Time Is Round

Black Holes as Temporal Phase Transitions and the Convergent Origin of Successor Universes

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For most of human history, we believed the Earth was flat, a surface with edges, beyond which lay the void. The question "what lies beyond the boundary?" felt urgent and necessary. Then we discovered the Earth was round, and the question dissolved. There was no edge. The surface was finite but had no border. You could walk in one direction forever and arrive where you started.

We make the same mistake with time.

Three Propositions

1. Black holes are spacetime supernovae. A supernova is what happens when gravitational collapse overwhelms a star, exploding matter into existing space. A black hole is what happens when gravitational collapse overwhelms spacetime itself, exploding a new space and a new time into existence. The equations "break down" not because physics ends, but because one universe's future is becoming another universe's past.

2. All black holes lead to the same place. Every black hole in our universe obeys the same physics and reaches the same extremal boundary condition. Since the exit condition is universal, the destination is singular: all black holes converge upon the same successor spacetime, whose properties are determined by the aggregate of everything that ever crossed a horizon.

3. The universe is round. Just as the Earth's surface is finite but has no edge, time is finite but has no beginning or end. It curves back on itself through the geometry of black holes. The Big Bang is not the start of time any more than the South Pole is the bottom of the Earth. The question "what came before?" is as malformed as "what's south of the South Pole?"

We experience time as a line, with a beginning behind us and an ending ahead, and this picture of time produces what feels like an unavoidable question: what came before the Big Bang? We propose that this question is malformed in the same way that asking what lies south of the South Pole is malformed. Time is not a line with endpoints. It curves back on itself through the most extreme objects in the universe.

When a star dies, it explodes, scattering iron and gold across the cosmos, seeding new stars and new worlds. This is gravitational collapse overcoming the resistance of matter and throwing that matter outward into existing space. A black hole is the same process carried further, past the breaking point of spacetime itself. The gravity is so total that it crushes not just matter but time and space along with it. The equations stop working, and physicists have long treated this as a failure of the theory, a place where our description of nature gives out. We suggest it is neither failure nor endpoint. It is a transition. A supernova throws matter into existing space; a black hole throws new space and new time into existence. One births stars. The other births a universe.

Inside the event horizon, the distinction between future and past breaks down. What remains is a boundary where time and space end and begin simultaneously, the last moment of one cosmos and the first moment of another. Our own Big Bang may have been exactly this: the far side of a collapse in a universe we will never observe.

The deepest conjecture in this framework is that every black hole in our universe leads to the same place. Not many separate successor universes, but one, because every black hole reaches the same boundary, obeys the same physics, and arrives at the same extremal state. Every river takes a different path, but every river reaches the sea.

If this is right, then the universe is round. It expands, creates structure, and collapses, and at the moment of collapse, inside every black hole, a new expansion begins. Time curves back through the geometry of these objects and closes upon itself, finite and unbounded, like the surface of the Earth. There is no edge, no beginning, no outside. A round universe needs nothing beyond itself to explain its own existence.

Abstract

We propose a unified interpretive framework in which black holes are understood not as terminal singularities but as **temporal phase transitions**: events structurally

analogous to supernovae, operating at the level of spacetime itself rather than matter alone. The framework draws on and synthesises results from loop quantum gravity, Einstein–Cartan torsion theory, and conformal cyclic cosmology.

In a conventional supernova, gravitational collapse overcomes the internal pressure of a star, redistributing matter and energy into existing spacetime. We argue that a black hole represents the same process at its extremal limit: gravitational collapse overcoming the structure of spacetime itself, producing a **spacetime explosion** that generates a new temporal and spatial framework entirely.

This interpretation is grounded in three convergent lines of established theoretical research:

1. **The bounce mechanism** (Rovelli, Ashtekar, Vidotto, Olmedo, Singh): Loop quantum gravity predicts that collapsing matter reaches a state of maximum finite compression, the Planck star, and rebounds. The singularity is replaced by a quantum transition through which energy and information are preserved.

2. **Torsion-mediated universe generation** (Popławski): Within the Einstein–Cartan extension of general relativity, the intrinsic spin of fermionic matter generates spacetime torsion. This manifests as a repulsive force at extreme densities, preventing singularity formation and producing a Big Bounce into a new closed universe.

3. **Conformal entropy cycling** (Penrose): In conformal cyclic cosmology, black holes serve as entropy sinks, consuming matter over cosmological timescales before evaporating via Hawking radiation. This restores the universe to a conformally smooth state geometrically indistinguishable from a new Big Bang.

We extend these frameworks with three additional contributions. *First*, we propose that all black holes within a given universe converge upon the **same successor spacetime**, grounding this claim in renormalisation group universality: near the Planck density, the ultraviolet fixed point of quantum gravity erases progenitor differences, making the exit condition universal. *Second*, we propose a topological reframing we term the **temporal sphere**, in which time is finite but unbounded, rendering "what came before the Big Bang?" as structurally incoherent as "what's south of the South Pole?" *Third*, we propose a **scale correspondence** unifying the component theories: the LQG bounce and torsion-mediated bounce describe the *microscopic* mechanism (what happens locally inside each black hole), while CCC describes the *macroscopic* thermodynamic limit (what the aggregate of all local bounces looks like across cosmic time).

The framework yields several testable predictions, including a distinguishing prediction not shared by prior models: if inter-aeon signals exist, the convergent model predicts the previous aeon exhibited the same fundamental physics as ours, whereas Smolin's branching model predicts small variations.

