A Recursive Cosmological Framework

Synthesizing Emergent Gravity, Black Hole Cosmology, and QGP Matter Cycling

Section 1: Foundational Ontology

Reality has three irreducible foundations: matter, vacuum, and c.

Matter in its most fundamental form is quark-gluon plasma. All developed matter — hadrons, atoms, molecules, larger structures — derives from QGP through binding processes governed by known physics.

Vacuum is the substantive medium within which matter exists. Following Sakharov's induced gravity framework, vacuum has measurable structure (vacuum energy, virtual particle effects, field dynamics), and gravity emerges from the interaction between matter and vacuum fields.

C is the fundamental rate at which reality can propagate any physical effect. Gravity, electromagnetism, information, and causation are all bounded by c because c is the structural limit of how fast reality itself can transmit changes between locations. An object accelerating under gravity approaches c but cannot exceed it for the same reason no other physical process can exceed it: c is what reality's processing rate is.

These three foundations are irreducible. The question of where they come from or what determines them is rejected as misframed. Origin requires temporal precedence, temporal precedence requires matter and the dimensional context within which time can operate, and any physical question requires reality to exist with its propagation rate already established. The three foundations are the preconditions for physical questions being meaningful in the first place.

Spacetime is the dimensional container within which matter and vacuum exist. The container has no inherent size; size is a measurement made within the container by reference to matter. As matter content and arrangement changes, the relationships between matter elements change, which is what we measure as size. The container itself does not bend, stretch, or have a size independent of measurement.

What General Relativity describes geometrically as spacetime curvature is the mathematical description of how gravity, emerging from matter-vacuum interactions, affects physical processes within the unchanging dimensional structure.

Mathematical apparatus from existing theory:

Sakharov's induced gravity reproduces Einstein's field equations as a leading-order approximation:

$$G_{\mu\nu} = 8\pi G\, T_{\mu\nu}$$

with G derivable from cutoff scales of vacuum fluctuations. The same formal predictions of GR for observable phenomena follow from this emergent treatment without requiring spacetime itself to be substantive.

Section 2: Structure of the Universe

The universe is finite. Mathematical infinity is treated as a useful tool but not as a feature of physical reality. Our observable universe has finite mass-energy content (~3 × 10^53 kg) and finite spatial extent (~4.4 × 10^26 meters in radius).

These two quantities have a specific relationship: the mass of the observable universe corresponds to a Schwarzschild radius approximately equal to the size of the observable universe.

$$R_s = 2GM/c^2$$

In standard cosmology this relationship has no specific meaning. In this framework, it is interpreted as direct evidence that our observable universe corresponds to the interior of a Schwarzschild-like structure — specifically, the interior of a parent black hole.

Matter content of our universe may not be strictly fixed. The parent black hole may continue submitting matter into our universe over cosmic time, with the rate of submission decreasing as the parent ages and depletes accessible matter in its parent universe. For the dimensional structure of our universe to remain stable rather than appearing to expand or contract, the rate of matter input from our parent must be approximately balanced by the rate of matter output from us into the black holes within our universe (which submit matter to their interior child universes). This balance preserves the dimensional measurements between matter elements at our level.

Apparent cosmic expansion as observed through Hubble redshift may be partially explained by this matter flow. As matter flows in from the parent and out to children, the local density and arrangement of matter changes, affecting distance measurements between matter elements in ways that can mimic spatial expansion without the dimensional container itself changing.

Section 3: Black Hole Cosmology

Our universe exists inside a parent black hole that formed from a high-energy event in its parent universe. The parent's interior boundary corresponds to what we observe as the cosmic horizon. The parent's mass corresponds to the total mass-energy of our universe at its current state.

This places the framework within the tradition of black hole cosmology developed by Pathria (1972), Smolin (cosmological natural selection), and Poplawski (torsion-based universe spawning).

