Can black hole interiors contain another universe

A study of classical geometry and conditional cosmological models

Prepared for Kalu Wu
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Abstract

An expanding universe beyond a black-hole horizon is a serious theoretical possibility in some proposed models, but it is not an established consequence of black-hole formation. This study separates three claims that are often mixed together: the second exterior of an idealized eternal black hole, a new expanding cosmological region created by collapse, and the claim that our own universe is such a region. They require different evidence.

In the classical, nonrotating Schwarzschild solution, the future interior ends at a singular boundary in finite proper time. Its geometry is anisotropic and cannot be converted by a change of coordinates into the homogeneous, isotropic geometry used in standard cosmology. The maximal mathematical extension contains a second exterior, but no future-directed traveller can cross from one exterior to the other. A black hole formed from a collapsing star does not automatically include that second exterior or the accompanying white hole.

Conditional routes to a daughter universe include an inflating high-density region, spin-torsion modifications of gravity, and quantum-inspired transitions replacing the singularity. These proposals must supply a consistent global spacetime, a justified transition law, stable evolution, and a cosmological history compatible with observations. An explicit effective-bounce calculation shows how contraction can change to expansion after a new dynamical assumption is introduced. It does not demonstrate that an astrophysical black hole undergoes that process.

Three numerical examples reproduce horizon scales and infalling clock times. A separate calculation gives a Hubble radius of 14.51 billion light-years for $H_0 = 67.4$ km s^{-1} Mpc^{-1}. The familiar equality between that radius and the Schwarzschild radius assigned to its critical-density contents follows algebraically from the flat Friedmann equation; it is not independent evidence that our universe is a black hole. The defensible conclusion is conditional possibility, with no positive observational demonstration in the evidence considered here.

Study status

AI-assisted theoretical feasibility study and literature synthesis. Prepared by dot for Kalu Wu. This is not a peer-reviewed paper, an original observational discovery, or a numerical-relativity simulation. The calculations and original diagrams are explanatory and reproducible.

Keywords Black hole interiors; general relativity; baby universes; FLRW cosmology; quantum bounce; causal structure

1 Definitions and hypotheses

The phrase “another universe” has no single technical meaning. Here it means a large spacetime region with its own cosmological evolution and observers, rather than merely a place that looks different or lies beyond our present view. “Inside” means behind the horizon relative to a specified parent exterior. It does not imply that an ordinary three-dimensional ball contains a scaled-down copy of the cosmos.

Three statements that need different tests

H1 A second asymptotic exterior exists. The maximally extended, eternal Schwarzschild solution contains two exterior regions. Each has an asymptotically flat far-away region. This is a fact about a particular exact solution and its boundary conditions [1]. It neither shows that stellar collapse produces both exteriors nor supplies a traversable passage between them.

H2 Collapse produces a daughter cosmology. A trapped region develops into a long-lived expanding region after the classical high-curvature endpoint is replaced or avoided. This is the main feasibility hypothesis. A candidate must specify its matter, gravitational equations, initial conditions, causal connection to the parent, and any transition through a regime where classical general relativity fails.

H3 Our observed universe is such a daughter region. This adds a demanding empirical claim to H2. The model must reproduce the observed expansion history, primordial element abundances, structure formation, and cosmic microwave background, and ideally predict an observable difference from standard cosmology. Possibility of H2 alone does not establish H3.

Geometric terms used throughout

An event horizon is a global causal boundary. In the asymptotically flat setting used for the classical example, points inside cannot send a future-directed light signal to the chosen exterior’s future null infinity, the ideal endpoint of outward-travelling light. A cosmological spacetime need not possess the same kind of infinity, so the definition must be adapted to the full model.

A future-trapped sphere has both inward and outward future light bundles initially decreasing in area. A past-trapped, or anti-trapped, sphere has both increasing. An apparent or trapping horizon is defined from such local or quasi-local expansions; it is not generally identical to the event horizon. “Horizon” therefore needs a qualifier when comparing collapse and cosmology.

Areal radius r is defined by the area $A = 4\pi r^2$. It is not automatically a ruler distance. Proper time τ is the time recorded by a specified observer’s clock. An asymptotic region is a far-away end of an idealized spacetime, not necessarily a separate Big Bang universe. Geodesic incompleteness means that at least one freely moving path ends after finite affine parameter or proper time without a continuation within the spacetime.

