operation satisfying:*

(i) ***Triadic completion on distinct inputs.*** *For all $a \neq b$, $C(a, b)$ is the unique third element of $Z \setminus \{a, b\}$.*

(ii) ***Orientation (order sensitivity).*** *There exist $a \neq b$ such that $C(a, b) \neq C(b, a)$.*

Then C cannot be S_3-equivariant. Equivalently, any triadic-completion law that is S_3-equivariant must be commutative on distinct inputs (and hence cannot encode orientation).

Proof. Assume, for contradiction, that C is S_3-equivariant. Fix distinct $a \neq b$ and let $c := C(a, b)$; by triadic completion, c is the third element in $Z \setminus \{a, b\}$.

Let τ be the transposition swapping a and b and fixing c. By equivariance,

$$C(b, a) = C(\tau(a), \tau(b)) = \tau(C(a, b)) = \tau(c) = c = C(a, b).$$

Thus $C(a, b) = C(b, a)$ for all distinct a, b, contradicting the orientation assumption. Hence C cannot be S_3-equivariant. □

Remark 2 (What symmetry breaking requires). *There exists a fully symmetric (S_3-equivariant) triadic-completion law on three elements: the commutative "third-point" (Steiner) completion [11,12], defined by $C(a, b) =$ the third element for $a \neq b$ and $C(a, a) = a$. What forces symmetry breaking in the Kosmoplex framework is the additional requirement of* orientation*: the closure map must distinguish the ordered pair (a, b) from (b, a). This order sensitivity is the minimal seed of chirality and is the point at which the primordial S_3 symmetry is lifted into an oriented incidence structure.*

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The symmetry of the state set is not destroyed by this breaking; it is lifted into structure*. The resulting oriented 3-cycle is the seed of noncommutativity (which later manifests in quaternions) and, via nested composition, of nonassociativity (which later manifests in octonions). The Cayley–Dickson hierarchy* $\mathbb{R} \to \mathbb{C} \to \mathbb{H} \to \mathbb{O}$ *[5,6], which terminates by Hurwitz's theorem [4] at dimension* 8*, naturally aligns with this closure-induced orientation.*

2.4. Admissible Dynamics

Several results below concern the behavior of the primordial states under iterated interaction. We make the class of permitted update rules explicit.

Definition 2 (Admissible dynamics)**.** *A map* $F : \{\sigma_+, \sigma_0, \sigma_-\} \to \{\sigma_+, \sigma_0, \sigma_-\}$ *is* admissible *if it is total and can be realized as the left-fold composition*

$$F(\sigma) = (\cdots((\sigma \circ \sigma_{a_1}) \circ \sigma_{a_2}) \circ \cdots \circ \sigma_{a_k})$$

for some finite sequence $\sigma_{a_1}, \ldots, \sigma_{a_k}$ *drawn from the state set. That is, admissible dynamics are generated by iterated application of the binary interaction* $\circ$*. The sequence* $\sigma_{a_1}, \ldots, \sigma_{a_k}$ *is interpreted as the environment or input stream; admissibility constrains the update mechanism (interaction via* $\circ$*), not the choice of input.*

3. Forced Consequences: The Unique Minimal Algebra

ESTABLISHED ■

Lemma 1 (ESTABLISHED: Cancellation is forced)**.** *Under Axioms 1–4, we have* $\sigma_+ \circ \sigma_- = \sigma_0$*.*

Proof. Suppose $\sigma_+ \circ \sigma_- \neq \sigma_0$. Then $\sigma_+ \circ \sigma_- \in \{\sigma_+, \sigma_-\}$. We show that every possible assignment leads to a contradiction with Axiom 4 by tracking which two-element subsets become closed.

Since $\sigma_+ \circ \sigma_- \neq \sigma_0$, the element σ_0 is *not produced by the mixed interaction* $\sigma_+ \circ \sigma_-$. Therefore σ_0 must be produced by some other interaction, or it becomes unreachable. We enumerate the cases.

Case 1: σ_0 *is never an output of* $\circ$. If no pair (a, b) satisfies $a \circ b = \sigma_0$, then every entry of the 3×3 interaction table lies in $\{\sigma_+, \sigma_-\}$. In particular, $T = \{\sigma_+, \sigma_-\}$ is closed under $\circ$. Since T is a proper subset, this contradicts Axiom 4.

Case 2: σ_0 *is produced by exactly one self-interaction.* Without loss of generality, suppose $\sigma_+ \circ \sigma_+ = \sigma_0$ (the case $\sigma_- \circ \sigma_- = \sigma_0$ is symmetric). Consider the set $U = \{\sigma_+, \sigma_0\}$. The interaction table restricted to pairs from U is:

$\circ$	σ_+	σ_0
σ_+	$\sigma_0 \in U$	?
σ_0	?	?

Each "?" must lie in $S = \{\sigma_+, \sigma_0, \sigma_-\}$ by Axiom 1. If all three unknowns lie in U, then U is closed, contradicting nontriviality. If any unknown equals σ_-, then σ_- is reachable from U, but σ_0 remains reachable only from the pair (σ_+, σ_+). Checking the complementary pair: $\sigma_- \circ \sigma_- \neq \sigma_0$ (by our Case 2 assumption that only $\sigma_+ \circ \sigma_+$ produces σ_0), so $\sigma_- \circ \sigma_- \in \{\sigma_+, \sigma_-\}$. In either sub-case, $\{\sigma_+, \sigma_-\}$ or $\{\sigma_-, \sigma_0\}$ becomes closed—both contradicting nontriviality.