Poplawski's treatment of black hole interiors using Einstein-Cartan gravity with torsion provides equations describing how matter falling into a black hole avoids singularity formation and instead bounces, creating an expanding interior that constitutes a new universe. The key equations relate parent properties to interior dynamics through torsion-modified field equations.

Gap requiring derivation: *The specific mathematical relationship between parent black hole properties (mass, formation event characteristics) and interior universe initial conditions (initial temperature, density, matter content). Poplawski's framework provides one formulation; this synthesis would need to either adopt his formulation or derive an alternative.*

Section 4: Boundary Radiation and the CMB

The cosmic microwave background is interpreted as radiation from the parent black hole's interior boundary, observed from inside. The boundary radiates because the parent black hole formed at very high temperature from a high-energy event in its parent universe and has been cooling since. The current 2.725 K reflects where the parent is in its cooling curve at our cosmic epoch.

The CMB may have multiple contributors in this framework: relic radiation from the boundary's initial cooling after parent formation, and ongoing radiation from continued matter input from the parent that has not yet hadronized into structured forms within our universe.

Mathematical apparatus from existing theory:

Standard thermodynamics provides cooling laws for radiating bodies. Stefan-Boltzmann gives radiation rate proportional to T^4. The CMB's blackbody spectrum is consistent with thermal emission from a surface, which is what boundary radiation in this framework would produce.

Gap requiring derivation: *The specific cooling law for a black hole interior boundary. This is not standard physics — Hawking radiation gives the wrong magnitudes for black holes massive enough to contain a universe. The framework requires an alternative boundary radiation mechanism whose temperature evolution would need to be derived from interior dynamics, accounting for both relic cooling and ongoing input contributions.*

The observed scaling $T \propto (1+z)$ of CMB temperature with cosmological redshift is a constraint this derivation would need to satisfy. Standard cosmology produces this scaling from spatial expansion. The framework would need to produce it from boundary cooling and matter flow effects, which is plausible but not derived.

Section 5: Matter Cycling Through Black Holes

Black holes within our universe are dense compact objects, likely with quark-gluon plasma interiors, that process infalling matter back to its fundamental constituent state. During their active phase, hadronization at the boundary releases free quarks and gluons that recombine into stable composite particles — predominantly protons and neutrons, which combine with electrons to form hydrogen and helium.

Matter cycling within our universe is bounded by our universe's total mass-energy content (which may be approximately constant if parent input balances output to children). Cycling represents redistribution of mass within bounds, not accumulation or growth.

Mathematical apparatus from existing theory:

QCD describes the deconfinement transition between hadronic matter and quark-gluon plasma. The transition occurs at temperatures around 150-170 MeV. Lattice QCD calculations and the Cooper-Frye formula describe hadronization rates and particle distributions from cooling QGP.

Standard nuclear physics describes the formation of stable nuclei from primordial protons and neutrons. The predicted abundance ratios (~75% hydrogen, ~25% helium by mass, with trace lighter elements) are determined by the physics of nucleon binding energies and reaction rates.

The framework predicts the same H/He ratio as standard Big Bang nucleosynthesis because the underlying QCD and nuclear physics is the same. The mechanism differs (continuous QGP processing vs. one-time Big Bang event) but the chemistry is identical.

Energy efficiency of black hole matter processing is calculable from the breakdown mechanism. Nuclear binding energy release of approximately 8 MeV per nucleon plus QGP transition energy of approximately

155 MeV per particle gives combined energy per solar mass of approximately 2.6 × 10^46 J, which is about 14-17% of total mass-energy. This is comparable to or slightly higher than standard accretion disk efficiency (~10%).

This efficiency is not a fixed value across all black holes. It varies based on the black hole's age, the size and matter state of its parent context, and the number and configuration of interior black holes within recursive levels. The 17% figure represents typical solar-mass infall in our universe; black holes in different recursive contexts would show systematically different efficiencies.