Method and evidential standard

The study compares exact classical geometry, elementary calculations, selected original model papers, and established observational benchmarks. It does not assign a probability to H2 or H3. A mathematical construction counts as conditional consistency under its assumptions; a measurement counts as evidence only for the features it can actually distinguish.

2 What classical collapse implies

The transparent baseline is a spherical, nonrotating, uncharged black hole of gravitational mass M in vacuum, with no cosmological constant. Let G be Newton's gravitational constant and c the speed of light. Outside and inside the horizon, away from the singular Schwarzschild coordinate chart at the horizon itself, the metric is [1, 2]

$$ds^2 = -(1 - r_s/r)c^2dt^2 + (1 - r_s/r)^{-1}dr^2 + r^2d\Omega^2 \quad (1)$$

$$r_s = 2GM/c^2 \quad (2)$$

Here ds^2 is the spacetime interval, t is Schwarzschild time, and $d\Omega^2 = d\theta^2 + \sin^2\theta\, d\varphi^2$ is the unit-sphere angular interval, with polar angles θ and φ. A massive observer has $ds^2 = -c^2d\tau^2$. The divergence of a coefficient at $r = r_s$ is removable with regular coordinates. The curvature at $r = 0$ is different: in the classical solution it diverges.

In the future black-hole region $0 < r < r_s$, every future-directed causal trajectory proceeds toward smaller r. A worldline at fixed r would be spacelike and cannot describe a hovering observer. The radius is functioning as a time-like direction in this region. Calling that region a stationary chamber with a door to somewhere else misrepresents its causal structure.

A cosmological form does not make it FLRW

Set $F = r_s/r - 1 > 0$, $x = ct$, and define an interior time T by $dT = -dr/(c\sqrt{F})$. Equation 1 then takes the homogeneous but anisotropic Kantowski-Sachs form

$$ds^2 = -c^2dT^2 + F[r(T)]dx^2 + r(T)^2d\Omega^2 \quad (3)$$

The scale along x grows as r falls, while the two angular scales shrink. Thus even "everything contracts" is too crude a description. In the usual unquotiented extension, a constant-T spatial slice has topology $\mathbb{R} \times S^2$, a line times a two-sphere. It is not the same spatial geometry as a three-sphere. The form is cosmological in a technical sense, but it is not an isotropically expanding FLRW universe.

Where the classical prediction ends

Oppenheimer and Snyder supplied an exact model of pressureless spherical collapse; the matter interior is a contracting portion of an FLRW solution matched to an exterior vacuum [3]. That result does not attach an expanding universe after the collapse. The black-hole interior can include matter, so Equation 1 should not be applied to every point during formation.

Penrose's theorem links a closed future-trapped surface, a noncompact Cauchy surface, and nonnegative null Ricci curvature to future null geodesic incompleteness [4, 5]. A Cauchy surface is initial data crossed once by every inextendible causal path; null Ricci curvature measures light-ray focusing. The theorem does not identify a quantum endpoint. In vacuum Schwarzschild the endpoint is a curvature singularity. A proposed nonsingular theory must specify which assumption fails and how evolution continues. Classical breakdown alone does not derive a daughter universe.

3 Why a second exterior is not a portal

The full eternal Schwarzschild extension contains four regions. The diagram below suppresses the two angular directions, compactifies distant boundaries, and preserves which events can causally influence which others. Future-directed timelike motion goes upward within the 45-degree light cones. The orange path is a possible infalling observer, not a path into another exterior [1, 2].