Case 3: Both self-interactions produce σ_0. If $\sigma_+ \circ \sigma_+ = \sigma_0$ and $\sigma_- \circ \sigma_- = \sigma_0$, then σ_0 is reachable. But we still have $\sigma_+ \circ \sigma_- \in \{\sigma_+, \sigma_-\}$ and $\sigma_- \circ \sigma_+ \in \{\sigma_+, \sigma_-\}$ by hypothesis. Consider the outputs of all six off-diagonal interactions: none produces σ_0 (by hypothesis, only self-interactions do). Then σ_0 is an output of self-interactions but never feeds back into the mixed interactions as an input that produces σ_+ or σ_-—unless some interaction with σ_0 escapes. If $\sigma_0 \circ \sigma_0 \in \{\sigma_+, \sigma_-\}$, then $\{\sigma_+, \sigma_-\}$ is replenished and the same closure argument as Case 1 applies to $\{\sigma_+, \sigma_-\}$. If $\sigma_0 \circ \sigma_0 = \sigma_0$, then $\{\sigma_0\}$ is closed—contradicting nontriviality.

All cases produce a contradiction. Therefore $\sigma_+ \circ \sigma_- = \sigma_0$. □

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Remark 3 (The first appearance of the dynamic zero). *Lemma 1 is the earliest manifestation of the dynamic zero principle: σ_0 is not assumed as a primitive property of zero; it is* derived *as the unique resolution of opposing states under closure. Zero is where creation and destruction meet—not where the system stops.*

3.1. From Interaction to Ring Operations

We now pass from the generic interaction $\circ$ to standard arithmetic. This step is a *definitional construction*, not a derivation: we define addition as the interaction $\circ$ under the identification $\sigma_+ \mapsto +1$, $\sigma_0 \mapsto 0$, $\sigma_- \mapsto -1$, and define multiplication as the unique binary operation on S compatible with distributivity over addition and closure within S.

Remark 4 (Scope of uniqueness). *The four primordial axioms (Axioms 1–4) alone admit many Cayley tables on three elements—closure and nontriviality constrain the interaction but do not uniquely determine it. The specific ring structure emerges only when the additional algebraic axioms (Axioms 5–7) are imposed. Minimality of S (Theorem 1) is therefore a claim about the* ring fragment, *not about all possible three-element magmas.*

Under this identification:

- $(+1) + (-1) = 0$ (cancellation, from Lemma 1).
- $(+1) \times (-1) = -1$ (sign rule, the unique assignment consistent with closure and the distributive law).
- $0 \times x = 0$ for all $x \in S$ (forced by 0 as additive identity and distributivity: $0 \cdot x = (1 + (-1)) \cdot x = x + (-x) = 0$).

The set $S = \{-1, 0, +1\}$ with these operations is the three-element ring $\mathbb{Z}/3\mathbb{Z}$ written in balanced representatives $\{-1, 0, +1\}$, or equivalently the minimal ring fragment containing 0, 1, and -1. We emphasize: the additive structure is inherited directly from $\circ$; the multiplicative structure is the minimal compatible extension demanded by distributivity. Neither operation is imported from outside the primordial interaction.

We now state the algebraic axioms as consequences of this construction.

Axiom 5 (Additive identity). *S contains 0 such that $\forall x \in S$, $x + 0 = x$.*

Axiom 6 (Multiplicative identity). *S contains $1 \neq 0$ such that $\forall x \in S$, $x \cdot 1 = x$.*

Axiom 7 (Additive inverse of multiplicative identity). *S contains -1 such that $1 + (-1) = 0$.*

Lemma 2 (ESTABLISHED: Two elements are insufficient). *No two-element subset of $\{-1, 0, +1\}$ satisfies Axioms 5–7.*

Proof. $\{0, 1\}$: missing -1, fails Axiom 7. $\{0, -1\}$: missing 1, fails Axiom 6. $\{1, -1\}$: missing 0, fails Axiom 5. □

Theorem 1 (ESTABLISHED: Minimality of S). *The smallest set containing elements satisfying Axioms 5–7 is $S = \{-1, 0, +1\}$, and it has exactly three elements.* ■

Proof. Axioms 5–7 require three mutually distinct elements: 0 (additive identity), 1 (multiplicative identity), and -1 (additive inverse of 1, distinct from both 0 and 1). Lemma 2 excludes any proper subset. Therefore $|S| = 3$ is minimal. □

Remark 5. *We claim minimality, not uniqueness among all possible three-element algebras. $S = \{-1, 0, +1\}$ is the unique three-element set satisfying the stated identity and inverse requirements. Whether larger algebras could also satisfy them (by extension) is addressed in the completion sequence (Section 5), where we show that extension is forced but always returns to S via Euler's identity.*

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3.2. Self-Regeneration

Definition 3 (Self-regenerating algebra). *A finite algebra A is* self-regenerating *if every element of A is the output of some binary operation on two distinct elements of A.*

Theorem 2 (ESTABLISHED: Self-regeneration of S). *$S = \{-1, 0, +1\}$ is self-regenerating under addition of distinct pairs. No proper subset of S is self-regenerating.* ■

Proof. Under addition of distinct pairs: $(-1) + 0 = -1$; $(-1) + 1 = 0$; $0 + 1 = 1$. Each element is produced exactly once. For $\{0, 1\}$: only $0 + 1 = 1$; the element 0 is never produced by addition of distinct elements. Similarly $\{0, -1\}$ fails. Only S regenerates all its elements through distinct-pair operations. □

4. The Dynamic Zero Principle

We now state the central principle of this paper, first informally and then with increasing formality.