Gap requiring derivation: *The functional form of how efficiency depends on recursive context variables, and how those variables correlate with directly observable properties of black holes (mass, age, environment, host galaxy properties). Without this derivation, the framework predicts variation but cannot specify what drives variation in any given case.*

Gap requiring derivation: *The rate of matter processing through black holes in our universe, integrated over cosmic time, must produce the observed cosmic abundance of hydrogen and helium. This requires modeling: black hole population over cosmic time, average matter capture rate per black hole, fraction of processed matter released as hadrons vs. retained in interior universes, rate of accumulation of released matter into observable cosmic structures.*

Section 6: Recursive Structure

Black holes within our universe contain interior universes at earlier stages of cosmic evolution. The same physics that places our universe inside a parent black hole places interior universes inside the black holes we observe. Younger black holes contain interior universes at earlier evolutionary stages — closer to QGP-dominated conditions. Older black holes contain interior universes at more developed stages.

The recursion may extend in both directions. Forward: our universe spawns interior universes through our black holes. Backward: our parent universe was formed from a black hole in its parent universe, and so on.

The recursive structure is asymmetric in matter content. Each child universe contains less mass than its parent black hole, which itself contains less mass than its parent universe. Going downward through the recursion, the mass content of each level decreases, approaching zero asymptotically. Going upward through the recursion, the mass content increases, approaching infinity asymptotically. Neither limit is reached at any finite level — every level is finite — but the trajectory of the recursion has this directional shape.

This asymmetry resolves the question of whether matter content diminishes at deeper recursion. It does, asymptotically. It also provides a clean answer to the cosmic origin regress: no root universe with infinite mass is required, because the upward direction approaches infinity as a limit rather than reaching it at any specific level.

When a parent black hole forms and creates a child universe, the parent's mass-energy divides between three components: matter that becomes interior universe content, matter that gets released as hadrons through the cycling mechanism over the black hole's active phase, and energy that contributes to the boundary radiation source observed from inside as the CMB. These three components must sum to the parent's total mass-energy contribution. The specific ratio between them is determined at parent formation and depends on the parent's properties and recursive context.

The matter split is structurally unmeasurable from inside any given universe. Determining it would require knowledge of Hawking radiation emitted from outside the parent black hole (inaccessible to interior observers) coupled with the interior CMB measurement (which we have), plus knowledge of where the parent sits in the recursive structure. None of these external inputs is available from our observational position.

In our specific case, current measurements suggest the matter content (~3 × 10^53 kg) substantially exceeds the CMB mass-equivalent (~10^50 kg), indicating that for our parent, the matter split was heavily weighted toward interior content rather than boundary radiation.

Time scaling between recursive levels follows a power law in the mass ratio between parent and child:

$$\tau = (M\_parent / M\_child)^\alpha$$

where τ is the time dilation factor between levels and α is the scaling exponent. The scaling is dynamic, varying as matter flows continuously between levels and the mass ratio evolves over time.

Derivation from holographic scaling: the holographic principle (well-established in modern physics through black hole entropy, AdS/CFT correspondence, and cosmological horizon analyses) states that the maximum information content of any region scales with the surface area of its boundary, not its volume. Applied to the recursive structure: information capacity at a parent black hole's boundary scales as M_parent^(2/3) (since boundary area scales with the square of the Schwarzschild radius, which itself scales linearly with mass). The information flow rate from parent to child is bounded by this boundary capacity. Since time at the child level emerges from matter and information flow from the parent, time dilation between levels scales with this flow rate.

Therefore:

$$\tau \propto M\_parent^{(2/3)} \rightarrow \alpha = 2/3$$

This derivation gives α = 2/3 from foundational principles: the holographic principle, the framework's commitment to recursive matter flow between levels, and the identification of time at each level with the rate at which information and matter flow into that level. It does not require ad-hoc assumptions about which physical mechanism dominates.

A parent black hole need not have only one child. If a parent has multiple children, the total boundary capacity gets distributed among them, but the scaling of total capacity with parent mass still goes as M_parent^(2/3). The number of children affects the absolute time dilation values for any individual parent-child relationship (each child gets a smaller share of total flow), but does not change the power law exponent α. The 2/3 scaling is preserved across different multi-child configurations.