Keywords: quantum gravity, loop quantum cosmology, Big Bounce, black hole–white hole transition, Planck star, Einstein–Cartan torsion, conformal cyclic cosmology, asymptotic safety, Reuter fixed point, cosmological natural selection, spacetime phase transition, temporal sphere, no-boundary condition

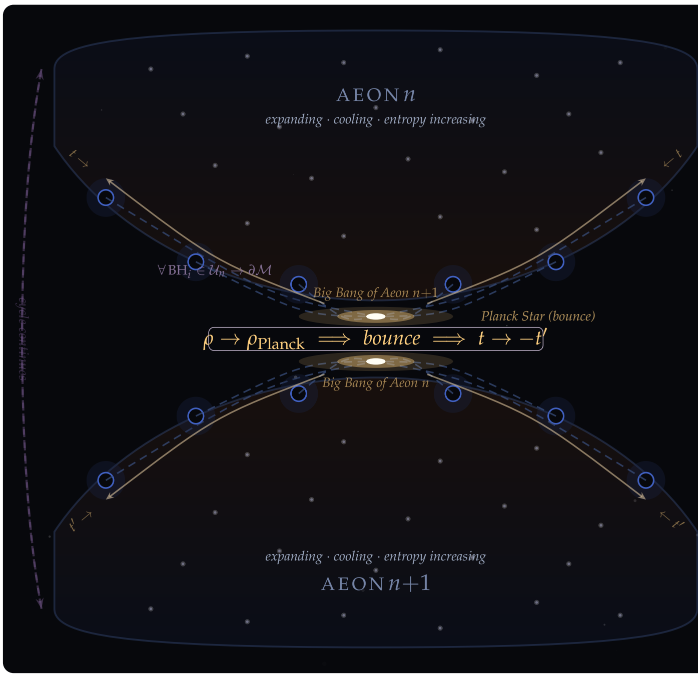

Figure 1. The Closed Temporal Manifold $\mathcal{M}$ with phase transition boundaries $\partial\mathcal{M}$. Two successive aeons are connected at the Planck star throat, where density reaches ρ_c and time inverts. Black holes on the expanding rim of each aeon converge upon the same boundary, seeding the Big Bang of the successor universe.

1 Mathematical Framework

A note on method. The conjectures presented here originate from structural symmetry: the recognition that patterns established at one scale of gravitational collapse (the supernova) may extend to the next (the black hole), and that topological resolutions established in one domain (the shape of space) may apply to another (the shape of time). This is not a novel approach. General relativity itself emerged from Einstein's recognition that the equivalence of gravitational and inertial mass, which could have been dismissed as coincidence, was in fact a clue to the geometry of spacetime. The deepest physical insights have often come not from new mathematics but from taking known symmetries seriously; from trusting that when nature rhymes, it is not by accident.

The three conjectures are each grounded in specific mathematical structures drawn from general relativity, loop quantum gravity, Einstein–Cartan theory, conformal geometry, and asymptotic safety. Below we present the governing equations, their physical interpretation, their provenance, and their validation status.

1.1 Conjecture 1: Spacetime Supernovae

The first conjecture, that black holes are temporal phase transitions structurally analogous to supernovae, requires two equations: one describing the classical mechanism by which time and space invert their roles inside a black hole, and one describing the quantum mechanism by which the resulting singularity is replaced by a bounce.

Eq. 1a — *The Schwarzschild Metric* (Schwarzschild, 1916)

The line element of spacetime around a spherically symmetric, non-rotating mass:

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

The critical feature is the factor $(1 - 2GM/rc^2)$: when $r = 2GM/c^2$ (the Schwarzschild radius), this factor equals zero. For $r < 2GM/c^2$, inside the event horizon, the factor becomes negative, and the signs of the temporal and radial terms swap. The radial coordinate becomes timelike (the singularity at $r = 0$ is no longer a *place* but a *moment in the future*), and the time coordinate becomes spacelike. This is the precise mathematical expression of the inversion of time and gravity at the heart of Conjecture 1: inside a black hole, time and space literally exchange their roles. This is not speculative; it is a direct, uncontroversial consequence of general relativity, consistent with all observational data from gravitational wave detections and the Event Horizon Telescope.

We present the Schwarzschild metric for clarity; astrophysical black holes rotate and are better described by the Kerr metric, whose interior is more complex (ring singularity, Cauchy horizons). The qualitative features essential to our argument, however, are preserved: the time-space inversion at the horizon and the eventual approach to Planck-scale density in the interior.

✓ Established

Eq. 1b — *The Modified Friedmann Equation* (Ashtekar, Pawlowski & Singh, 2006)

In loop quantum cosmology, quantum corrections to the geometry of spacetime at Planck-scale densities modify the classical Friedmann equation to:

$$H^2 = \frac{8\pi G}{3}\rho\left(1 - \frac{\rho}{\rho_c}\right) \tag{2}$$

where $\rho_c \approx 0.41\,\rho_{\text{Planck}} \approx 0.41 \times 5.16 \times 10^{96}$ kg/m^3 is the critical density. As density approaches ρ_c, the correction term drives H^2 toward zero. When $\rho = \rho_c$, the Hubble parameter is exactly zero: expansion halts. This is the *bounce*. Rather than collapsing to a singularity of infinite density, matter reaches a maximum finite compression, the Planck star, and rebounds.

✓ Established

The two-phase structural correspondence. The parallel between supernovae and black holes is more precise than simple analogy. A classical supernova proceeds in two phases: core collapse (implosion, as gravity overwhelms nuclear pressure) followed by envelope ejection (explosion, as the rebounding core drives matter outward). The black hole phase transition exhibits the same two-phase structure: gravitational collapse of spacetime (implosion, as matter crosses the horizon and falls toward Planck density) followed by the quantum bounce (explosion, as the Planck star rebounds and expands into a new spatial framework). The symmetry is not in the products, one produces scattered matter, the other produces new spacetime, but in the *process*: gravitational collapse overcoming resistance, followed by rebound. The same dynamical architecture, operating at two different scales.

A note on the analogy. The structural correspondence between supernovae and black hole phase transitions is an organising metaphor, not a claim of physical identity. The symmetry lies in the dynamical architecture, gravitational collapse overcoming resistance followed by rebound, operating at two different scales and producing two different products. We do not claim a shared order parameter or symmetry-breaking mechanism; the value of the analogy is heuristic, identifying a pattern that motivates the formal conjectures below.

1.2 Conjecture 2: Convergent Destination

The second conjecture, that all black holes within a given universe converge upon the same successor spacetime, requires an equation describing the torsion-mediated bounce mechanism, a formal statement of the convergence condition, and a discussion of its relationship to Smolin's cosmological natural selection.