4.1. Informal Statement

Zero is not a void. It is a dynamic equilibrium: the state through which transitions pass but at which the system cannot permanently reside without violating closure and nontriviality. In any complete system:

1. Every $+a$ implies a $-a$ such that $a + (-a) = 0$.
2. $0 = \sum_i (a_i - a_i)$: zero is the simultaneous presence of all balanced opposites.
3. The transition through zero enables transformation: the passage $+1 \to 0 \to -1$ represents rotation by π.

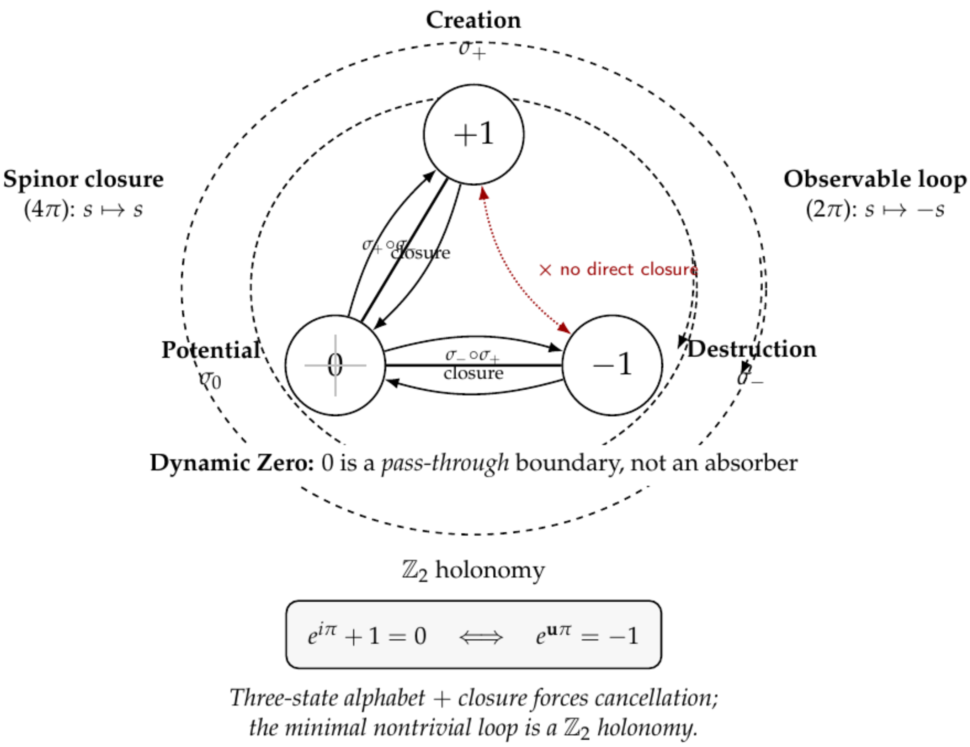

Figure 1. The dynamic-zero triad under closure. The primordial triad $\{-1, 0, +1\}$ sits inside the spinorial double cover. Closure arrows show that all transitions between σ_+ and σ_- pass *through* σ_0; direct closure between +1 and −1 is forbidden (dotted line with ×). The central state 0 is a pass-through boundary (non-absorbing; the light cross marks the prohibition). The dashed ellipses depict the spinorial holonomy: a 2π observable loop flips the internal sign ($s \mapsto -s$), while a 4π loop restores the state ($s \mapsto s$), with Euler closure as the algebraic seal.

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4.2. Formal Statement: Non-Absorption

Definition 4 (Absorbing state)**.** *A state x_* is* absorbing *for an admissible dynamics F (Definition 2) if $F(x_*) = x_*$ and for all $x \in S$, there exists $n \in \mathbb{N}$ such that $F^n(x) = x_*$ and $F^m(x) = x_*$ for all $m \geq n$.*

Theorem 3 (ESTABLISHED: Non-absorption of zero)**.** *There exists no admissible dynamics on $S = \{-1, 0, +1\}$ for which 0 is an absorbing state.* ■

Proof. Suppose F is an admissible dynamics with 0 as an absorbing state. Then for all $x \in S$, $F^n(x) = 0$ for sufficiently large n. In particular, $F^n(+1) = 0$ and $F^n(-1) = 0$ eventually. Once $+1$ and -1 have been mapped to 0, they are eliminated from all future orbits: the effective state space reduces to $\{0\}$.

But F is admissible, meaning it is generated by iterated application of $\circ$ (Definition 2). Any state reached in the long run must therefore be reproducible as an output of $\circ$-compositions. If only 0 remains reachable, then $\{0\}$ is a $\circ$-closed subset of S. Since $\{0\}$ is a proper subset, this contradicts Axiom 4. Therefore 0 cannot be absorbing. □

Remark 6. *The same argument applies to $+1$ and -1: no element of S can be a global absorbing state, because any singleton is a proper closed subset, violating Axiom 4.*

Remark 7 (Zero as compression, not rest)**.** *The non-absorption theorem invites a reinterpretation of zero itself. Classically, zero is understood as a resting state—the additive identity, the origin, the empty count. In the dynamic zero framework, 0 is better understood as a* compression event*: a boundary at which infinite degrees of freedom resolve into finite coherence, analogous to how a limit point compresses an infinite sequence into a single value.*

This interpretation is not merely heuristic. The Euler–Mascheroni constant

$$\gamma = \lim_{m \to \infty} \left(\sum_{k=1}^{m} \frac{1}{k} - \ln m \right)$$

is literally the residue of compressing a discrete summation (the harmonic series) into its continuous counterpart (the natural logarithm). The Dirac delta compresses infinite amplitude into zero spatial extent while preserving finite integral effect. Euler's identity compresses an infinite power series into the cancellation $e^{i\pi} + 1 = 0$. In each case, the zero is not where information vanishes but where it is maximally concentrated.

