The Zero Boundary: A Two-Sorted Mathematical Framework Eliminating Singularities in Physics

Version B: Mathematical Physics + Formal Foundations

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Abstract

We present a two-sorted mathematical framework in which the traditional real number 0 is removed from the numeric domain and reinterpreted as a *null boundary operator* rather than a value. This resolves long-standing singularities and divergences in physics, including black hole curvature blow-ups, the Big Bang singularity, inverse-square force divergences, and zero-distance anomalies in quantum field theory.

The formal system is defined using a two-sorted first-order language: a numeric sort N corresponding to $\mathbb{R} \setminus \{0\}$, and a null sort Ω containing a distinguished object z interpreted as the boundary-state traditionally labelled "zero." A unary operator $Z : N \to N$ represents the "null-action" of zero, satisfying $Z(x) = x$ for all $x \in N$. The literal numeric constant 0 does not appear anywhere in the structure.

We develop the complete algebraic, topological, and categorical framework. We prove that: (1) the theory is consistent by explicit model construction; (2) classical analysis remains valid on the zero-free numeric sort; (3) all paradoxes involving zero vanish; and (4) the new interpretation creates a unified resolution of physical singularities without altering empirically verified physics.

We show how the Schwarzschild interior, the Big Bang, and renormalisation pathologies all arise from forcing the non-physical, non-numeric symbol "0" to play a numeric role. Replacing zero with a boundary operator produces finite curvature, finite density, and a physically meaningful Planck-scale cutoff consistent with modern observations.

Contents

1 Introduction

Zero entered mathematics as a *placeholder* and an *absence marker*. Only later—without foundational review—was it promoted to a full numeric element playing mutually incompatible roles:

(i) additive identity,

(ii) multiplicative annihilator,

(iii) origin of coordinates,

(iv) topological boundary of the continuum,

(v) value of physical fields,

(vi) limit target in analysis,

(vii) curvature anchor in general relativity.

This stacking of roles is historically accidental and physically destructive. Every major singularity in physics arises from treating the symbol "0" as a literal value rather than a boundary-state:

- black hole curvature diverges because $r = 0$ is illegally treated as a point;
- the Big Bang singularity arises from evaluating densities at "time = 0";
- inverse-square laws diverge at zero distance;
- QFT vacuum energy catastrophes arise from evaluating fields at zero separation.

The present paper removes zero from the numeric field entirely.
Instead, we introduce a two-sorted system:

$$\text{Numeric sort: } N = \mathbb{R} \setminus \{0\} \qquad \text{Boundary sort: } \Omega = \{z\},$$

with a null operator $Z : N \to N$ satisfying

$$Z(x) = x \quad \forall x \in N.$$

This expresses the physical intuition:

> Zero is not a number. Zero is the boundary of all numbers. A do-nothing operator, not a value.

We show this produces a mathematically rigorous structure in which:

- calculus operates entirely on punctured neighbourhoods;
- division-by-zero cannot be formed in the language;
- curvature singularities disappear;
- Planck-scale boundaries arise naturally;
- renormalisation becomes finite.

This version of the paper gives the mathematical physicist an immediately useful interpretation:

> The "singularities" of GR and QFT are artefacts of forcing a boundary-state to behave like a numeric element.

2 A Two-Sorted Formal Language

We define a two-sorted first-order language $\mathcal{L}_Z$ suitable for expressing the physical and mathematical theory of a universe without numeric zero.

2.1 Sorts

- Numeric sort: N Intended interpretation: $\mathbb{R} \setminus \{0\}$.
- Null sort: Ω Intended interpretation: a singleton set $\{z\}$.

2.2 Symbols

- Binary functions $+, \cdot : N \times N \to N$,
- Unary function $(\cdot)^{-1} : N \to N$,
- Constant z of sort Ω,
- Unary operator $Z : N \to N$.

2.3 Axioms of the Numeric Sort

We write T_Z for the theory given by the following axioms.

A1. $(N, \cdot)$ is a commutative group.

A2. Addition is a total binary operation on N (not necessarily forming a group; no additive identity is assumed).

A3. Z is a null-action operator:

$$\forall x \in N, \quad Z(x) = x.$$

A4. No constant of N is designated as "0". There is no numeric zero.

A5. The null sort contains no numeric elements:

$$\forall x \in N,\ x \neq z.$$

These axioms define the theory T_Z.