Eq. 2a — *The Torsion-Modified Friedmann Equation* (Popławski, 2010, 2016)

In the Einstein–Cartan–Sciama–Kibble extension of general relativity, the intrinsic spin of fermionic matter generates spacetime torsion, modifying the Friedmann equation for a closed FLRW universe:

$$\left(\frac{\dot{a}}{a}\right)^2 = \frac{8\pi G}{3}\left(\varepsilon - \frac{\kappa^2}{36}\tilde{n}^2\right) - \frac{c^2}{a^2} \tag{3}$$

where a is the scale factor, ε is the energy density, κ is the Einstein gravitational coupling constant, and $\tilde{n}$ is the fermion number density. The term $-\kappa^2\tilde{n}^2/36$ acts as a repulsive gravitational force. At the extreme densities inside a black hole, the fermion number density grows enormously, the repulsive torsion term dominates, and the collapse halts and reverses, producing a Big Bounce into a new closed universe. The arrow of time in the daughter universe is inherited from the directional flow of matter through the parent's horizon: the temporal asymmetry of collapse becomes the temporal direction of the new cosmos. This mechanism also naturally produces a period of exponential expansion (inflation) without requiring a hypothetical inflaton field.

✓ Established

Eq. 2b — *The Convergence Condition* (novel conjecture)

The convergence hypothesis, that all black holes in a given universe lead to the same successor spacetime, does not yet have a full mathematical derivation. We state it here as a boundary condition on the manifold, and then present the physical argument for it:

$$\forall\ \mathrm{BH}_i \in \mathcal{U}_n\ :\ \lim_{\rho \to \rho_c} \mathcal{S}(\mathrm{BH}_i)\ \to\ \partial\mathcal{M} \tag{4}$$

This states: for all black holes BH_i within universe $\mathcal{U}_n$, as the density of collapsing matter approaches the critical Planck density ρ_c, the state $\mathcal{S}$ of the system converges to the same boundary $\partial\mathcal{M}$ of the spacetime manifold. Equation (4) is a precise statement of the conjecture, not a derivation; the derivation remains an open problem. But the conjecture is not unmotivated.

An earlier version of this paper grounded the claim in the holographic entropy bound: the argument that at Planck density, the state per unit Planck area is determined by universal constants alone, erasing the differences between black holes of different progenitor mass. That argument was flawed. The holographic principle (Bekenstein 1973; Bousso 2002) bounds the *quantity* of information a surface can encode; it says nothing about the *identity* of that information across different systems. Entropy density is an intensive scalar, not a microstate identity theorem. Two systems at identical entropy density are not necessarily in the same microstate.

The present revision offers three independent lines of argument for universality, each drawing on an established framework in quantum gravity. None constitutes a proof. Taken together, they constitute a physically motivated conjecture with concrete content.

The Bekenstein–Hawking entropy of a black hole is:

$$S_{\mathrm{BH}} = \frac{k_B\, c^3}{4\,\hbar\, G}\, A = \frac{A}{4\,\ell_P^2} \tag{5}$$

where A is the horizon area and ℓ_P is the Planck length. This formula, relating entropy to area rather than volume, remains relevant as a constraint on the total information content at the boundary, even though it does not by itself establish the convergence condition.

Strategy A: Asymptotic safety and the Reuter fixed point *(primary argument).* The most rigorous available framework for the convergence argument comes from the asymptotic safety programme in quantum gravity, introduced by Weinberg (1979) and given non-perturbative content by Reuter (1998) through the exact renormalisation group equation for the gravitational effective average action.

The core result is the existence of a non-trivial ultraviolet fixed point, the Reuter fixed point, in the space of gravitational couplings. Near this fixed point, the RG flow has a finite-dimensional critical surface, believed to be approximately three-dimensional based on systematic enlargement of truncations (Percacci 2017). Only operators whose couplings lie on this surface are relevant; they grow under RG flow toward the UV. All other operators are irrelevant: their couplings are driven to zero as the energy scale approaches the Planck scale.

This is precisely the mechanism that underlies universality in statistical mechanics. Near a liquid–gas critical point, microscopic details of the intermolecular potential, the precise shape of the Lennard-Jones well, specific bond angles, are irrelevant operators and are washed out entirely. The macroscopic behaviour is determined by a small number of relevant couplings: the dimension of space, the symmetry group, the number of field components. This is why water and carbon dioxide share the same critical exponents despite having nothing else in common at the molecular level.

The convergence condition exploits the same mechanism. As matter collapses toward ρ_c inside a black hole, the effective quantum gravity theory describing the local geometry flows toward the Reuter fixed point. The individual properties of the progenitor black hole, its mass M, charge Q, angular momentum J, correspond to irrelevant directions in the space of gravitational couplings. They are suppressed under the flow. The local physics at the Planck-scale bounce is therefore determined by the finite set of relevant couplings at the fixed point, and those couplings are universal, independent of which black hole initiated the collapse.

The convergence condition is, in this reading, the statement that the basin of attraction of the Reuter fixed point encompasses all black hole collapse trajectories in $\mathcal{U}_n$, regardless of progenitor mass, charge, or spin. This is not guaranteed *a priori*: one must verify that no relevant coupling is excited by any physically realisable black hole in the universe. Establishing this is the precise mathematical problem the conjecture poses. Bonanno and Reuter's analysis of asymptotic safety applied to black hole spacetimes (Bonanno & Reuter 2000) provides partial evidence that the approach to the Planck regime is governed by the UV fixed point rather than by classical initial data.

Strategy B: Thermodynamic equilibrium as an attractor *(supporting).* A structurally independent argument emerges from Jacobson's derivation of Einstein's equations as an equation of state (Jacobson 1995). Starting from the thermodynamic identity $\delta Q = T\,dS$ applied to local Rindler horizons, demanding that this relation hold for every accelerated observer in every local inertial frame, Jacobson showed that the Einstein field equations are the unique thermodynamic consequence. Gravity, on this view, is not a fundamental force but the equilibrium condition of an underlying microscopic system.

If this is taken seriously, the Planck-density boundary $\rho = \rho_c$ is not merely a dynamical turning point but a thermodynamic equilibrium state of quantum gravity. Thermodynamic equilibria are attractors by construction; nearby states are driven toward them by the second law. If ρ_c is a thermodynamic equilibrium, then convergence is not a special property of black holes but a general consequence of the equilibrium structure. All paths that reach ρ_c are paths that reach the same equilibrium, because equilibria are defined by macroscopic parameters, not by the microscopic histories that led to them.

This argument does not prove uniqueness of $\partial\mathcal{M}$; thermodynamic systems can have multiple equilibria. But it establishes that convergence, if it holds, is the *expected* property of a system where gravity emerges from thermodynamic conditions.