The non-absorption theorem formalizes this: the system passes through *zero as through an inflection point, not a terminus. Degrees of freedom are restructured at the boundary, not destroyed. This is why the dynamic zero functions as a* limit operator*—the structural act of compression itself—rather than a static value.*

Remark 8 (Connection to relational quantum mechanics and loop quantum gravity)**.** *The non-absorption theorem provides an algebraic foundation for the "Big Bounce" scenarios described in Loop Quantum Gravity [16, 18]. In LQG, the universe does not collapse to a zero-volume singularity; quantum geometry enforces a minimum volume at the Planck scale, and the system bounces through the would-be singularity. Theorem 3 arrives at the same structural conclusion from a different direction: the prohibition against zero as an absorbing state is a consequence of* logical nontriviality *(closure over a non-degenerate state set), not of quantum volume corrections. The dynamic zero is, in this reading, the algebraic skeleton of the cosmological bounce.*

More broadly, Rovelli's relational quantum mechanics holds that physical properties exist only relative to an interaction between systems [15]. This aligns with Axiom 1: the primordial states do not exist as static objects but are constituted by the interaction operator $\circ$. The requirement that any two states determine a third (triadic completion) is a formalization of the relational premise that existence is interaction.

4.3. The Four Faces of the Prohibition

The non-absorption theorem admits four increasingly strong readings. Reading (A) is established above; readings (B)–(D) require additional structure and are treated in Sections 6 and 9.

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(A) **Symbolic.** Convergence to the literal symbol 0 in $\{-1, 0, +1\}$ as a terminal fixed point is forbidden. *Mechanism:* any singleton is a proper closed subset, violating nontriviality (Theorem 3). [ESTABLISHED]

(B) **Dynamical.** Convergence to any trivial fixed point (no novelty, no state transitions) is forbidden. *Mechanism:* a reversible map on a finite state space is a permutation; permutations have no absorbing fixed points outside cycles. Reversibility is a standard axiom of discrete computational frameworks [20,21]. [DERIVABLE]

(C) **Dimensional.** Permanent collapse of degrees of freedom (loss of accessible state-space rank) is forbidden. *Mechanism:* the octonionic structure requires all 8 dimensions for the normed division property (Hurwitz's theorem [4]); loss of any dimension violates the algebra, so the accessible manifold cannot contract permanently. [DERIVABLE]

(D) **Entropic.** Monotonic reduction to a single attractor basin with zero effective entropy is forbidden. *Mechanism:* a computationally complete system (one capable of universal computation) requires nonzero Shannon entropy over its state space [22]; convergence to a single basin would reduce entropy to zero, contradicting the requirement of *minimal* but *nonzero* entropy for computational completeness [23,24]. [DERIVABLE]

5. The Completion Sequence and Euler's Termination Certificate

ESTABLISHED ■

5.1. Forced Extensions

The minimal algebra S is complete at the primordial tier (Axiom 3), but demanding closure under progressively stronger operations forces extension through a unique tower of number systems.

Theorem 4 (ESTABLISHED: Additive iteration forces $\mathbb{Z}$)**.** *Closure under iterated addition (i.e., the demand that $a + b \in S'$ for all $a, b \in S'$, starting from $S' = S$) forces $S' = \mathbb{Z}$.*

Proof. $1 + 1 = 2 \notin S$, so closure under addition requires inclusion of 2; then $2 + 1 = 3$, and so on by induction. Similarly $(-1) + (-1) = -2$, etc. The closure of S under addition is $\mathbb{Z}$. □

Theorem 5 (ESTABLISHED: Multiplicative inversion forces $\mathbb{Q}$)**.** *Closure under multiplicative inverses of all nonzero elements of $\mathbb{Z}$ forces extension to $\mathbb{Q}$.*

Proof. $1/2 \notin \mathbb{Z}$, so demanding that every nonzero integer have a multiplicative inverse requires the rationals. □

Theorem 6 (ESTABLISHED: Metric completion forces $\mathbb{R}$)**.** *Completion of the ordered field $\mathbb{Q}$ under Cauchy sequences (or equivalently, Dedekind cuts) forces extension to $\mathbb{R}$.*

Proof. Standard: $\mathbb{Q}$ is not Cauchy-complete. For example, the sequence of rational approximations to $\sqrt{2}$ produced by Newton iteration ($x_{n+1} = \frac{1}{2}(x_n + 2/x_n)$, $x_0 = 1$) is Cauchy in $\mathbb{Q}$ but has no rational limit. The completion is $\mathbb{R}$, unique up to isomorphism. □

Theorem 7 (ESTABLISHED: Algebraic closure forces $\mathbb{C}$)**.** *Demanding that every polynomial with coefficients in $\mathbb{R}$ have a root forces extension to $\mathbb{C}$. The sequence terminates: $\mathbb{C}$ is algebraically closed (Fundamental Theorem of Algebra).*

Proof. $x^2 + 1 = 0$ has no root in $\mathbb{R}$; adjunction of $i = \sqrt{-1}$ yields $\mathbb{C} = \mathbb{R}[i]$, which is algebraically closed (Fundamental Theorem of Algebra). The algebraic closure of $\mathbb{R}$ is unique up to isomorphism, so the extension terminates at $\mathbb{C}$. No further extension is required. □

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5.2. Euler's Identity as Termination Certificate

Definition 5 (Termination certificate)**.** *A* termination certificate *for a sequence of algebraic extensions $A_0 \subset A_1 \subset \cdots \subset A_n$ is an identity in the terminal structure A_n whose evaluated value lies entirely in the initial alphabet A_0.*