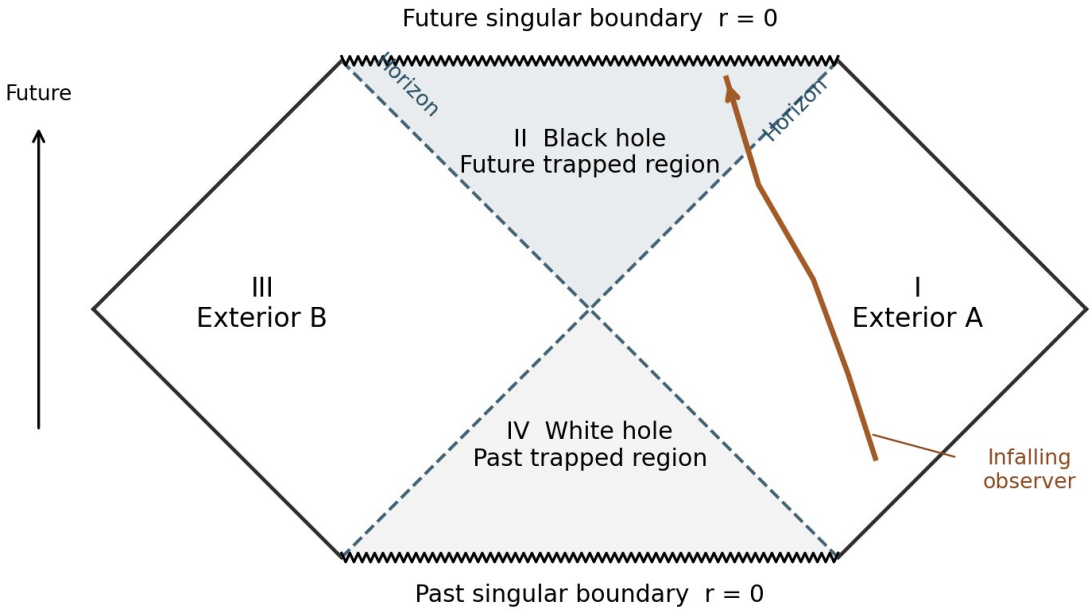


Figure 1. Original conformal causal schematic of eternal Schwarzschild spacetime. Dashed diagonals are horizons; jagged horizontal boundaries are singular. Regions I and III are different exteriors. Their null-infinity boundaries are the outer diagonal edges. A future-directed infaller from I enters II and encounters the future singular boundary. Distances and elapsed times cannot be read from this diagram.

No future-directed causal path connects exterior I to exterior III through this geometry. The Einstein-Rosen bridge is a feature of some spatial slices, not a traversable tunnel. The white-hole region IV is the time reverse of a black hole: future paths can emerge from it. It is not the destination of an observer who falls into region II.

A realistic formation history is a separate problem. In the simplest stellar-collapse diagrams, a regular pre-collapse center and the matter-filled star replace the eternal solution's extra exterior and white-hole regions. One cannot infer the entire four-region extension merely by observing a black hole's exterior. The extension assumes a different global history [2, 3].

Rotation does not remove the need for a physical model

The exact Kerr solution for a rotating vacuum black hole has a richer analytic interior. However, idealized inner horizons are sensitive to perturbations. The mass-inflation mechanism was demonstrated for perturbed charged black holes, and illustrates why smooth analytic extensions through inner horizons cannot simply be assumed in astrophysical settings [6]. This is a warning about stability, not a proof of every possible rotating endpoint.

For H2, the relevant task is therefore to construct a collapse spacetime with a well-defined transition and expanding future region, then test it under perturbations. Re-labelling an exterior region on an eternal diagram does not complete that task.

4 Comparing a black hole with cosmology

The Friedmann-Lemaître-Robertson-Walker (FLRW) metric describes exact spatial homogeneity and isotropy. It is the background approximation behind standard cosmology; actual galaxies and perturbations make the real universe inhomogeneous on smaller scales. A useful convention is

$$ds^2 = -c^2dt^2 + a(t)^2[d\chi^2/(1 - k\chi^2) + \chi^2 d\Omega^2] \quad (4)$$

Here t is comoving cosmic proper time, a(t) is a length-valued scale factor, χ is a dimensionless comoving radial coordinate, and k = +1, 0, or −1 is the spatial-curvature sign. The areal radius is $R = a\chi$. Expansion is measured by $H = (da/dt)/a$. With total mass-equivalent energy density ρ, including a cosmological constant as a fluid if present, the first Friedmann equation is

$$H^2 + kc^2/a^2 = 8\pi G\rho/3 \quad (5)$$

This is an equation for a cosmological matter-filled geometry, not an isolated mass in vacuum. A decisive invariant difference is that exact FLRW has zero Weyl curvature, whereas Schwarzschild has nonzero Weyl curvature for $M \neq 0$ and finite r. Changing coordinates cannot erase that distinction. Schwarzschild vacuum has $R_{\mu\nu} = 0$, where $R_{\mu\nu}$ is the Ricci tensor; ordinary FLRW matter generally does not [2].