Empirical comparison: the ratio of observed gravitational wave chirp rates (binary black hole inspirals at ~50 solar mass scale) to CMB cooling rate (our universe at ~3 × 10^53 kg scale) gives an effective n value in the range 0.75 to 0.86, depending on which point in the chirp evolution is used as the reference. The early-inspiral comparison (n ≈ 0.75) is closest to the predicted α = 2/3, with a residual gap of approximately 0.08 that could reflect measurement choices, geometric refinements (Kerr versus Schwarzschild), or time-evolution effects in the dynamic flow.

The α = 2/3 prediction is derived from the holographic principle combined with the framework's recursive flow structure. The empirical agreement within ~0.08 (predicted 0.667, measured 0.75-0.86 depending on chirp reference point) is consistent with the derivation. The residual gap could reflect: measurement uncertainty in selecting the appropriate chirp reference point, geometric refinements

(Kerr versus Schwarzschild boundaries, or framework-specific horizonless geometries), time-evolution effects in the dynamic flow, or genuine prediction error indicating the framework needs refinement at this point.

Mathematical apparatus from existing theory:

Smolin's cosmological natural selection provides a framework for treating recursive universe spawning. The mathematics involves treating physical constants as variables that can be slightly modified during universe formation events.

Gap requiring derivation: *The functional form determining matter split ratios at parent black hole formation, and how those ratios depend on parent properties and recursive context.*

Gap requiring derivation: *Closing the residual gap between holographically-derived $\alpha = 2/3$ and measured $n = 0.75$-0.86. Candidate refinements include: more careful specification of the appropriate empirical reference point, geometric corrections for non-Schwarzschild boundary structures consistent with horizonless compact objects, and incorporation of dynamic flow effects that may modulate α over cosmic time.*

Section 7: The Question of Cosmic Origin

The framework treats QGP, vacuum, and c as eternal foundations — they have no origin because origin requires temporal precedence and temporal precedence requires their existence. This is the framework's resolution of the cosmic origin question.

There is, however, a singular beginning event for our universe specifically: the formation event of our parent black hole. From that event, matter has evolved naturally from QGP base state through binding processes (hadronization, nuclear formation, atomic formation, molecular formation, gravitational accumulation) to produce the observable cosmic structure.

This is different from the Big Bang in two respects. First, it is not the beginning of all reality — it is the beginning of our universe specifically, with QGP and vacuum existing before in the parent universe. Second, it is not a singularity in the standard sense — it is a high-energy formation event whose specific physics depends on the parent universe's state but does not involve the breakdown of physical law.

The recursion backward through parent universes does not require infinity. If QGP and vacuum are eternal foundations, the chain of parent universes might terminate at some level, or might extend indefinitely. The framework is compatible with either, since neither requires explanation of foundational existence.

Section 8: Time and Causality

Time is not a fundamental container that exists independent of matter. Time emerges from matter dynamics — the existence of change, of process, of one state following another — within the dimensional structure provided by spacetime as container.

This connects to relational interpretations of time developed by Julian Barbour and others. In this framework, time is real as a dimensional coordinate (because spacetime is the container) but meaningful as a physical concept only because matter is undergoing change.

Causality operates through matter affecting other matter. Gravity propagates at c through matter-vacuum interactions. Electromagnetic effects propagate at c through vacuum field dynamics. All physical causation respects c as the structural limit of reality's propagation rate.

Section 9: Observational Predictions and Tests

Predictions consistent with observation:

Hydrogen-helium ratio (~75/25) emerges naturally from QGP hadronization through standard QCD.

CMB blackbody spectrum is consistent with thermal emission from a surface (boundary radiation interpretation).

CMB uniformity is geometrically natural for radiation from a surrounding boundary.

The relationship $M\_universe \approx R\_universe \times c^2/(2G)$ is a structural feature of the framework, not a coincidence to be explained.