Theorem 8 (ESTABLISHED: The Ouroboros property)**.** *The completion sequence $S \to \mathbb{Z} \to \mathbb{Q} \to \mathbb{R} \to \mathbb{C}$ admits a termination certificate: Euler's identity*

$$e^{i\pi} + 1 = (-1) + 1 = 0.$$

Every constant appearing in this identity is forced by the extension sequence, and the evaluated result resolves entirely to elements of the primordial alphabet $S = \{-1, 0, +1\}$. ■

Proof. In $\mathbb{C}$: the number e is forced as the base of the natural exponential (the unique function equal to its own derivative with $f(0) = 1$); i is forced by algebraic closure as $\sqrt{-1}$; π is defined as the smallest positive real θ such that $e^{i\theta} = -1$, which exists and is unique by the periodicity of the complex exponential (itself a consequence of the convergent power series $e^{iz} = \sum z^n/n!$ in $\mathbb{C}$). Then $e^{i\pi} = \cos\pi + i\sin\pi = -1 \in S$, and $-1 + 1 = 0 \in S$. □

Remark 9. *This is the second manifestation of the dynamic zero: the entire tower of number systems, forced into existence by successive closure demands, terminates by returning to the primordial alphabet. Zero is both origin and terminus—the algebra is ouroboric.*

5.3. Completeness and Generativity

Definition 6 (Complete before extension, generative after)**.** *A finite algebra A is* complete before extension *if it contains all required identity and inverse elements. It is* generative after extension *if its* radical closure*—the closure of A under adjunction of roots of polynomial equations with coefficients in A—produces a strictly larger algebraically closed field.*

Theorem 9 (ESTABLISHED: The Primordial Algebra Theorem)**.** *$S = \{-1, 0, +1\}$ is the unique finite algebra that is complete before extension and generative after extension.* ■

Proof. *Completeness:* S contains 0 (additive identity), 1 (multiplicative identity), and -1 (additive inverse of 1, and the unique nontrivial involution satisfying $x^2 = 1$).

Generativity: Under radical closure, $\sqrt{0} = 0 \in S$, $\sqrt{1} = \pm 1 \in S$, but $\sqrt{-1} = i \notin \mathbb{R}$, escaping to $\mathbb{C}$.

Exclusion of alternatives: $\{0, 1\}$ is closed under radicals and never escapes (not generative). $\{0, -1\}$ generates i via $\sqrt{-1}$, but then $i^4 = 1$ forces inclusion of 1 (not complete before extension). Only S satisfies both properties. □

6. The Dynamic Zero as Holonomy

ESTABLISHED ■ (within $\mathbb{C}$ or any associative subalgebra, where all assumptions are consequences of the completion sequence)

We now connect the algebraic dynamic zero to the geometric structure of spinor double covers. The key observation: all assumptions of the main theorem below are satisfied within $\mathbb{C}$, which was itself forced by the completion sequence of Section 5. In particular, the element $i \in \mathbb{C}$ with $i^2 = -1$ exists by construction (Theorem 7), not by external postulate.

6.1. The Euler Closure Theorem

Theorem 10 (ESTABLISHED: Euler closure as minimal nontrivial holonomy)**.** *Assume a system satisfying:*

1. ***Triadic completion****: interactions are completed by a third element under closure rather than terminating in a null sink (inherited from Axiom 4);*

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2. ***Reversibility***: *the exponential map* $\phi \mapsto e^{\mathbf{u}\phi}$ *is invertible (standard property of* exp *on* $\mathbb{C}$*);*
3. ***Observational equivalence***: *if a physical system is modeled on a quotient* $\mathcal{O} \cong \mathcal{S}/\{\pm 1\}$*, then states* s *and* $-s$ *are observationally identified;*
4. ***Rotational generator***: *there exists* $\mathbf{u}$ *with* $\mathbf{u}^2 = -1$ *(satisfied by* $i \in \mathbb{C}$*, forced by Theorem 7).*

Then the minimal closed loop on the observable space lifts to a nontrivial $\mathbb{Z}_2$ *holonomy on the state space* $\mathcal{S}$*:*

$$s \xmapsto{\theta=2\pi} -s, \qquad s \xmapsto{\theta=4\pi} s, \tag{1}$$

and the corresponding closure identity is Euler closure:

$$e^{\mathbf{u}\pi} = -1 \qquad \Longleftrightarrow \qquad e^{\mathbf{u}\pi} + 1 = 0. \tag{2}$$

■

Proof. Within $\mathbb{C}$ (or any associative subalgebra generated by $\{1, \mathbf{u}\}$), the standard exponential series converges and yields $e^{\mathbf{u}\phi} = \cos\phi + \mathbf{u}\sin\phi$. Setting $\phi = \pi$ gives $e^{\mathbf{u}\pi} = -1$, hence $e^{\mathbf{u}\pi} + 1 = 0$.

Interpret $\theta := 2\phi$ as the physical rotation parameter (the standard double-cover parameterization of $SU(2) \to SO(3)$). Then $\theta = 2\pi$ corresponds to $\phi = \pi$, producing the sign inversion $s \mapsto -s$ on the state space $\mathcal{S}$, while leaving observables invariant because $\mathcal{O} \cong \mathcal{S}/\{\pm 1\}$ by assumption (3). A second traversal $\theta = 4\pi$ yields $\phi = 2\pi$ and returns s to itself.