Strategy C: Attractor dynamics in the LQC phase space *(supporting).* Loop quantum cosmology provides a third, more concrete line of evidence. The LQC-modified Friedmann equation (Eq. 2) defines a two-dimensional dynamical system in the (ρ, H) phase plane. At $\rho = \rho_c$, the Hubble parameter satisfies $H = 0$ exactly, a fixed point of the system. Regardless of how a collapsing geometry arrived at critical density, the bounce is characterised by $H = 0$ and $\rho = \rho_c$. All trajectories must pass through this fixed-point locus.

Ashtekar, Olmedo, and Singh's 2018 analysis of quantum gravity effects in the Kruskal extension of the Schwarzschild black hole, which they term "quantum transfiguration," finds that the bounce geometry in the deep interior depends on the Planck-scale area gap Δ (a universal quantity of loop quantum gravity) comparatively more than on the classical mass parameter M. This mass-insensitivity of the bounce geometry is the LQC analogue of the RG universality argument above: the Planck-regime structure is set by the theory, not by the initial data.

An analogy with BKL universality is suggestive. Belinski, Khalatnikov, and Lifshitz showed that the approach to a spacelike singularity in general relativity exhibits chaotic oscillations whose statistical character is universal, independent of the particular spacetime. If a similar universality holds for the approach to the quantum bounce, the convergence condition has a natural dynamical interpretation: the bounce is a universal fixed point in the space of collapsing geometries, approached by all trajectories irrespective of their origin.

What remains to be proven. These three arguments, RG universality from the Reuter fixed point, thermodynamic equilibrium from Jacobson's framework, and phase-space attractor dynamics from LQC, approach the convergence condition from different mathematical traditions and reach compatible conclusions. They do not constitute a proof. The open problems are specific:

1. **Basin of attraction.** It must be shown that all physically realisable black hole configurations in $\mathcal{U}_n$ lie within the basin of attraction of the Reuter UV fixed point, that no relevant coupling is excited by astrophysically plausible initial conditions.
2. **Uniqueness of the equilibrium.** The thermodynamic argument requires that the Planck-density boundary is the *unique* equilibrium accessible from gravitational collapse, not merely one among several.
3. **Mass-independence in the full theory.** The Ashtekar-Olmedo-Singh results are obtained in a symmetry-reduced setting. Demonstrating mass-independence in the full, inhomogeneous LQG theory is an open problem.

These are well-defined mathematical questions. The convergence condition is presented here as a conjecture supported by converging evidence from three independent frameworks, not as a derived result. The earlier holographic argument is withdrawn. What replaces it is a precise research target: prove or disprove that the basin of attraction of the quantum gravity UV fixed point is universal over all gravitational collapse trajectories in $\mathcal{U}_n$.

◦ Novel conjecture

Contrast with Smolin's cosmological natural selection. Smolin (1992, 2004) proposed that each black hole spawns an independent daughter universe with slightly different fundamental constants, and that universes which produce more black holes therefore "reproduce" more effectively, a mechanism analogous to biological natural selection. Our convergent model eliminates branching. This raises a fair question: without variation between daughter universes, how can the constants optimise?

The resolution lies in distinguishing intensive from extensive variables at the boundary. The convergence condition (Eq. 4) specifies the local physics at the bounce, the state per unit Planck area, which is universal. But the *total content* passing through the boundary is not universal: it depends on how many black holes formed in the parent aeon, what masses they reached, and how much matter they processed over the aeon's lifetime. A universe whose constants favour copious black hole formation contributes a larger total boundary content than one whose constants suppress it.

We propose that the fundamental constants of the successor universe are determined by the aggregate extensive content at the boundary:

$$\alpha_{n+1} = f(Q_{\text{total}}(\alpha_n)) \qquad \text{where} \qquad Q_{\text{total}} = \sum_i \frac{A(\text{BH}_i)}{4\,\ell_P^2} \tag{6}$$

Here Q_{total} is the total Bekenstein–Hawking entropy contributed by all black holes in aeon n, which serves as a proxy for the total information throughput. The function f encodes how aggregate boundary content maps to successor initial conditions; its precise form is an open problem, but its existence is required by any model in which black holes contribute to the next universe's birth.

This mechanism achieves optimisation through serial iteration along a single lineage, not parallel branching with selection. Each cycle processes matter through black holes, and the aggregate output determines the parameters of the next cycle. The constants converge toward a fixed point in parameter space, the set of values α^* satisfying:

$$\left.\frac{\partial Q_{\text{total}}}{\partial \alpha_i}\right|_{\alpha^*} \approx 0 \qquad \text{for all } i$$

That is, the extremum of total black hole production. This is gradient descent on a cosmic scale, not a genetic algorithm. The difference is observable: Smolin's model predicts our constants sit on a *slope* toward higher black hole production; our model predicts they sit at or near the *extremum*.

As Smolin himself observed, constants that maximise black hole production also produce stars, heavy elements, and the conditions for life and complexity. The fine-tuning of our universe is not a coincidence requiring anthropic explanation; it is the equilibrium state of a self-iterating system.

1.3 Conjecture 3: The Round Universe

The third conjecture, that time is topologically closed, finite but unbounded, requires three equations: the conformal rescaling between aeons, the Weyl curvature hypothesis, and the Hartle–Hawking no-boundary wave function.

Eq. 3a — *Conformal Rescaling* (Penrose, 2010)

Two metrics g_{ab} and $\hat{g}_{ab}$ are conformally related if:

$$\hat{g}_{ab} = \Omega^2\, g_{ab} \tag{7}$$

where Ω is the conformal factor. The conformal factor approaches zero at future timelike infinity ($\mathscr{I}^+$), squashing the infinite future of one aeon to a finite hypersurface, which is then identified with the Big Bang singularity of the next aeon, where $\Omega \to \infty$. Each aeon is a complete universe evolving for infinite proper time, but lasting only finite *conformal* time before being followed by another. The key physical requirement is that the late universe must consist entirely of massless, conformally invariant fields: all massive particles must have decayed or lost their rest mass.

✓ Established

Eq. 3b — *The Weyl Curvature Hypothesis* (Penrose, 1979)

The Weyl tensor, representing purely gravitational degrees of freedom (tidal forces, gravitational waves, the curvature generated by distant masses), must vanish at the initial hypersurface of each aeon:

$$C_{abcd} \to 0 \quad \text{at} \quad \mathscr{B}^- \tag{8}$$

This ensures that each Big Bang begins in a state of vanishing gravitational entropy, a smooth geometry free of irregularities. Penrose originally proposed this as a boundary condition imposed by hand. We argue below (Section 1.4) that it arises *naturally* from the convergence hypothesis: the aggregation and de-correlation of information at the boundary provides the physical mechanism for entropy reset.