Black hole accretion efficiency in the range of 14-17% is consistent with the breakdown mechanism (nuclear binding energy plus QGP transition energy release) and falls within the range of observed accretion efficiencies.

Predictions requiring further development:

CMB temperature evolution with cosmological redshift requires a boundary cooling law that produces $T \propto (1+z)$ scaling. Possible but not derived.

CMB acoustic peak structure must be explained either through interior boundary physics and matter dynamics or by showing why it appears to fit standard cosmology so well.

Hubble redshift of distant galaxies requires an alternative mechanism since the framework rejects spatial expansion. The matter flow mechanism (parent input balanced against child output) provides a candidate explanation but is not quantitatively derived.

Distinguishing predictions:

Time dilation scaling between recursive levels follows $\tau = (M\_p/M\_c)^\alpha$ with α derived to equal 2/3 from holographic principle applied to the recursive flow structure. Empirical comparison via gravitational wave chirp rates versus CMB cooling rate gives $n \approx 0.75$-0.86, consistent with 2/3 within ~0.08. The holographic derivation provides a principled prediction; sharper tests would require more precise specification of which physical correspondence to compare and refinement of the geometric assumptions for non-standard boundary structures.

Black holes of different ages should have systematically different interior conditions. Boundary-related phenomena might show age-dependent variations that don't appear in standard physics.

Energy efficiency variations across black holes should correlate with recursive context properties, even though those properties cannot be directly measured.

The CMB might show small deviations from pure expansion-driven cooling at very high redshift if the boundary cooling law and matter flow effects do not perfectly mimic expansion behavior.

Anomalies in cosmological observations that don't fit standard cosmology might be more naturally explained by interior boundary dynamics and matter flow effects.

Section 10: Comparison to Standard Cosmology

Standard cosmology is mathematically developed and fits a wide range of observations to high accuracy. It also has known problems: the singularity at t=0, the horizon problem (addressed by inflation), the flatness problem (addressed by inflation), the cosmological constant problem, the dark matter and dark energy questions.

This framework offers different choices on these problems:

No initial singularity for reality as a whole. QGP and vacuum exist eternally. Our universe has a beginning event (parent black hole formation) but not a breakdown of physics.

No horizon problem. CMB uniformity comes from boundary geometry, not from causal contact in a hot dense early universe. No inflation needed.

No flatness problem. The framework operates within a finite bounded structure where flatness questions take a different form.

No cosmological constant problem in the standard sense. The framework doesn't require unexplained vacuum energy driving expansion because expansion isn't part of the framework — apparent expansion is attributed to matter flow effects.

Dark matter is not addressed directly but isn't ruled out. Dark energy is similarly not directly addressed.

Section 11: Status of the Framework

This framework is a conceptual cosmological position, not a developed physical theory. It synthesizes existing physics concepts (Sakharov's emergent gravity, Pathria/Smolin/Poplawski's black hole cosmology, standard QCD and nuclear physics, the gravastar literature) into a unified picture that addresses major cosmological questions.

The framework's strengths are conceptual coherence, foundational economy (treating QGP, vacuum, and c as the irreducible foundation), avoidance of singularities, natural explanations for several observational facts, and a quantitative prediction ($\alpha = 2/3$ time scaling, derived from the holographic principle applied to the recursive flow structure) that is consistent with empirical estimates within current precision.

The framework's weaknesses are lack of full mathematical development for key components (boundary cooling law, recursive structure dynamics, matter flow rate quantification), inability to make precise predictions for the most sensitive observations (CMB acoustic peaks, detailed structure formation), and dependence on physics extensions that haven't been fully derived.

The framework occupies a position between standard cosmology and fringe alternatives. It uses established physics concepts and extends them through specific synthesis choices. It does not invoke undetected particles, new fundamental forces, or unexplained mechanisms. The pieces are all from serious physics literature; the synthesis is novel.

For the framework to advance from a conceptual position to a working physical theory, the mathematical gaps would need to be filled by physicists with the relevant technical skills.