Light bundles distinguish collapse from expansion

For radial future null rays in FLRW, choosing cosmic time t as the ray parameter gives $dR/dt = HR \pm c\sqrt{(1 - kR^2/a^2)}$. The plus sign denotes the outward ray and the minus sign the inward ray in the coordinate patch. Since a sphere's area is $4\pi R^2$, define its area expansion with this positive parameter normalization by

$$\theta_{out,in} = 2[H \pm (c/R)\sqrt{1 - kR^2/a^2}] \quad (6)$$

The magnitude of each expansion depends on normalization, but its sign is the relevant invariant statement. In an expanding spatially flat model, H > 0 and k = 0: the outward expansion is positive everywhere. Beyond R = c/H, the inward expansion is also positive. These large spheres are anti-trapped, unlike future-trapped spheres in a black-hole interior, where both expansions are negative.

The FLRW apparent-horizon areal radius is $R_A = c/\sqrt{(H^2 + kc^2/a^2)}$. When k = 0 it equals the Hubble radius $R_H = c/H$ for H > 0. A vanishing light-bundle expansion can occur in both collapse and cosmology. The time orientation and the global spacetime decide what kind of horizon it is.

The immediate lesson

A cosmological horizon and a black-hole horizon share useful mathematical structures, but they cannot be identified from their radius alone. An expanding FLRW region behind a parent black-hole horizon would need an explicit transition from trapped to expanding behavior, together with a consistent connection between the two regions.

5 Horizon scales and infalling clocks

The following diagnostic calculations use the Schwarzschild model, not a quantum interior. They show why horizon size and a low nominal density do not establish the presence of another universe. For a fixed mass M, define a reference density by dividing M by a Euclidean sphere volume constructed from the areal horizon radius:

$$\bar{\rho} = 3M/(4\pi r_s^3) = 3c^6/(32\pi G^3 M^2) \quad (7)$$

This is not the local density of the vacuum solution, which is zero away from the singular boundary. It is also not a unique relativistic interior volume average: interior spatial volume depends on the chosen slice. The quantity is only a convenient mass-radius scaling, falling as M^{-2}.

A specified geodesic clock

For a radial freely falling test observer released from rest at infinity, the dimensionless conserved energy per unit rest energy is E = 1. The radial equation is $dr/d\tau = -c\sqrt{(r_s/r)}$. Integration from r_s to the classical r = 0 boundary gives

$$\Delta\tau = \int_0^{r_s} \sqrt{r/r_s}\, dr/c = 2r_s/(3c) = 4GM/(3c^3) \quad (8)$$

This result neglects spin, accretion, the infaller's self-gravity, and quantum effects. It is elapsed time on that observer's clock. It is not the time seen on a distant clock and not the age of any hypothetical daughter universe.

Mass M	Horizon radius r_s	Reference $\bar{\rho}$ kg m^{-3}	E = 1 clock $\Delta\tau$	Interior bound τ_{max}
10 $M_\odot$	29.53 km	1.843×10^{17}	65.68 µs	154.7 µs
10^6 $M_\odot$	2.953×10^6 km	1.843×10^7	6.568 s	15.47 s
10^9 $M_\odot$	2.953×10^9 km	18.43	1.824 h	4.298 h

Table 1. Values use G = 6.67430×10^{-11} m^3 kg^{-1} s^{-2}, c = 299792458 m s^{-1}, and the adopted solar mass $M_\odot$ = 1.98847×10^{30} kg. Rounded figures are explanatory, not precision measurements of actual black holes.

The upper bound has its own assumptions

Within the future Schwarzschild interior, the timelike line element implies $d\tau \le -dr/[c\sqrt{(r_s/r - 1)}]$. The terms due to changing Schwarzschild t or angles decrease proper time. Integrating the bound yields

$$\tau_{max} = \int_0^{r_s} \frac{dr}{c\sqrt{r_s/r - 1}} = \pi r_s/(2c) = \pi GM/c^3 \quad (9)$$

Equality is associated with an ideal radial E = 0 trajectory from the bifurcation sphere in the eternal geometry. Ordinary radial geodesic infallers from the chosen exterior have E > 0 and approach this bound as E tends to zero. Neither column predicts time through a singularity, which the classical metric does not define.