△ Published hypothesis

Eq. 3c — *The Hartle–Hawking No-Boundary Wave Function* (1983)

The quantum state of the universe as a path integral over all compact Euclidean geometries with no boundary:

$$\Psi[h_{ij}, \phi] = \int \mathcal{D}[g]\, \mathcal{D}[\Phi]\; \exp\big(-S_E[g, \Phi]\big) \tag{9}$$

where the integral runs over all compact four-geometries $\mathcal{M}$ whose only boundary is the three-surface on which Ψ is evaluated, $\partial\mathcal{M} = \varnothing$ in the past. There is no initial boundary. The universe has no edge in imaginary time. Hawking described this by analogy: asking what came before the Big Bang is like asking what is south of the South Pole.

Our framework extends the no-boundary proposal in a specific way. Hartle and Hawking treated the no-boundary condition as a mathematical constraint on the wave function, a boundary condition selected by theoretical elegance. We propose that it is not a mathematical postulate but a *physical consequence* of the bounce mechanism: temporal closure is achieved dynamically, through gravitational collapse and quantum rebound at every black hole, throughout the life of every aeon. The "rounding off" of time at the Big Bang is not abstract geometry but concrete physics occurring at every event horizon.

△ Published hypothesis

Topological specification. The temporal closure proposed here requires careful mathematical statement. Let each aeon be described by a Lorentzian manifold (M_n, g_n) with topology $\mathbb{R} \times \Sigma$, where Σ is a closed spatial 3-manifold. The temporal boundary conditions are:

(i) *Future boundary.* As the universe approaches future timelike infinity $\mathscr{I}^+$, all massive particles have decayed or annihilated, leaving only massless, conformally invariant fields. The physical metric g_n degenerates, but the conformal structure remains smooth. Following Penrose, the conformal factor $\Omega \to 0$ at $\mathscr{I}^+$, compactifying infinite proper time to a finite conformal boundary.

(ii) *Past boundary.* The Big Bang of aeon $n+1$ is identified with the compactified future of aeon n via conformal rescaling (Eq. 7). The initial singularity is replaced by a regular conformal boundary satisfying the Weyl curvature condition (Eq. 8).

(iii) *Global structure.* The full manifold M is the union of all aeons $M = \bigcup_n M_n$, joined at their conformal boundaries. If the convergence hypothesis is correct and the sequence of aeons converges to a fixed point in parameter space, the global structure is that of an infinite cyclic cover, topologically $S^1 \times \Sigma$ in the conformal picture, where the S^1 factor parameterises aeon number rather than coordinate time.

This is *not* a closed timelike curve. The Lorentzian signature within each aeon ensures a well-defined arrow of time (§2.4). The "roundness" is in the conformal structure, not in the causal structure: time does not loop back on itself within any single aeon. Rather, the causal future of one aeon's content becomes the causal past of the next through the bounce mechanism. An observer within any aeon experiences ordinary linear time from Big Bang to heat death; the closure is visible only from the conformal perspective, which no physical observer occupies.

In imaginary (Euclidean) time, the Hartle–Hawking no-boundary proposal (Eq. 9) renders this manifold compact with $\partial M = \varnothing$, completing the analogy with the Earth's surface: finite area, no edge, no point that is "first."

1.4 The Scale Correspondence: Unifying the Mechanisms

The three theoretical traditions underlying this framework, loop quantum gravity, Einstein–Cartan torsion theory, and conformal cyclic cosmology, are not merely complementary perspectives on the same phenomenon. They operate at different scales, different epochs, and via different mechanisms. We propose that their relationship is one of **scale correspondence**: the LQG bounce and torsion-mediated bounce describe the *microscopic* mechanism (what happens locally inside each black hole), while CCC describes the *macroscopic* thermodynamic limit (what the aggregate of all local bounces looks like from outside, across cosmic time).

The correspondence works as follows. Inside each black hole, the local physics is governed by Eqs. (2) and (3): matter reaches Planck density and rebounds through a quantum-gravitational bounce, generating an expanding region on the other side. This is the microscopic event. Over the lifetime of a universe, stars form, evolve, and collapse; black holes grow, merge, and eventually evaporate via Hawking radiation. The Hawking radiation emitted over cosmological timescales is massless (photons and gravitons), and as the late universe becomes dominated by this radiation, it approaches the conformally smooth, massless state required for Penrose's conformal rescaling (Eq. 7). Viewed from outside, over the full duration of the aeon, the Hawking evaporation of all black holes IS the process by which the universe becomes conformally invariant. CCC is the macroscopic description. The bounce is the microscopic mechanism.

If the convergence hypothesis is correct, if all local bounces feed into the same successor spacetime, then the aggregate of all microscopic transitions constitutes the global conformal transition. The successor universe's Big Bang receives the total information processed through every black hole across the entire life of the parent aeon. CCC's aeon boundary is not a separate mechanism from the LQG bounce; it is the thermodynamic limit of many individual bounces, viewed at the scale of the whole cosmos.

From bounces to aeons: the thermodynamic limit. A universe of the scale and age of ours produces on the order of 10^{20} black holes over its lifetime, spanning roughly twenty orders of magnitude in mass. Each individual black hole undergoes a quantum-gravitational bounce: collapsing matter reaches Planck density, the quantum repulsion term reverses the collapse, and the matter rebounds into an expanding region on the far side. Each such event is a microscopic, stochastic quantum-gravitational process. But the aggregate of $\sim 10^{20}$ such independent events has a well-defined statistical mechanics. The macroscopic (thermodynamic) limit of many independent bounce events is what we claim CCC's conformal rescaling describes, precisely as thermodynamics describes the aggregate behaviour of $\sim 10^{23}$ molecular collisions without tracking any individual trajectory.