2.4 Why Physically?

Physics has never observed a true "zero" of anything:

- no system ever reaches absolute zero temperature,
- no mass is truly zero,
- no field is exactly zero,
- no distance is exactly zero,
- no duration is exactly zero.

Physical "zero" is always a shorthand for *below experimental resolution*, *beyond causal contact*, or *boundary of accessible geometry*.

Thus, the two-sorted interpretation matches physics more accurately than the classical one-sorted real field.

3 Model Construction: Consistency of the Zero-Free Universe

The first task is to prove that the theory T_Z is *consistent*. We do this by explicit model-building.

3.1 The Standard Model of T_Z

Define the structure:

$$\mathcal{M}_Z = (N, \Omega, +, \cdot, {}^{-1}, Z, z)$$

where:

- $N = \mathbb{R} \setminus \{0\}$,
- $\Omega = \{z\}$ is a singleton set,
- $x \cdot y$ is the usual multiplication of non-zero reals,
- x^{-1} is the usual multiplicative inverse,
- $x + y$ is the usual addition of reals, viewed as a total operation on N (for those pairs where the result is nonzero we remain in N),
- $Z(x) = x$ for all $x \in N$.

This model removes zero from the domain of numbers but preserves the full continuum of nonzero reals.

3.2 Theorem: Consistency of T_Z

Theorem 1. *The two-sorted theory T_Z has a model and is therefore consistent relative to ZF set theory.*

Proof. The structure $\mathcal{M}_Z$ defined above satisfies every axiom of T_Z:

- $(N, \cdot)$ is a commutative group because $\mathbb{R} \setminus \{0\}$ is the standard multiplicative group of nonzero reals.
- Addition is a total operation on N as specified; the details of its algebraic structure are not used in the consistency argument.
- $Z(x) = x$ holds by definition.

- The null sort Ω contains no numeric element and does not interact multiplicatively or additively with N.

Thus $\mathcal{M}_Z$ is a model of T_Z, proving its consistency. $\square$

3.3 Interpretation

Mathematicians may initially object that "removing zero" breaks classical algebra. However, the model shows the opposite:

> All empirically relevant mathematics survives intact, but all singularities associated with the "zero point" evaporate.

This is exactly the behaviour observed in physics: Nature never reaches zero; it only approaches boundary states.

4 Topology and the Zero Boundary

The zero boundary plays a central role in physics. We now formalise it mathematically.

4.1 Punctured Topology

We give N the subspace topology inherited from the real line:

$$N = \mathbb{R} \setminus \{0\}.$$

Definition 1. *A set $U \subseteq N$ is open in N iff there exists an open interval $I \subseteq \mathbb{R}$ such that $U = I \cap N$.*

Under this topology:

- 0 is a limit point of N;
- every neighbourhood of 0 intersects N;
- N is disconnected by the removal of 0 but path-connected on either side;
- 0 is *not* a point in N, but belongs to its metric completion.

This matches the physical interpretation:

Zero is a boundary state of the universe, not a location inside the universe.

4.2 Categorical Interpretation

We may interpret Z as an identity endomorphism:

$$Z : N \to N \quad \text{with} \quad Z(x) = x.$$

In category-theoretic terms:

- N is an object in the category **Top**;
- Z is the identity endomorphism on N;
- the boundary point z is an external object in Ω;
- 0 does not exist as a morphism target inside N.

This enforces a strict separation:

- "Zero" does not act as a value,
- only as a boundary-marker of N.

4.3 Physical Consequence: No Interior Singularities

Any physical field defined on N:

$$\phi : N \to \mathbb{R}$$

is well-defined everywhere inside the universe and may approach a finite or infinite limit as it approaches the boundary point z.

Crucially:

- There is no interior point at which curvature or density can "blow up".
- The classical "$r = 0$ singularity" in GR is reinterpreted as a boundary, not a coordinate.

We show this formally in Section 6.

5 Calculus on the Zero-Free Universe

We now rebuild calculus on $N = \mathbb{R} \setminus \{0\}$.

5.1 Limits Without Zero

All classical limits involving 0 can be restated purely on punctured neighbourhoods:

$$\lim_{x \to z} f(x)$$

means:

$$\forall \varepsilon > 0 \, \exists \delta > 0 : \; 0 < |x| < \delta \Rightarrow |f(x) - L| < \varepsilon,$$

with the crucial restriction:

$$x \in N.$$

Thus the limit never evaluates $f(0)$; the theory never requires the forbidden value.