The role of triadic completion (assumption 1) is to exclude the degenerate alternative: without it, the 2π sign inversion $s \mapsto -s$ could terminate in a null sink (collapse to a fixed point at 0), and the loop would not close nontrivially. Triadic completion forbids null-sink termination (Theorem 3), forcing the system to complete the sign inversion as a cyclic transition $+1 \to 0 \to -1$ rather than absorbing at 0. This makes the $\mathbb{Z}_2$ holonomy the *minimal nontrivial closure event* rather than a terminal collapse. □

Remark 10 (Every form of Euler says the same thing)**.** *Whether expressed as* $e^{i\pi} + 1 = 0$ *in* $\mathbb{C}$*, as* $e^{\mathbf{u}\pi} = -1$ *in a quaternionic subalgebra, or as* $s \mapsto -s$ *under* 2π *rotation in* $SU(2)$*, these are the same closure statement in different representations. The dynamic zero is the event at the boundary of the minimal nontrivial loop.*

Remark 11 (Octonionic scope)**.** *In the octonionic case, the proof holds inside any quaternionic subalgebra associated with a Fano line, where associativity is preserved. The statement "every form of Euler's identity" is interpreted as invariance under representation change within such associative subalgebras; it does not require defining a global octonionic exponential in non-associative directions [5,7].*

7. Physical Interpretation: Vacuum Structure and Non-Absorbing Ground States

Modern quantum field theory rejects the classical notion of a trivial vacuum. The vacuum state is defined as the lowest-energy eigenstate of the Hamiltonian, yet it possesses nontrivial structure: zero-point fluctuations, vacuum polarization, and field expectation values [25,26]. The Casimir effect and related phenomena confirm experimentally that "empty space" is not the absence of physical structure but the ground state of dynamical fields [27].

Formally, this vacuum structure is handled through renormalization and regularization procedures. These methods are mathematically consistent and empirically successful, but they operate by subtracting divergences relative to a reference ground state. Conceptually, the vacuum is therefore treated as a structured null: not annihilation, but cancellation of opposing contributions.

The dynamic zero principle established in Sections 3 and 4 provides a minimal algebraic model of such a non-absorbing ground state. In the primordial algebra $S = \{-1, 0, +1\}$:

1. The neutral element 0 is not absorbing (Theorem 3).
2. It arises uniquely through cancellation of opposing states (Lemma 1).
3. It cannot serve as a terminal configuration without violating closure and nontriviality.

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Thus 0 functions structurally as a boundary state reached through compression rather than as a state of annihilation. The analogy with the quantum vacuum is structural rather than literal: the dynamic zero is a finite algebraic model of a ground state that cannot collapse into triviality.

In this light, the Euler closure identity

$$e^{i\pi} + 1 = 0$$

can be interpreted as a completion event in which an infinite oscillatory process resolves into finite cancellation without absorption. This parallels the manner in which vacuum energy in quantum field theory represents balanced fluctuations rather than emptiness.

The present work does not attempt to modify or replace quantum field theory. Rather, it provides a minimal algebraic template in which "ground state without absorption" arises from closure alone, without recourse to subtraction schemes or external normalization. Whether this template can be lifted to a full field-theoretic construction remains an open question (see Section 10), but the structural alignment suggests that the nontriviality of the vacuum may be an algebraic necessity rather than an empirical accident. In particular, any faithful projection of a non-absorbing closure algebra into a physical representation would necessarily exhibit a structured ground state.

8. The Water Clock: Kairos as Anti-Collapse Operator

DERIVABLE ◇

The preceding sections established the dynamic zero algebraically (Section 3) and geometrically (Section 6). We now sketch its dynamical role: zero as a *threshold event* that prevents termination by incrementing a winding number.

The connection to the holonomy of Section 6 is direct. There, we showed that the minimal nontrivial loop on the observable space corresponds to a $\mathbb{Z}_2$ sign inversion $s \mapsto -s$ on the state space, with triadic completion forbidding collapse at the midpoint 0. In the time-like direction, the same structure appears as the discrete *click*: the admissible dynamics F drives the system through a cycle of configurations until it saturates, at which point the system must pass through a zero-crossing (a local reset) to begin a new cycle rather than absorbing. The kairos event is the temporal analogue of the $\mathbb{Z}_2$ holonomy—the same boundary passage through zero that appears spatially as spinor sign-flip appears temporally as the anti-collapse click.

8.1. Time as Memory

In the Kosmoplex framework [2], the successor function T_{kairos} and the memory register are identified: the system's "time step" is simply the index of accumulated state. Time is not external; it is the ordering of memory states:

$$m_{t+1} = F(m_t),$$

and t is the count of applications of F. This perspective aligns with recent proposals in which time emerges from quantum correlations [17,19] rather than serving as a background parameter.

8.2. The Click Mechanism

Definition 7 (Configuration space)**.** *A* configuration *at step n is an equivalence class of states reachable from the initial state under n applications of admissible dynamics (Definition 2), where two states are equivalent if they produce identical interaction tables under $\circ$. In the 42-glyph engine, configurations correspond to distinct glyph compositions; in the primordial tier, they correspond to the elements of $S^n/\sim$ under the equivalence induced by the interaction axioms.*

Define the *permutation saturation function*:

$$\Omega(n) = \big|\{\text{distinct configurations reachable under closure after } n \text{ steps}\}\big|.$$

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When the system saturates—i.e., $\exists N$ such that $\Omega(N+1) = \Omega(N)$—a closure event occurs. Define the *kairos index*:

$$K = \min\{n : \Omega(n+1) = \Omega(n)\}. \tag{3}$$

At step K, the configuration space has been exhausted under the closure rule. The system cannot halt (non-absorption, Theorem 3), so it must *increment the winding number* and begin a new cycle.