6 The Hubble mass equality is not evidence

A common argument says that the mass of the universe has a Schwarzschild radius close to its size, so the universe must be a black hole. In a flat FLRW universe the usual version of this equality is built into the equations. It cannot independently test the hypothesis.

For $H > 0$ and $k = 0$, let $R_H = c/H$. Let $\rho_c = 3H^2/(8\pi G)$ be the critical mass-equivalent energy density. When $\rho = \rho_c$, the mass-equivalent energy in a homogeneous Hubble sphere is

$$M_H = (4\pi/3)\rho_c R_H^3 = c^3/(2GH) \quad (10)$$

$$2GM_H/c^2 = c/H = R_H \quad (11)$$

Substitution proves the equality exactly at any time satisfying these assumptions. It adds no new measurement, no exterior vacuum region, and no parent universe. In spherical FLRW geometry the quantity $(4\pi/3)\rho R^3$ is the corresponding Misner-Sharp mass, with vacuum energy included in ρ when that convention is used [7]. Its marginal-sphere relation is not a license to replace the cosmological metric with Schwarzschild.

A reproducible numerical example

Use $H_0 = 67.4$ km s^{-1} Mpc^{-1} as a benchmark, the central value inferred by Planck under the base flat ΛCDM model [8]. It is a model-dependent reference, not a claim that all measurements agree on H_0. With 1 Mpc = $3.08567758 \times 10^{22}$ m, the values are

Quantity	Calculated benchmark
H_0	2.18429×10^{-18} s^{-1}
$R_H = c/H_0$	1.37250×10^{26} m = 14.5073 Gly
ρ_c	8.53286×10^{-27} kg m^{-3}
M_H	9.24096×10^{52} kg = 4.64727×10^{22} $M_\odot$
$2GM_H/(c^2R_H)$	1 by the flat Friedmann identity

Table 2. Gly means one billion light-years; a light-year here uses the Julian year of 365.25 days. M_H includes total energy-equivalent density, including dark energy in this convention. It is not a count of ordinary matter or an isolated-system mass defined at spatial infinity.

Using only matter changes the comparison. Let $\rho_m = \Omega_m\rho_c$ be matter density and M_m its mass-equivalent energy in the same sphere. Then $2GM_m/(c^2R_H) = \Omega_m$, about 0.315 in this benchmark. Choosing total density is exactly what creates the ratio of one. Neither choice changes the actual cosmological causal geometry.

The Hubble radius is also not the radius of the whole universe. It is not generally the particle horizon, which marks how far light could have reached us since the early universe, or the cosmological event horizon, which concerns all future communication. Conflating these different scales can produce apparently striking but physically irrelevant numerical comparisons.

7 Conditional routes to a daughter universe

Several research programs have constructed geometries or effective dynamics that motivate H2. They are not one established theory and should not be combined as if each supplied a verified piece of the same mechanism. Their shared challenge is connecting ordinary collapse to a stable expanding region with a justified high-density evolution law.

An inflating region behind a horizon

A region dominated by approximately constant positive vacuum energy can have de Sitter-like expansion. Matching it to an exterior, sometimes through a thin shell, yields models in which a large inflating region lies beyond a narrow connection to the parent. The shell stress, global geometry, and formation history are physical requirements, not graphical choices. Farhi and Guth identified an obstruction to creating an inflating universe from nonsingular laboratory initial data under the relevant classical energy and causal assumptions [9].

Farhi, Guth and Guven investigated a quantum-tunnelling route [10]. Such a transition is a conditional semiclassical proposal, not an observed process or a recipe known to create universes. Frolov, Markov and Mukhanov explored a limiting-curvature model in which a black-hole interior could lead to a closed world [11]. A prescribed bound on curvature and the junction construction are additional assumptions beyond vacuum general relativity.

Spin and torsion

Einstein-Cartan gravity extends the geometric description by allowing torsion coupled to intrinsic spin. In certain averaged spin-fluid treatments, a high-density correction can oppose collapse. Popławski studies black-hole cosmology in this framework [12]. A viable bounce depends on the matter model, shear, and particle-production assumptions. The selected paper's 2026 revision explicitly treats the competition with anisotropy as important and says a more general geometry is needed for the intended closed-universe evolution.

