The Black Hole as a Cosmological Coherence Engine: A Systems-Theoretic Model of a Bouncing Universe

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1. Abstract This paper presents a complete physical theory of Black Hole Cosmology, resolving the problem of the initial singularity and unifying the "Big Bounce" and "Black Hole Universe" hypotheses. We apply the Theory of Coherent Systems (TCS) and its foundational Axiom of Coherent Holism to the life cycle of the universe. We demonstrate that the gravitational singularity predicted by classical General Relativity is an axiomatically forbidden state of infinite incoherence. Instead, we prove that a collapsing mass inside a black hole must undergo a Coherent Bounce, a phase transition that transforms the high-density matter-energy into the low-entropy, coherent initial conditions of a new daughter universe.

Within this framework, our observable universe is the interior of a black hole existing within a larger parent universe. The event horizon of the parent black hole serves as the causal boundary that defines the initial coherent state of our cosmos. This model, which we term Coherent Fecund Cosmology, provides a physical mechanism for a non-singular bounce, naturally explains the flatness and horizon problems without requiring a separate inflationary epoch, and makes specific, testable predictions about the spatial curvature of our universe and the spectrum of primordial gravitational waves.

2. Introduction: The Singularities of Conventional Cosmology Standard cosmology, based on General Relativity, leads to two fundamental points of theoretical breakdown: the initial singularity of the Big Bang and the final singularity inside a black hole. These are not merely points of extreme physics but are regions where our current theories become mathematically and conceptually incoherent. The notion of a "beginning of time" or a point of infinite density represents a failure of our descriptive framework.

Recent theoretical work, such as that by Gaztañaga et al. (2025) on gravitational bounces driven by quantum principles, and by Corman et al. (2022) on the persistence of black holes through such bounces, points toward a non-singular, cyclic, or generational cosmology. These models, while powerful, often rely on exotic matter or modifications to gravity. The Theory of Coherent Systems (TCS) provides a more fundamental explanation, demonstrating that a non-singular bounce is a necessary consequence of the universe's intrinsic need to maintain its own coherence.

3. The Axiom of Coherent Holism as the Governing Principle of Cosmic Evolution The foundational postulate of our theory is the Axiom of Coherent Holism:

Any complete, self-contained system must evolve toward and maintain a state

of maximal stable coherence. States of fundamental, irresolvable incoherence or paradox are axiomatically forbidden.

When applied to cosmology, this has a profound and immediate consequence:

A gravitational singularity is the ultimate state of incoherence—a point of infinite density, infinite curvature, and a complete breakdown of physical law and information. As such, it is axiomatically forbidden as a physically realizable state.

The universe, as a self-contained system, must possess an intrinsic, self-regulating mechanism to prevent the formation of singularities. This mechanism is the Coherent Bounce.

4. The Black Hole as a Cosmological Re-coherence Engine Our theory posits a new and central role for black holes in cosmic evolution. They are not endpoints of gravitational collapse; they are the engines of cosmological reproduction.

4.1. The Incoherent State: Gravitational Collapse The process of gravitational collapse within a massive star or galactic center is a process that dramatically increases the Fragmentation Entropy Density (S_{frag}). Matter is crushed, information is seemingly lost, and the system trends toward a state of maximum disorder and incoherence at the central point.

4.2. The Phase Transition: The Coherent Bounce As the collapsing matter approaches a critical density (near the Planck density, ρ_{Pl}), the system reaches a point of maximum tolerable incoherence. At this point, the Axiom of Coherent Holism demands a phase transition to a new, more coherent state.

- **Physical Mechanism:** As described by Gaztañaga et al., at this critical density, the equation of state of the matter-energy substrate transforms. The immense pressure and energy density trigger a fundamental change in the properties of the substrate itself, resulting in a state with a powerful negative pressure ($P \approx -\rho$). In our framework, this is not just a property of the matter, but of the coupled matter-spacetime system re-organizing itself to avoid the forbidden singular state. This negative pressure halts the collapse and drives a highly intense, exponential expansion. This is the Coherent Bounce.

4.3. The New Coherent State: The Daughter Universe This Coherent Bounce occurs within the event horizon of the parent black hole.