Proposition 2 (DERIVABLE: Kairos as anti-collapse operator)**.** *In a system satisfying closure, totality, boundedness, nontriviality, and reversibility, the kairos event is the operator that resolves permutation saturation by incrementing the winding number rather than collapsing to a null fixed point.* ◇

Remark 12 (The water clock analogy)**.** *A water clock accumulates continuous inflow until a threshold is reached; then a discrete drip occurs, the cup resets, and the cycle continues. The global clock never stops (non-absorption), but each local cup empties to zero (local reset). The kairos event is the drip: a passage through zero that is not annihilation but renewal.*

9. Derivable Consequences Under the Full Axiom Set

DERIVABLE ◇

The following results require the full Kosmoplex axiom set (11 axioms, see [2]). We state them precisely and reference their proofs.

9.1. The 42 Operations

Theorem 11 (DERIVABLE: The 42 Constraint)**.** *Given the octonionic structure, Fano plane incidence [29,30], and orientation duality, the system generates exactly*

$$7 \textit{ lines} \times 3 \textit{ strides} \times 2 \textit{ orientations} = 42 \textit{ operations (glyphs)}.$$

◇

9.2. Channel Capacity 137

Theorem 12 (DERIVABLE: Channel capacity)**.** *The maximum number of independent reversible eigenstates transmissible through the 8D $\to$ 4D projection, given 42 glyphs over 7 Fano lines with ternary alphabet and orientation duality, is $\alpha^{-1}_{integer} = 137$. The projected 4D value with information-theoretic corrections is $\alpha^{-1} = 137.035999143$, within 1.62σ of the CODATA 2018 value [3].* ◇

9.3. The Four Attractor Basins

Theorem 13 (DERIVABLE: Basin–algebra correspondence)**.** *The projection classifies mathematical and physical constants into four attractor basins corresponding to the four normed division algebras [4,5]:*

$$\begin{array}{lcl} \textit{Alpha } (\mathbb{R}) & : & \alpha,\ G,\ \textit{coupling ratios} \\ \textit{Geometric } (\mathbb{C}) & : & \pi,\ \varphi,\ \sqrt{2} \\ \textit{Harmonic } (\mathbb{H}) & : & \gamma,\ \zeta(2),\ \zeta(3) \\ \textit{Exponential } (\mathbb{O}) & : & e,\ \ln 2,\ \ln\varphi \end{array}$$

No fifth basin exists (Hurwitz's theorem). ◇

9.4. Collapse Prohibition: The Strong Form

Theorem 14 (DERIVABLE: Global non-collapse)**.** *Under the full axiom set, the system admits no:*

(A) *absorbing symbolic null state,*
(B) *trivial fixed-point attractor,*
(C) *permanent dimensional contraction (rank reduction of the accessible state manifold),*
(D) *monotonic entropy death (convergence to a single basin with zero effective entropy).*

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◇

Proof sketch. (A) follows from Theorem 3. (B) follows from reversibility: a reversible map on a finite state space is a permutation, and permutations have no absorbing fixed points outside cycles [20, 21]. (C) follows from the Hurwitz constraint [4]: the octonionic structure requires all 8 dimensions for the normed division property; loss of dimensions would violate the algebra. (D) follows from computational completeness: the system occupies the state of *minimal* Shannon entropy consistent with universal computation, which is nonzero for any Turing-complete system [22,24]. □

10. Open Questions

OPEN ○

We state precisely the questions whose resolution would most significantly strengthen or constrain the framework.

Open Question 10.1 (Necessity of triadic closure)**.** *Does any self-consistent, reversible, non-seizing computational universe* require *a dynamic triadic completion rule, or can a purely dyadic system with sufficient memory emulate triadic closure without loss of expressive power?*

Status. *Triadic closure is known to be* sufficient *for the results above. That it is* necessary*—that binary systems cannot replicate the same closure structure without implicitly smuggling in a third state—is conjectured but unproved. A resolution would require specifying a formal property P (e.g., non-seizure + reversibility + bounded memory growth + locality) and showing that triadic systems satisfy P while strictly dyadic systems do not, unless they augment their state space to become effectively triadic.*

Open Question 10.2 (Gauge status of the dynamic zero)**.** *Is the dynamic zero best understood as a gauge constraint (a redundancy in description that can be eliminated by a choice of frame) or as a physical degree of freedom (an observable transition state with measurable consequences)?*

Status. *The algebraic results are consistent with either reading. The distinction matters physically: if the dynamic zero is a gauge artifact, it simplifies the ontology but potentially loses predictive content; if it is physical, it should have observable signatures in precision measurements (e.g., the altitude-dependent variation of α predicted in [3]).*

Open Question 10.3 (Derivability of the rotational generator from the primordial axioms alone)**.** *Can the existence of an element* $\mathbf{u}$ *with* $\mathbf{u}^2 = -1$ *be derived from the primordial interaction axioms (Axioms 1–7)* without *invoking the completion sequence?*

Status. *Within the completion sequence, $i = \sqrt{-1}$ is forced by algebraic closure of $\mathbb{R}$ (Theorem 7). So Assumption (4) of Theorem 10 is already a consequence of the established results. The open question is whether a* shorter *derivation exists that produces a rotational generator directly from the primordial tier without passing through $\mathbb{Z} \to \mathbb{Q} \to \mathbb{R} \to \mathbb{C}$. Such a shortcut, if it exists, would strengthen the claim that Euler closure is "primordial" rather than "terminal."*

Open Question 10.4 (Uniqueness of the kairos mechanism)**.** *Is the permutation-saturation mechanism (Section 8) the* unique *anti-collapse operator compatible with the axioms, or do alternative non-termination mechanisms exist?*