This proposal should therefore be presented as a dynamical research hypothesis. It does not follow merely from matter having spin. One must verify the approximation used to average microscopic spins, solve the transition, and show that the expanding branch becomes compatible with our nearly isotropic observed cosmos.

Quantum geometry and black to white hole transitions

Ashtekar, Olmedo and Singh construct an effective quantum extension of the eternal Kruskal geometry with a nonsingular transition from trapped to anti-trapped regions [13]. This is an explicit model of singularity resolution. It is not, by itself, a simulation of stellar collapse producing a realistic FLRW daughter universe. A white-hole-like region and an expanding cosmology are different outcomes and must be identified from the full solution.

Loop quantum cosmology supplies another useful example of a bounce in symmetry-reduced cosmological models [14]. Its equations cannot simply be inserted into an anisotropic black-hole interior without justification. A successful model needs a controlled effective regime, sensible low-curvature behavior, and robustness to inhomogeneity. The existence of a smooth formula alone does not establish these properties.

8 A bounce calculation with explicit assumptions

To see exactly what an extra dynamical assumption buys, consider a spatially flat, homogeneous toy cosmology. Assume a constant equation-of-state ratio $w = p/(\rho c^2) > -1$, ordinary fluid conservation, and an effective Friedmann equation of the form motivated by simple loop-quantum-cosmology models [14]:

$$H^2 = (8\pi G/3)\rho(1 - \rho/\rho_b) \quad (12)$$

$$d\rho/dt = -3H\rho(1 + w) \quad (13)$$

Here p is pressure and ρ_b is a fixed positive bounce density, expressed as mass-equivalent energy per volume. Equation 12 is assumed for this calculation; it is not derived here from black-hole collapse. At low ρ/ρ_b it approaches the flat classical Friedmann equation. At $\rho = \rho_b$ it allows $H = 0$.

Define $n = 3(1 + w)$, a_b as the minimum scale factor, and $t_b = 1/[(1 + w)\sqrt{(6\pi G\rho_b)}]$. With the bounce at cosmic time $t = 0$, an exact solution of these two assumed equations is

$$a(t) = a_b[1 + (t/t_b)^2]^{1/n}, \qquad \rho(t) = \rho_b/[1 + (t/t_b)^2] \quad (14)$$

$$H(t) = 2t/[n(t_b^2 + t^2)] \quad (15)$$

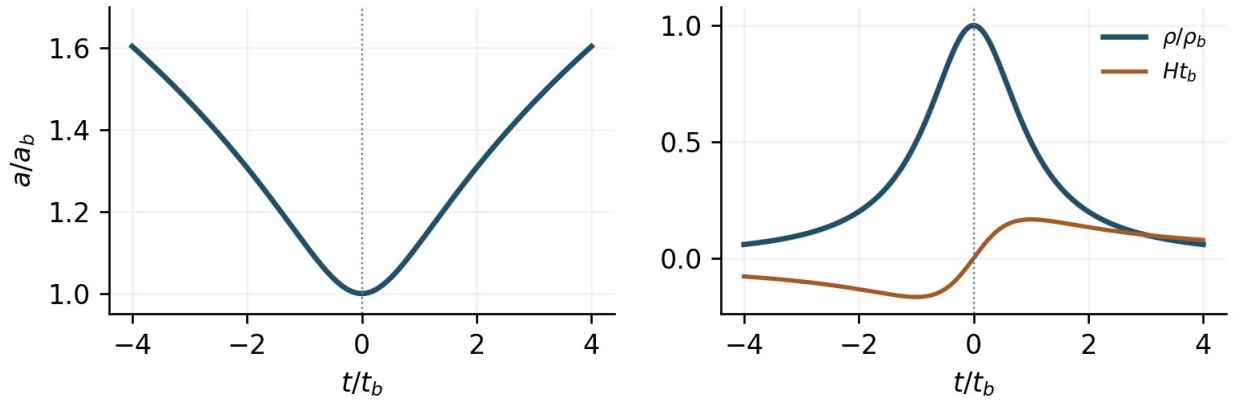


Figure 2. Original dimensionless calculation for $w = 1$, the stiff-fluid or massless-scalar case. The scale factor remains positive; H changes from negative to positive; the density peaks at ρ_b. No numerical bounce density is chosen, so the graph predicts no absolute duration or size.