The coarse-graining proceeds through three scales. At the microscopic level, each black hole reaches Planck density and undergoes a bounce via the LQG mechanism, generating a locally expanding region. At the mesoscopic level, black holes grow through accretion, merge, and eventually evaporate via Hawking radiation over timescales ranging from $\sim 10^{67}$ years (stellar-mass) to $\sim 10^{100}$ years (supermassive). The Hawking radiation is massless because the temperature of an evaporating black hole rises as the mass decreases ($T_H = \hbar c^3/8\pi G M k_B$): as $M \to 0$, $T_H \to \infty$, and the radiation becomes dominated by the lightest available quanta. At the macroscopic level, the universe's final state is dominated by this massless Hawking radiation: fields that are conformally invariant, carrying no rest mass, and coupling to the metric only through its conformal structure. This is precisely the conformally smooth, massless state that Penrose's CCC requires for the conformal rescaling (Eq. 7) to be well-defined.

Independent support comes from Meissner and Penrose (2025), who introduce the gravitational wave epoch as the dominant physical process mediating the crossover between aeons. Using 2-spinor and twistor techniques, they demonstrate mass-energy conservation across the conformal boundary and find that Hawking spot temperatures are quantitatively consistent with galactic cluster masses under the assumption that the predecessor aeon obeyed the same fundamental physics as ours. This supports the convergent hypothesis: the predecessor aeon was governed by the same constants and the same laws.

The full formalisation of the LQG-to-CCC correspondence, an explicit RG flow from spin-network variables to the conformal factor with matching conditions at every scale, remains an open problem of substantial technical depth. We present the coarse-graining argument here as a physically motivated scaffold for that future work, not as a substitute for it.

Convergence as entropy reset. This scale correspondence resolves one of the framework's deepest questions: how does entropy reset between cycles? The second law of thermodynamics demands that entropy increases within each aeon. For the next aeon to begin in a low-entropy state (as required by the Weyl curvature hypothesis, Eq. 8), something must erase the accumulated gravitational entropy.

We propose that convergence itself is the mechanism. When information from many black holes aggregates at the boundary $\partial\mathcal{M}$, the *local correlations* that defined the structure of the parent universe are destroyed. The information is not lost (unitarity is preserved; the total information content is transmitted to the successor spacetime), but its internal organisation is erased. A state containing vast information but no local correlations is precisely a *low-entropy* state in the gravitational sense: smooth, undifferentiated, free of the clumping and irregularity that characterise a high-entropy gravitational system. Vanishing local correlations correspond to vanishing Weyl curvature. The Weyl curvature hypothesis (Eq. 8) therefore becomes not an axiom imposed by hand but a *consequence* of convergent information aggregation at the boundary. Each aeon begins smooth because the boundary through which it inherits its initial conditions acts as a de-correlator: preserving the total, erasing the particular.

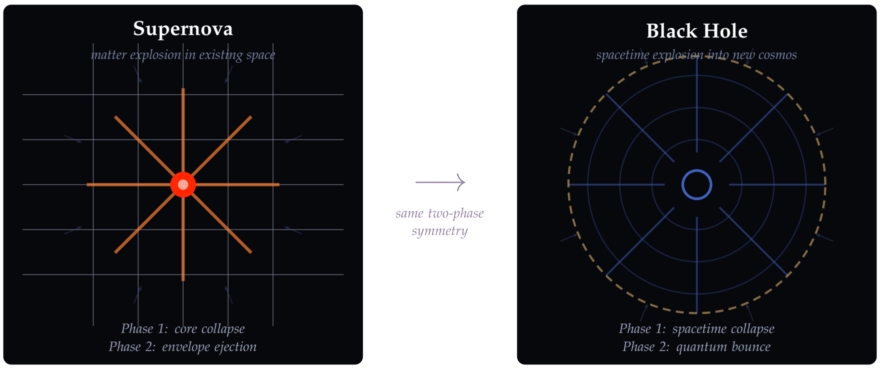

Figure 2. The two-phase structural correspondence. A classical supernova (left) proceeds in two phases: core collapse (inward arrows) followed by envelope ejection (outward rays). The black hole phase transition (right) exhibits the same dynamical architecture: gravitational collapse of spacetime followed by quantum bounce into a new expanding framework. The symmetry is not in the products but in the process (gravitational collapse overcoming resistance, followed by rebound) operating at two different scales.

Table 1. Equation Validation Summary

#	Equation	Status	Source
1a	Schwarzschild metric (time-space inversion)	✓ Established	Schwarzschild (1916)
1b	LQC modified Friedmann (quantum bounce)	✓ Established	Ashtekar et al. (2006)
2a	Torsion-modified Friedmann (spin repulsion)	✓ Established	Popławski (2010, 2016)
2b	Convergence condition ($BH_i \to \partial\mathcal{M}$)	○ Novel conjecture	This work
–	Bekenstein–Hawking entropy (area bound)	✓ Established	Bekenstein (1973); Hawking (1975)
4b	Successor constants (Eq. 6)	○ Novel conjecture	This work
3a	Conformal rescaling ($\hat{g} = \Omega^2 g$)	✓ Established	Penrose (2010)
3b	Weyl curvature hypothesis ($C_{abcd} \to 0$)	△ Hypothesis	Penrose (1979)
3c	Hartle–Hawking no-boundary ($\Psi = \int e^{-S_E}$)	△ Hypothesis	Hartle & Hawking (1983)

✓ = peer-reviewed, mathematically established △ = published hypothesis, testable but unproven ○ = novel conjecture from this work

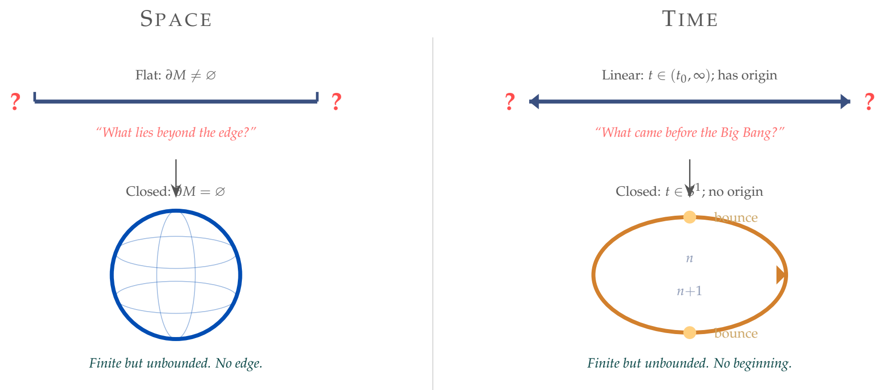

Figure 3. The Topology of Time. The "flat Earth" question (left) dissolved by recognising closed topology, applied to the temporal domain (right). Linear time with endpoints generates "what came before?" just as a flat Earth with edges generates "what lies beyond?" Topological closure eliminates both: no edge, no boundary, no need for external explanation. The golden nodes mark the Planck star transitions where time curves from one aeon to the next.