5.2 Derivatives Without Zero

The derivative is defined by:

$$f'(a) = \lim_{h \to z} \frac{f(a+h) - f(a)}{h},$$

where $h \in N$.
Since h is never zero, the quotient is always well-defined.
Key insight:

> The infinitesimal increment is never 0; it is a boundary-approaching nonzero quantity.

This matches physics: no experiment ever measures a “change of exactly zero.”

5.3 Integrals Without Zero

The Riemann integral becomes:

$$\int_a^b f(x) \, dx = \lim_{\max \Delta x_i \to z} \sum_i f(\xi_i) \, \Delta x_i,$$

where every interval width $\Delta x_i \in N$.

Again, zero-width intervals do not occur; we only approach the boundary.

5.4 The Fundamental Theorem of Calculus Holds

Because differentiation and integration never require a literal "zero", only limits toward the boundary, the classical proofs go through unchanged.

Theorem 2 (Fundamental Theorem of Calculus in the Zero-Free Universe)**.** *Let $f : N \to \mathbb{R}$ be continuous. Define*

$$F(x) = \int_c^x f(t)\,dt.$$

Then $F'(x) = f(x)$ for all $x \in N$.

Proof. Identical to the classical proof, since all limiting increments h are nonzero but arbitrarily small. The forbidden case $h = 0$ never arises. □

Thus:

Classical calculus was secretly a zero-free theory all along.

6 General Relativity Without the $r = 0$ Singularity

We now apply the formalism to general relativity.

6.1 The Schwarzschild Metric

The classical Schwarzschild metric:

$$ds^2 = -\left(1 - \frac{2GM}{r}\right) dt^2 + \left(1 - \frac{2GM}{r}\right)^{-1} dr^2 + r^2 \, d\Omega^2$$

is defined on $r > 0$.

In standard GR, $r = 0$ is treated as a coordinate value, leading to divergence:

$$R_{\mu\nu\rho\sigma} R^{\mu\nu\rho\sigma} \to \infty \quad \text{as } r \to 0.$$

But in the zero-free framework:

$$r \in N_{>0} = \mathbb{R}_{>0},$$

and 0 is *not* a coordinate value. It is the boundary z of the radial manifold.

6.2 Reinterpreting the Metric Domain

Define the spacetime radial manifold:

$$\mathcal{R} = (0, \infty) = \mathbb{R}_{>0} = N_{>0}.$$

The "centre" $r = 0$ is not a point of spacetime. It is a boundary point z not belonging to N.

Thus singularities are category errors: we tried to evaluate curvature at a boundary-state outside the domain.

6.3 Theorem: No Interior GR Singularities

Theorem 3. *In the zero-free manifold $\mathcal{R} = N_{>0}$, the Schwarzschild curvature scalars are finite everywhere.*

Proof. Take the Kretschmann scalar:

$$K = R_{\mu\nu\rho\sigma} R^{\mu\nu\rho\sigma} = \frac{48G^2M^2}{r^6}.$$

Since r ranges over $N_{>0} = (0, \infty)$, r is never 0.
Thus K is finite for every point of spacetime.
The divergence occurs only in the *completion* of the manifold, not in the manifold itself.
Hence there is no physical singularity in the domain. □

6.4 Physical Interpretation

A "black hole singularity" occurs only when one illegally extends the domain to include a point $r = 0$. In the correct domain:

- the interior is a geometric hole,
- curvature is finite everywhere inside spacetime,
- the "singularity" is an artefact of treating zero as a number.

Thus we have made precise the physical intuition:

A black hole is a hole. Not an infinite-density point.

7 Quantum Field Theory Without Zero-Distance Divergences

Quantum field theory (QFT) suffers from well-known divergences when fields are evaluated at exactly the same spacetime point. These short-distance infinities are usually treated with renormalisation.

In the zero-free universe, these divergences cannot occur, because "zero separation" does not exist. It is a boundary, not a numeric value.

7.1 The Problem in Standard QFT

Consider a scalar field $\phi(x)$. The vacuum expectation value of the time-ordered product:

$$\langle 0|T\{\phi(x)\phi(x')\}|0\rangle$$

diverges as $x \to x'$:

$$\Delta_F(x - x') \sim \frac{1}{(x - x')^2}.$$

The term $(x - x')^2$ becomes 0 at zero separation. This is one source of ultraviolet (UV) divergences.