Differentiating away from $H = 0$ and extending this smooth solution gives $dH/dt = -4\pi G\rho(1 + w)(1 - 2\rho/\rho_b)$. At the bounce its value is positive for $w > -1$, so this branch genuinely changes from contraction to expansion. A zero of H alone would not have established that.

The result proves only that the stipulated equations possess a nonsingular homogeneous bounce. There is no parent exterior, black-hole junction, trapped-surface evolution, shear, or perturbation calculation here. Those missing elements are precisely what must be supplied before using this illustration as evidence for H2 or H3.

9 What observations can and cannot decide

Observations of black holes mostly test the exterior and the near-horizon environment. The Event Horizon Telescope's M87 analysis found a horizon-scale image consistent with the expected shadow of a Kerr black hole [15]. Gravitational-wave consistency tests compare binary dynamics and the remnant signal with general relativity [16]. Neither measurement directly images or receives a classical signal from a daughter universe behind a persistent event horizon.

Make the hypothesis predictive before comparing data

A proposal that differs from standard physics only in a permanently hidden region may produce exactly the same parent-exterior observations. If it supplies no distinguishing observable, exterior agreement cannot select it over competing interiors. Conversely, failure to see a signal that the model never predicted cannot refute it. This is an identifiability limitation, not evidence in favor of the hidden region.

Models with a transition affecting the exterior must specify the signal: for example, a waveform deviation, delayed emission, or a change in the causal boundary. The predicted amplitude, frequency or timescale, population dependence, and uncertainty must come from the model. Generic suggestions of "echoes" or unusual transients do not uniquely imply a baby universe, and this study reports no such detection.

If our universe is the daughter region

The expanding branch must connect to a hot early universe with an appropriate matter content. It must reproduce the observed near-isotropy, a viable expansion history, light-element abundances, and the statistics of primordial perturbations. Parent mass or spin cannot simply be equated with today's total matter or cosmic rotation without solving the connection and evolution.

Planck provides a specified benchmark: in its base flat ΛCDM analysis $H_0 = 67.4 \pm 0.5$ km s^{-1} Mpc^{-1} and $\Omega_m = 0.315 \pm 0.007$. Define the curvature parameter $\Omega_K = -kc^2/(a^2H^2)$, evaluated today. In a curvature extension, Planck plus baryon acoustic oscillations gives $\Omega_K = 0.001 \pm 0.002$ at 68% confidence [8]. These constraints depend on the model and do not measure global topology. A closed daughter model is not automatically excluded: sufficiently small present curvature can be allowed.

Four tests for a concrete proposed model

1. Recover ordinary gravity at low curvature. Calculate the exterior metric and perturbations, and compare the resulting observables with data. An unexpected long-range modification can constrain the model before any interior interpretation is considered.

2. Establish a stable transition. Evolve nonzero shear and inhomogeneous perturbations, not just an exactly symmetric trajectory. Determine whether trapped surfaces, a regular bounce, and an expanding region survive together.

3. Predict the primordial perturbations. Specify the initial quantum or statistical state and derive the scalar and tensor spectra. Compare the resulting parameters and correlations with observations, rather than using the observed spectrum as an input and calling it a prediction.

4. State a result that could rule out the model. Identify a finite parameter range or a sharp correlation before examining the data. If each possible result can be absorbed into an arbitrary transition law, the broad possibility may remain, but that formulation is not a useful empirical test.

10 Findings and a defensible conclusion

The answer to the motivating question is yes in a conditional theoretical sense: some proposed models replace the high-curvature interior with an expanding region that could qualify as another universe. The answer is not yes as a demonstrated property of astrophysical black holes. Classical Schwarzschild collapse supplies a trapped future interior and an incomplete endpoint, not a verified cosmological continuation.

Hypothesis	Finding in this study
H1 Second exterior in eternal Schwarzschild	Present in that exact extension; not traversable and not implied by stellar collapse
H2 Daughter cosmology created by collapse	Conditional constructions exist; a realistic, stable and empirically established mechanism is not supplied
H3 Our universe is a daughter cosmology	Not established; mass-radius coincidences do not provide an independent test

What the calculations establish

The Schwarzschild proper-time integrals quantify how the classical future interior differs from a static container. The density calculation shows that a supermassive horizon can have a small nominal mass-to-volume ratio without resembling a low-density cosmology locally. The FLRW light-bundle calculation distinguishes future trapping from cosmological anti-trapping. The Hubble mass identity explains an apparent coincidence. The bounce solution shows exactly where an additional equation changes the endpoint.