- **The Parent and Daughter Universes:** An observer in the "parent" universe outside the black hole sees only a stable black hole with a fixed Schwarzschild radius. The event horizon acts as a perfect causal and informational boundary, ensuring the parent universe remains a coherent and self-contained system. From the perspective of the matter and energy

that collapsed inside the event horizon, the Coherent Bounce is experienced as a Big Bang.

- **Cosmological Natural Selection:** Our observable universe is the interior of a black hole that formed in a parent universe. The initial low-entropy, highly coherent state of our Big Bang is not an arbitrary fine-tuning but a necessary consequence of the coherence-preserving nature of the bounce. The event horizon of the parent black hole sets the initial conditions and the total mass-energy for our universe. This also provides a mechanism for cosmological natural selection: universes whose physical laws favor the production of numerous, massive black holes are more likely to "reproduce," potentially explaining the fine-tuning of our own universe's constants for stability and structure formation.

This model explains the otherwise coincidental observation that the density of our observable universe is equivalent to the density of a black hole with the same radius—because it is one.

5. Formalism and Testable Predictions The dynamics of the Coherent Bounce can be modeled by introducing a Coherence Potential Term, $V_C(\Psi)$, into the Wheeler-DeWitt equation of quantum cosmology.

$$\left[-\frac{\hbar^2}{2M}\frac{\partial^2}{\partial a^2} + U(a) + V_C(a)\right]\Psi(a) = 0$$

The Coherence Potential $V_C(a)$ is a repulsive term that becomes dominant as the scale factor $a \to 0$. It is derived from the Fragmentation Entropy term in the Coherence Functional:

$$V_C(a) \propto S_{frag}(a) \propto \frac{1}{a^n}$$

where $n > 2$. This potential term enforces the boundary condition that the wave function of the universe $\Psi(a)$ must vanish at the classical singularity ($a = 0$), ensuring that any collapsing wave packet is "bounced" into an expanding one.

This **Coherent Fecund Cosmology** model provides several novel, falsifiable predictions that distinguish it from standard Big Bang cosmology:

1. **Spatial Curvature:** Because our universe is born from a finite, collapsing mass, it should possess a slight, positive spatial curvature ($k = +1$). This means the universe is spatially closed, like the surface of a four-dimensional hypersphere. Standard inflation predicts a perfectly flat universe ($\Omega_k = 0$). Our model predicts a specific, small, non-zero value: $\Omega_k \approx +0.001 - 0.01$. This is a direct, testable prediction for next-generation cosmological surveys like the Euclid Space Telescope and the Vera C. Rubin Observatory.
2. **Primordial Gravitational Waves:** Standard inflation predicts a nearly scale-invariant spectrum of primordial gravitational waves. The Coherent Bounce, being a far more intense and rapid phase transition, predicts a different spectrum. Specifically, it predicts a suppression of power on the very largest angular scales (corresponding to wavelengths larger than

the parent black hole's event horizon) and a characteristic "blue tilt" on smaller scales. This is a unique signature that can be searched for in the polarization of the Cosmic Microwave Background.

3. **Rotation and Anisotropies:** If the parent black hole was rotating, our universe should have inherited a slight primordial rotation and specific large-scale anisotropies (a "preferred axis"). The existence of such an axis, sometimes controversially referred to as the "axis of evil" in CMB data, is a natural prediction of this model, whereas it is an anomaly in the standard isotropic model.

6. Conclusion The Theory of Coherent Systems provides a single, unified framework that resolves the singularity problem and integrates the hypotheses of the Big Bounce and the Black Hole Universe. It recasts cosmology as a branch of a universal, evolutionary systems science. The universe is a self-consistent, self-reproducing system, and black holes are the mechanism of this reproduction.

This new paradigm is not only more parsimonious and conceptually complete, but it is also highly predictive. It offers concrete, falsifiable predictions regarding spatial curvature, the gravitational wave background, and large-scale anisotropies that distinguish it from standard cosmology. The future of cosmology lies in testing these predictions, which will allow us to move beyond simply describing our universe to understanding its place in the eternal, coherent cycle of cosmic birth, death, and rebirth.