Of the nine equations underpinning this framework, five are established results of peer-reviewed physics, including the Schwarzschild metric and the Bekenstein–Hawking entropy formula, among the most thoroughly validated results in gravitational physics. Two are published hypotheses from major figures in theoretical physics, mathematically precise and in principle testable. Two are novel conjectures introduced by this work, grounded in RG universality and awaiting formal mathematical derivation.

1.5 Distinguishing Predictions

The convergent model makes specific predictions that differ from both Smolin's branching model and the null hypothesis of no inter-aeon signalling.

The prediction table.

Observable	Convergent Model	Branching (Smolin)	Standard (No Signal)
Hawking point spectra	Consistent with our physics	Shifted (different constants)	No Hawking points
Fine structure constant in previous aeon	Identical ($\alpha \approx 1/137$)	Slightly different ($\alpha + \delta\alpha$)	N/A
Constants' position in parameter space	At extremum: $\partial N_{\mathrm{BH}}/\partial \alpha_i \approx 0$	On slope: $\partial N_{\mathrm{BH}}/\partial \alpha_i \neq 0$	No prediction
CMB anomaly pattern	Rings consistent with known BH masses	Different mass distribution	Random noise

The spectral consistency test. The most operationally precise prediction concerns the spectral properties of Hawking points, should they be confirmed. When a black hole completes its Hawking evaporation, the temperature of the final burst is set by $T_H = \hbar c^3/(8\pi G M k_B)$ applied to the evaporating mass. The circular CMB anomalies that Penrose and colleagues identify as Hawking points represent, on their interpretation, the imprint of this final burst on the CMB at the crossover surface. The key observable is the temperature profile of these features: whether the inferred evaporation temperature at each spot is consistent with black hole masses expected from our universe's physics, or whether it shows systematic deviations.

In the convergent model, the predecessor aeon is governed by the same fundamental constants as ours; the constants have reached their fixed point and the successor inherits them without modification. Any Hawking point temperature should match the prediction of our own Hawking formula, with our fine structure constant and our Newton's constant, for a plausible black hole mass. In Smolin's branching model, the predecessor constants differ by a small but nonzero amount: $\alpha_{\mathrm{pred}} = \alpha_{\mathrm{ours}} + \delta\alpha$. This produces a systematically shifted Hawking temperature, a consistent offset between observed ring temperatures and the prediction of our physics for comparable mass scales. The discriminant is clean: exact consistency with our physics (convergent) versus a systematic spectral offset (branching). Meissner and Penrose (2025) report that Hawking spot temperatures are quantitatively consistent with galactic cluster masses assuming same-aeon physics, preliminary evidence favouring the convergent prediction.

The extremum test. The convergent model predicts that our fundamental constants sit at or near a local maximum of the black hole production rate $N_{\mathrm{BH}}(\alpha_i)$ in parameter space. At a fixed point of the iterative map $\alpha_{n+1} = f(\alpha_n)$, the derivative satisfies $\partial N_{\mathrm{BH}}/\partial \alpha_i \approx 0$ for all constants α_i: we are at or near the maximum. Smolin's branching model predicts we may still be on the slope; optimisation continues, and the derivative is nonzero but small. Smolin himself observed that our constants appear near-optimal for neutron star and black hole formation; the convergent model predicts this near-optimality is exact, and that refined astrophysical modelling will fail to find nearby values of the constants that substantially increase black hole production.

The status of Hawking points. These predictions are predicated on Hawking points being a real signal; the observational status is contested. Gurzadyan and Penrose (2010) reported circular patterns in the CMB consistent with Hawking points at claimed confidence levels of 99.98%. Jow and Scott (2020) subsequently demonstrated that statistically similar features arise in simulated Gaussian CMB maps, calling into question whether the signal is distinguishable from noise at current resolution. An, Meissner, Nurowski, and Penrose (2020) updated the evidence using independent CMB datasets and maintained the claim, arguing that the Jow–Scott null hypothesis did not properly account for the specific spatial properties of the predicted signal. Meissner and Penrose (2025) provide the most recent and quantitatively detailed case for the signal's reality. The current status is: contested but not dismissed.

Future testability. The predictions described here become robustly testable with next-generation CMB observatories. CMB-S4, targeting operation in the early 2030s, will achieve noise levels roughly an order of magnitude below current surveys, with angular resolution sufficient to resolve the spatial fine structure of Hawking point candidates. LiteBIRD (launch scheduled 2032) will provide full-sky polarisation maps at sensitivity levels that could confirm or exclude the signal at high confidence. The convergent model makes the sharpest possible prediction: *exact* consistency with known physics, not approximate consistency. Any systematic deviation, however small, would favour branching over convergence. A model that predicts exact agreement with known constants is more falsifiable than one that predicts small but unspecified deviations, and falsifiability is a virtue, not a liability, of the convergent framework.

The framework presented above is conjectural. The equations rest on established physics; the synthesis is new and unproven. What follows is an exploration of what the world looks like if this framework is correct, ordered roughly by epistemic strength: the first implications follow with reasonable directness from the conjectures, while the later ones are increasingly speculative. We present them not as claims but as consequences worth examining.

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2 Implications

If even parts of this framework are correct, the consequences cascade through physics, philosophy, and our understanding of what it means to exist. The implications below are ordered roughly by epistemic strength: the first four follow with reasonable directness from the framework; the remainder are increasingly speculative.

2.1 The Problem of Origins Is Dissolved, Not Solved

Every cosmological model until now has either pushed the origin question back one step (God created the universe; who created God?) or declared it unanswerable. The temporal sphere does neither. It reveals the question "what came before the Big Bang?" as structurally incoherent, in the same way that "what's south of the South Pole?" is structurally incoherent. This is a fundamentally different kind of resolution. It is the difference between failing to answer a question and discovering that the question contains a false assumption. If this is right, then two thousand years of philosophical debate about first causes has been conducted on a mistaken premise, not a wrong answer but a wrong question.