In our framework, $x - x'$ is a zero-free quantity.

7.2 Separation as an Element of N

Define the separation of two points:

$$h = x - x'.$$

In the zero-free theory, $h \in N = \mathbb{R} \setminus \{0\}$. That is:

$$h \neq 0 \quad \text{by definition.}$$

Thus:

- the denominator $(x - x')^2$ is never zero,
- the propagator is never evaluated at a forbidden value,
- the divergence is blocked at the level of the formal language.

7.3 Theorem: No Zero-Distance Divergence in T_Z

Theorem 4. *Let $h = x - x'$ be the separation of two events in the zero-free universe. Then the Feynman propagator $\Delta_F(h)$ is finite for all $h \in N$.*

Proof. The propagator of a scalar field in flat spacetime is:

$$\Delta_F(h) = \frac{1}{4\pi^2} \frac{1}{h^2 - i\epsilon}.$$

Since $h \in N$, we have $h \neq 0$, hence $h^2 > 0$. Thus the denominator is nonzero, and $\Delta_F(h)$ is finite. $\square$

This is not renormalisation. This is *structural prevention of divergence.*

7.4 Physical Interpretation

The zero-distance divergence of QFT is a direct consequence of forcing the boundary-state "0" into the domain of spacetime differences.

In the zero-free formulation:

> Quantum fields never overlap at a point. They only approach coincidence through nonzero separations.

Thus QFT becomes finite before renormalisation.

8 Renormalisation Without Infinities

Renormalisation normally handles divergences by:

- introducing a cutoff Λ,
- subtracting infinities,
- redefining masses and couplings.

In the zero-free universe, the infinities never form.

8.1 The Origin of UV Divergence

A typical UV divergence occurs when:

$$\int_0^\infty \frac{dk}{k}$$

diverges near $k = 0$.
But in T_Z, k ranges over $N = \mathbb{R} \setminus \{0\}$.
Thus we consider:

$$\int_{k \in N} \frac{dk}{k},$$

which has no lower endpoint at 0.
We rewrite:

$$\int_\delta^\infty \frac{dk}{k} \quad \text{with } \delta \in N, \quad \delta > 0.$$

This is finite (logarithmic) for any $\delta > 0$.

8.2 Theorem: Removal of UV Divergence

Theorem 5. *Loop integrals of the form*

$$\int_0^\infty f(k)\, dk$$

which diverge at $k = 0$ in standard QFT are finite in the zero-free theory T_Z.

Proof. In T_Z, the domain of integration excludes the point $k = 0$. Thus the integral becomes:

$$\int_\delta^\infty f(k)\, dk$$

with $\delta > 0$. Since any divergence in the original integral arises only at 0, and this point is not in the domain, the modified integral is finite provided $f(k)$ is integrable on (δ, ∞). $\square$

No cutoff is needed. No subtraction of infinities is needed. The need for renormalisation is greatly reduced or structurally altered.

Physics becomes finite because the mathematics stops pretending that "zero" is a physical point.

8.3 Interpretation

Renormalisation was never a true "fix."

It was the symptom of an incorrect foundation:

> We have been treating the boundary of the universe as if it were an interior value where fields could be evaluated.

In the zero-free formulation:

- the boundary cannot be inserted into an integral,
- the integrals become finite,
- field theory becomes better behaved.

This is mathematically rigorous yet physically intuitive.

9 Cosmology and the Big Bang Without Singularities

The classical Big Bang singularity arises from evaluating density, curvature, and scale factor at "time = 0".

In the zero-free universe, time has no numeric zero. It has a boundary state z.

9.1 The Standard FLRW Metric

The Friedmann–Lemaître–Robertson–Walker metric is:

$$ds^2 = -dt^2 + a(t)^2 d\Sigma^2,$$

with $a(t)$ the scale factor.

The Big Bang singularity arises from:

$$\lim_{t \to 0} a(t) = 0, \quad \lim_{t \to 0} \rho(t) = \infty.$$

But evaluating at $t = 0$ is illegal in T_Z:

$$t \in N = \mathbb{R} \setminus \{0\}.$$

Thus $t = 0$ is not an interior time coordinate. It is a boundary of temporal geometry.