The next research step

For an original follow-on project, choose one specified matter and gravity model. Construct a spherical collapse solution with a parent exterior and a fully defined transition region, verify its constraint and matching equations, and track the signs of both null expansions. Then add perturbations to test stability and derive a distinguishing observable. A successful first milestone is a consistent spacetime with these properties; fitting one radius or drawing an expanding bubble is insufficient.

Even a successful result would first establish conditional consistency. Determining whether nature uses that solution requires the extra empirical step. It may also be impossible for a parent observer to distinguish interiors that remain causally hidden. A useful paper should state that limitation openly rather than treating inaccessibility as confirmation.

Scope and limitations

This is a selected, source-grounded feasibility study rather than an exhaustive review. It omits detailed Kerr evolution, numerical collapse with realistic equations of state, quantum state construction, and cosmological likelihood fitting. The observational examples are established benchmarks, not a claim to summarize every measurement available in 2026. No evidence here assigns a probability to our universe having a parent black hole.

Bottom line. “A black hole could lead to another universe in a specified theory” is defensible. “Black holes are known to contain universes” and “the size of our universe proves we are inside one” are not supported by this analysis.

Appendix Reproducibility and notation

Computational method

The accompanying reproduce_calculations.py uses only the Python standard library. Run it with Python 3 to regenerate calculation_results.json. It calculates every dimensional value in Tables 1 and 2, verifies the two equivalent reference-density expressions, checks the flat Hubble identity to floating-point precision, and substitutes sample bounce values into Equation 12. The figure and document builder is provided separately; it requires NumPy, Matplotlib and python-docx.

For the bounce, set $u = (a/a_b)^n = \rho_b/\rho$ using fluid conservation. Substitution in Equation 12 gives $(du/dt)^2 = n^2(8\pi G\rho_b/3)(u - 1)$. The branch $u = 1 + (t/t_b)^2$ solves it with $t_b^2 = 1/[6\pi G\rho_b(1 + w)^2]$. This verifies Equations 14 and 15 without assuming a value for the unknown density scale. For the plotted $w = 1$ case, a/a_b at $t/t_b = \pm 1$ is $2^{1/6} \approx 1.12246$ and $\rho/\rho_b = 1/2$.

For Equation 9, use $r = r_s \sin^2 u$, with u running from 0 to $\pi/2$. The remaining integral of $\sin^2 u$ over that interval equals $\pi/4$, giving $\pi r_s/(2c)$. This substitution is only an integration device; its u is unrelated to the bounce variable in the preceding paragraph.

Main symbols and their domains

Symbol	Meaning
G and c	Newton's constant and the speed of light
M and $M_\odot$	Schwarzschild gravitational mass and adopted solar-mass unit
r and r_s	Spherical areal radius and Schwarzschild horizon radius
τ and τ_{max}	Observer proper time and the stated Schwarzschild interior bound
a H k χ	FLRW scale factor, expansion rate, curvature sign and comoving radius
ρ and p	Mass-equivalent energy density and pressure; $p/(\rho c^2)$ is dimensionless
R_H R_A ρ_c	Hubble radius, FLRW apparent-horizon radius and critical density
ρ_b a_b t_b	Assumed bounce density, minimum scale factor and bounce timescale
w and n	Constant equation-of-state ratio and $n = 3(1 + w)$
ΛCDM	Cosmological-constant plus cold-dark-matter benchmark model

All displayed equations use SI quantities unless a unit is shown explicitly. Schwarzschild t, interior T, FLRW t and trajectory τ are different time coordinates or clock readings; sharing a letter in separate models does not identify their physical meaning. Density conventions and total-energy content must be kept fixed when comparing formulas.

References

Original research is cited for model claims and observations. Reference 2 is an author's lecture-note treatment of general relativity; reference 5 is a review used to clarify the precise singularity-theorem statement. Bibliographic links were checked on 1 October 2026. Version-specific statements about reference 12 concern its June 2026 revision.

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Reproducibility materials. The source package includes the calculation script, machine-readable results, original figure PNG and SVG files, the document builder, and a readable manuscript text export. These materials explain and reproduce the study; they do not contain a black-hole formation simulation or observational data analysis.