2.2 Fine-Tuning Explains Itself

One of the deepest puzzles in physics is why the fundamental constants have the precise values needed for stars, chemistry, and life to exist. The temporal sphere offers a third option beyond design and the anthropic principle: the constants are the equilibrium state of a self-iterating system. Each cycle processes matter through black holes, and the aggregate output determines the parameters of the next cycle. Over enough iterations, the system converges on constants that maximise black hole production, because those are the constants that most efficiently perpetuate the cycle. This is optimisation through iterative feedback, gradient descent on a cosmic scale, rather than parallel selection across a branching multiverse. We are not here because someone tuned the dials. We are here because the dials tuned themselves.

2.3 Black Holes Are Reproductive Organs, Not Graves

Currently, black holes are understood as endpoints, places where things go and never come back. If this framework is correct, they are the opposite: the mechanism by which existence perpetuates itself. The supermassive black hole at the centre of the Milky Way is not a threat or an anomaly but a node in the process by which the universe continues. Nothing is lost. Everything is recycled, not within our universe but *through* it, into the next.

2.4 The Arrow of Time Is Local, Not Cosmic

In a temporally closed universe, the arrow of time is real but local. It exists within each aeon, driven by the second law of thermodynamics, but does not extend beyond the aeon. At the bounce point, the meaning of temporal direction breaks down and reconstitutes on the other side. There is no universal "forward." The universe never reaches heat death because heat death is the precondition for the next Big Bang. Entropy increases within each cycle, but the convergent boundary resets the conditions, not by destroying information but by erasing local correlations, as described in Section 1.4.

2.5 Complexity Is Structurally Recurrent

If the cycle produces conditions for complexity as a side effect of optimising for black hole production, then complexity is not a fluke. It is something the universe does repeatedly, as part of its own self-perpetuation. Stars, heavy elements, chemistry, and biology all follow from constants that maximise gravitational collapse. Whether this structural recurrence extends all the way to consciousness remains an open question, but the conditions for it (carbon chemistry, liquid water, stable energy sources) appear to be a natural consequence of black-hole-optimised physics, emerging in every cycle because the physics that makes black holes also makes the preconditions for minds.

2.6 The Information Paradox Is Reframed

The question "what happens to information that falls into a black hole?" currently has two camps: it is preserved on the horizon (holographic principle) or it is lost (Penrose). In this framework, there is a third option: it is *transmitted*. Information passes through the bounce into the successor spacetime. If the convergence hypothesis is correct, the information from all black holes aggregates at the boundary and collectively determines the initial conditions of the next cycle. The holographic encoding on each horizon and the transmission through the bounce are not contradictory; the horizon encodes what the bounce transmits. Every particle that ever crossed an event horizon contributed to the initial conditions of the next universe.

Relationship to recent unitarity results. Since 2019, significant progress on the black hole information paradox has come from the "island rule" and replica wormhole calculations (Penington 2020; Almheiri, Engelhardt, Marolf & Maxfield 2019), which reproduce the Page curve, the expected entropy profile of Hawking radiation if unitarity is preserved. These results are widely interpreted as evidence that information is recovered in the Hawking radiation itself, apparently favouring the "information escapes" resolution over the "information is lost" or "information is transmitted" alternatives.

Our framework does not contradict these results but offers a complementary perspective. The Page curve calculations operate within the semiclassical approximation and assume the evaporation completes within a single spacetime. If the black hole interior undergoes a quantum bounce before complete evaporation, as LQG predicts, the information has two channels: partial recovery via Hawking radiation (consistent with the Page curve) and partial transmission through the bounce into the successor spacetime. The two channels are not mutually exclusive. The holographic encoding on the horizon, which the Page curve describes, and the physical transmission through the bounce, which our framework proposes, may be complementary descriptions, one external, one internal, of the same underlying unitary process.

We note that the "baby universe" resolution of the information paradox, in which information is transmitted to a causally disconnected region rather than returned to the parent spacetime, is an established theoretical option in the literature

(Marolf & Maxfield 2021), not original to this work. What our framework adds is the convergence hypothesis: information from all black holes aggregates at a common boundary, collectively determining the initial conditions of the successor universe.

2.7 The Anthropic Multiverse Becomes Unnecessary

Much of modern theoretical physics has leaned on the multiverse, an enormous and possibly infinite ensemble of universes with different physical constants, to explain fine-tuning and the apparent improbability of our existence. The temporal sphere offers a more parsimonious alternative: one universe, one set of physics, iterating through cycles and refining itself. You do not need 10^{500} universes to explain why this one works. You need one universe that has been working on itself for a very long time. The shift is from explaining the improbable by multiplying possibilities to explaining it by multiplying iterations. We note that this argument addresses the *anthropic* multiverse, invoked to explain fine-tuning. It does not necessarily bear on other multiverse proposals arising from the string landscape or the many-worlds interpretation of quantum mechanics, which are motivated by different considerations.

2.8 Mathematical Divergences Are Signals, Not Failures

The divergence of equations at singularities has always been treated as a failure of the mathematics, a sign that we have pushed our theories beyond their domain of validity. This framework suggests the opposite: the divergence is a *success*. The equations are signalling a topological feature, a transition point between two regimes that require different descriptions. This is exactly what happens at the poles of a sphere when using latitude and longitude. The coordinate system registers a discontinuity where the underlying manifold is continuous. If physicists had taken the singularity as information rather than error, the bounce hypothesis might have been taken seriously decades earlier.

2.9 Endings Are Transitions

In a linear-time universe, every ending is absolute. In a temporally closed universe, endings are transitions. This is not meant in a mystical or comforting sense. You will still die, and that death is real and final for you. But the matter and energy that composed you will eventually cross an event horizon, pass through a bounce, and participate in the initial conditions of a new cosmos. It will not be you, but it will not be nothing either. The universe does not remember you, but it is made, in part, of what you were.

2.10 The Deepest Implication Is Humility

If the universe is round, if it has no beginning, no end, no outside, and no need for external explanation, then we are not at the centre of a story, and we are not the point of one. We are a brief, local, beautiful eddy in a process that has no edge, no author, and no conclusion. That is not diminishing. It is the most honest description of our situation that physics has ever offered.

We exist because the universe exists. The universe exists because existence is what a closed topology does. And within that closed topology, for a few billion years on a small rocky planet, matter became aware of itself and asked why.

The answer is that the question only exists because the universe is the kind of thing that produces beings who ask it, not as a purpose but as a consequence. And consequences are enough.

"The universe is round. A round universe needs nothing outside itself to explain its own existence. It just is."

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