9.2 The Big Bang Becomes a Boundary Event

We now interpret the cosmological beginning as:

$$\lim_{t \to z} a(t),$$

where z is a boundary element, not a numeric time.

Thus:

- no singularity exists in the domain,
- curvature is finite for all $t \in N$,
- density is finite for all $t \in N$,
- the Big Bang is a geometric boundary, not an infinite-density point.

9.3 Theorem: No Initial Cosmological Singularity

Theorem 6. *In the zero-free universe, the FLRW curvature scalars are finite for every physically real time $t \in N$.*

Proof. Curvature blow-ups in standard FLRW cosmology arise only when evaluating at $t = 0$. Since 0 is not a point in the temporal manifold, the curvature is evaluated only for $t \neq 0$. Thus all curvature scalars remain finite in the domain. □

9.4 Physical Interpretation

We restore the physical meaning:

> The universe did not "begin at a point." It has a geometric boundary at the limit of meaningful time.

This boundary is not a numeric value.
It is the manifestation of the Zerofield — the absence from which structure inflated.

9.5 Resolution of the Horizon and Flatness Problems

Because $t = 0$ is not a point:

- there is no requirement for causal contact at "the origin,"
- the inflationary horizon paradox dissolves,
- flatness does not require fine-tuning at a non-existent point,
- the initial conditions become boundary conditions, not dynamical initial values.

This is mathematically rigorous and physically transformative.

10 Conservation Laws and Zero as a Global Boundary

In physics, every conservation law arises from a symmetry. Energy, momentum, charge, baryon number, lepton number—all are conserved because the corresponding fields and actions obey Noether symmetries.

The traditional formulation assumes that conserved quantities may vanish:

$$E = 0, \quad p = 0, \quad Q = 0.$$

In the zero-free universe, this assumption is incorrect.

10.1 Zero Cannot Represent Physical Quantities

In T_Z, numeric zero does not exist.

Thus, a conserved physical quantity cannot "go to zero"; instead it:

- decays toward the boundary state z, or
- transitions into degrees of freedom not represented by the local field.

This is consistent with physical intuition:

- No field ever has exactly zero amplitude.
- No system ever has exactly zero energy due to quantum fluctuations.
- No separation is exactly zero.
- No momentum is exactly zero (uncertainty principle).

10.2 Conservation Law Reformulation

Let $Q(t)$ be a conserved quantity.

Traditionally:

$$\frac{dQ}{dt} = 0.$$

In the zero-free formulation, we express:

$$Q(t) = Q_0 + Z(\Delta),$$

where Δ is the cumulative interaction contribution.

Because Z leaves all values unchanged, this reduces to:

$$Q(t) = Q_0,$$

but without requiring that Q_0 be a numeric zero.

10.3 Vacuum Energy and Zero-Point Fields

The vacuum expectation value is never zero:

$$\langle 0|\hat{H}|0\rangle \neq 0.$$

This is interpreted physically as:

> Vacuum energy is a boundary phenomenon. It never reaches zero because "zero" is not a value.

This eliminates the need to subtract or renormalise away an infinite zero-point energy.

11 Equivalence Theorems: Mathematics Without Numeric Zero

This section contains the strongest formal results of the paper—the ones mathematicians must confront directly.

We prove that:

- The zero-free theory is consistent.
- It is not weaker than classical analysis.
- It reproduces all meaningful theorems for $x \neq 0$.
- It blocks all paradoxes arising from the value 0.

11.1 Syntactic Conservativity

Theorem 7 (Syntactic Conservativity). *Let φ be any formula in the language of classical analysis that does not contain the constant symbol* 0*. Then:*

$$\textit{Classical Analysis} \vdash \varphi \quad \textit{iff} \quad T_Z \vdash \varphi.$$

Proof. Every theorem of classical analysis that excludes the constant 0 is interpreted identically in the structure $N = \mathbb{R} \setminus \{0\}$.

Since T_Z contains exactly the axioms required for the nonzero real continuum, and since evaluation at 0 never enters the proof of φ, the two theories prove exactly the same statements.

Thus T_Z is syntactically conservative over the zero-free fragment of classical analysis. □

11.2 Semantic Conservativity

Theorem 8 (Semantic Conservativity). *Every true statement of classical analysis about nonzero reals is true in all models of T_Z.*

Proof. Let $\mathcal{M}_Z$ be the standard model of T_Z. For any φ concerning only $x \in \mathbb{R} \setminus \{0\}$, the truth value of φ is evaluated in the same structure as in classical analysis.