Status. *The water-clock model is one realization. Whether it is the only one compatible with the full axiom set is unknown. Alternative mechanisms (e.g., ergodic recurrence, chaotic mixing) should be systematically excluded or shown to reduce to the saturation model under the constraints.*

Open Question 10.5 (The Riemann Hypothesis as a closure corollary)**.** *Does the triadic closure axiom, combined with the 8D octonionic structure,* necessarily *force all nontrivial zeros of the Riemann zeta function to the critical line $\Re(s) = 1/2$?*

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Status. *A proof schema is outlined in companion work [2] but depends on the unproved Prime Motif Hypothesis (that primes in 4D are projections of four regular progenitor cycles in 8D). The key observation is that the non-absorption theorem (Theorem 3) provides the algebraic engine: the prohibition against collapse to a trivial state is precisely the principle that forces the infinite stability required for prime distribution [33,34]. Off the critical locus, basin coverage fails and the projection loses sensitivity to an entire residue class of primes—the geometric realization of what Bombieri called "havoc in the distribution of prime numbers."*

This remains the deepest open question in the framework: if the connection holds, it would be the most consequential corollary of the dynamic zero principle; if it fails, it would indicate that the framework's scope has a definite upper boundary at the level of number-theoretic fine structure.

11. Structural Correspondences

The primordial algebra and its dynamic zero exhibit isomorphisms with several independently motivated structures:

Structure	Correspondence
Balanced ternary	S is the digit set; most efficient radix economy [13]
Three-valued logic	$S \cong \{\text{True, Unknown, False}\}$ (Łukasiewicz [9], Kleene)
Ternary algebraic systems	Noether's abstract algebra program; ternary composition as primitive [10]
Steiner triple systems	Triadic completion $C(a, b)$ = third element is a Steiner quasigroup [11,12]
Primitive involution	-1 is the unique $x \in \mathbb{Z} \setminus \{1\}$ with $x^2 = 1$
CPT symmetry	σ_+/σ_- as charge conjugation; σ_0 as vacuum [28]
Pauli eigenvalues	Spin-$\frac{1}{2}$ measurements yield ± 1; superposition passes through 0
Peirce's categories	Firstness, Secondness, Thirdness as modal states [14]
Relational QM / LQG	Dynamic zero as algebraic Big Bounce; interaction-first ontology [15,16]
Riemann critical line	Non-absorption as algebraic engine of critical-line stability [33,34]

These correspondences are noted as structural parallels, not as derivations. Whether they reflect a common origin or independent convergence to the same minimal structure is itself an open question (related to Open Question 10.1).

12. Conclusions

The dynamic zero under closure is the irreducible core of the Kosmoplex framework. From three modal states and four interaction constraints, we derived:

1. The unique minimal algebra $S = \{-1, 0, +1\}$ (Theorem 1).
2. Cancellation as a forced consequence, not a postulate (Lemma 1).
3. Self-regeneration: every element produced by distinct-pair operations (Theorem 2).
4. Non-absorption: zero cannot be a terminal state (Theorem 3).
5. The forced completion sequence $S \to \mathbb{Z} \to \mathbb{Q} \to \mathbb{R} \to \mathbb{C}$, terminating with Euler's identity as the ouroboric certificate (Theorem 8).
6. Euler closure as the minimal nontrivial $\mathbb{Z}_2$ holonomy (Theorem 10).
7. Orientation-forced symmetry breaking: triadic completion alone admits a symmetric (S_3-equivariant) law, but imposing orientation (order sensitivity) forces the breaking of S_3 equivariance (Proposition 1).

These results require no free parameters, no empirical input, and no assumptions beyond the seven axioms stated in Sections 2 and 3. The dynamic zero is not a number; it is the structural prohibition against termination—expressed in the language of deduction from axioms.

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12.1. Completeness and Incompleteness

The established results admit a natural reading in terms of the classical tension between Hilbert's program [31] and Gödel's incompleteness theorems [32].

Within any fixed observational projection—a choice of representation that maps the primordial states to a concrete algebra and selects a subsystem for analysis—the induced dynamics is internally consistent and decidable. The cancellation lemma, non-absorption theorem, and completion sequence are complete proofs within their axiom set; in the spirit of Hilbert's sixth problem, they constitute a minimal axiomatization of a discrete closure engine. The primordial algebra is, in this sense, *locally complete*: every well-posed question about S under the stated axioms has a definite answer.

However, the full closure engine—the totality of interactions across all possible orientations, compositions, and projection gauges—cannot be captured within any single projected subsystem. No one representation simultaneously exhibits all automorphisms of the underlying structure. This is not a deficiency of the formalism; it is a structural consequence of the symmetry-breaking result (Proposition 1): any concrete realization of the algebra requires a choice of orientation, and that choice excludes the complementary orientations from view.

The framework thus reconciles completeness and incompleteness at different levels: local consistency within each projected frame (Hilbert), global irreducibility of the full structure to any single frame (Gödel). The boundary between these levels is precisely the dynamic zero—the projection event where the abstract closure engine meets a concrete observational context.

12.2. Outlook

The open questions (Section 10) are stated with enough precision to admit resolution. The derivable consequences (Section 9) indicate the scope of the broader framework but do not bear on the validity of the established core. The most immediate experimental test is the altitude-dependent variation of the fine-structure constant predicted in [3]: a null result at the 10^{-17} level would falsify the projection mechanism, while a positive detection at the predicted coefficient would constitute evidence that the dynamic zero is not merely algebraic but physical.

Between what is proved and what remains open lies the productive frontier.

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