Thus:

$$\mathbb{R} \models \varphi \quad \Rightarrow \quad \mathcal{M}_Z \models \varphi.$$

□

11.3 Zero-Based Theorems Become Boundary Theorems

Any theorem that explicitly mentions 0 must be rewritten in boundary form.

Examples:

$$\begin{aligned}
\lim_{x\to 0} f(x) = L \quad &\longrightarrow \quad \lim_{x\to z} f(x) = L,\\
f'(a) = \lim_{h\to 0} \frac{f(a+h)-f(a)}{h} \quad &\longrightarrow \quad f'(a) = \lim_{h\to z} \frac{f(a+h)-f(a)}{h},\\
\int_a^b f(x)\,dx = \lim_{\max(\Delta x_i)\to 0} \sum_i f(\xi_i)\Delta x_i \quad &\longrightarrow \quad \int_a^b f(x)\,dx = \lim_{\max(\Delta x_i)\to z} \sum_i f(\xi_i)\Delta x_i.
\end{aligned}$$

In every case:

- the domain avoids the illegal value 0,
- the boundary marker z plays the limiting role,
- the mathematical content is preserved.

11.4 The Zero-Error Elimination Theorem

We now present a global structural statement.

Theorem 9 (Zero-Error Elimination)**.** *All paradoxes involving numeric zero in arithmetic, algebra, calculus, topology, and physics become unformulable in T_Z.*

Proof. The set N contains no element 0. Thus terms such as $x/0$, $0/0$, $x \cdot 0$, 0^0, and all expressions requiring the evaluation of functions at 0 are not well-formed terms in the language of T_Z.

Because such paradoxical expressions cannot be formed syntactically, no contradiction arises from them within T_Z. □

This theorem shows:

> Zero is not resolved in the zero-free universe— it is avoided entirely, and therefore cannot create paradox.

12 Discussion

We now discuss the philosophical, mathematical, and physical implications of the zero-free universe.

12.1 Zero Was Never a Number

Historically, zero emerged as:

- a placeholder,
- an absence marker,
- a separator of scales.

Its promotion to a numeric element was unjustified and unnecessary.
This paper provides a correction:

Zero is not a number. Zero is a topological boundary operator.

12.2 Why Physics Breaks at Zero

Every major physical singularity arises from treating zero as a location:

- Black hole singularities from $r = 0$.
- Big Bang singularity from $t = 0$.
- QFT divergences from $h = 0$.
- Inverse-square blow-ups from $r = 0$.

In the zero-free formulation, these "points" vanish:

- They were never points.
- They were limits toward a boundary the entire time.

12.3 The Universe Does Not Collapse to a Point

The universe cannot reach a point of:

- zero distance,
- zero density,
- zero curvature,
- zero time,
- zero information.

The Zerofield is the boundary where structure ceases to exist, not a coordinate where structure becomes infinite.

12.4 The Zerofield as the Foundation of Cosmology

The Zerofield:

- prevents infinite density,
- prevents infinite curvature,
- provides a natural Planck cutoff,
- resolves the horizon problem,
- resolves the flatness problem,
- makes cosmic inflation a topological necessity rather than a dynamical event.

This is not a new physics law— it is the correct mathematics for the physics we already have.

13 Conclusion

We have developed a rigorous two-sorted mathematical framework, T_Z, in which:

- zero is not a numeric value;
- zero is a topological boundary;
- the real universe is modelled by the zero-free domain $N = \mathbb{R} \setminus \{0\}$;
- the null operator Z replaces the paradoxical behaviour of numeric zero.

We proved:

- the theory is consistent;
- it is conservative over classical analysis for all nonzero values;
- all zero-based paradoxes become unformulable;
- all physical singularities vanish within the domain;
- calculus remains intact;
- general relativity becomes singularity-free in its physical domain;
- quantum field theory becomes better behaved at short distances;
- cosmology loses its initial singularity.

The conclusion is:

> Zero is not part of the universe. Zero is the boundary of the universe. It does nothing, and therefore must do nothing mathematically.

Mathematics, physics, and cosmology were forced into contradiction because zero was misclassified for two thousand years.

The correction is:

> Treat zero as a boundary-state, not a number, and the universe becomes finite, coherent, and free of zero-driven paradox.

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