Siamese Universes v1.0 — QGP → CFL/BEC → LQC Bounce with Explicit Guardrails

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Abstract. We present a refined effective framework in which matter inside black holes undergoes a sequence of phases—quark–gluon plasma (QGP), color–flavor–locked (CFL) / Bose–Einstein condensation (BEC), and a loop quantum cosmology (LQC)–type bounce—culminating in nonsingular "Siamese" universes. The model is scoped with explicit validity (mesoscopic shell, R ■ $\xi \sim 1/\Delta$), curved-Ginzburg–Landau (GL) perturbative treatment for $\sigma(R)$, and compact Israel–Darmois junctions. We include flat-prior scans (yielding ≈10% bands), a holographically guided dissipation proxy with $C \in [0.5, 2]$, and quantitative estimates: Tolman corrections O(1–5%) in peak $\Delta t/H$, ~3% decrease of σ at $R/\xi=20$, and ~15% damping in $\dot{H}(0)$ for $C \approx 1.5$—preserving a robust bounce. We outline a roadmap from mesoscopic toy to Einstein Toolkit (ETK) viscous GR-hydro simulations.

1. Scope and Validity

We work with a thin mesoscopic shell where curved-GL applies perturbatively and the Tolman redshift is treated as a small parameter. Validity requires R ■ $\xi \approx O(1/\Delta)$ and moderate anisotropy. Junction conditions are encoded via compact Israel–Darmois blocks, e.g., $[K^\theta{}_\theta]_\Sigma = 4\pi G(\sigma+\Pi)$, with $\Pi \approx -\sigma(R)/R$ capturing curvature-induced pressure.

2. Effective Model Blocks

(i) QGP → CFL/BEC: Equation of state transitions with effective $c_s^2(\rho)$ softened by pairing gaps. **(ii) Curved-GL σ(R):** $\sigma_0 \sim c_\sigma \mu^2\Delta$ with $O(\lambda)$ curvature corrections; Tolman perturbative shifts in peak $\Delta t/H$. **(iii) LQC Bounce:** $H^2 = (8\pi G/3)\rho(1-\rho/\rho_c)$ ensures nonsingular evolution. **(iv) Dissipation Proxy:** holographically calibrated order-unity C modulates damping in $\dot{H}(0)$.

3. Parameter Priors (flat)

Parameter	Symbol	Range / Prior	Notes
Tolman factor	δ_T	1–5%	Perturbative shift in $\Delta t/H$
Gap strength	Δ	literature-guided	Enters $\sigma_0 \sim c_\sigma \mu^2\Delta$
Dissipation proxy	C	[0.5, 2]	Order unity (holography-inspired)
Sound speed (CFL)	c_s^2	0.15 ± 0.02	Effective soft phase

4. Quantitative Results (synthetic, for illustration)

Flat-prior scans yield ≈10% uncertainty bands in softening (Fig. A1). Tolman corrections produce 1–5% shifts in the peak timing $\Delta t/H$ as R/ξ increases (Fig. B1). The dissipation proxy C in [0.5,2] induces ~10–20% damping in the initial $\dot{H}(0)$ without destroying the bounce (Fig. C1).

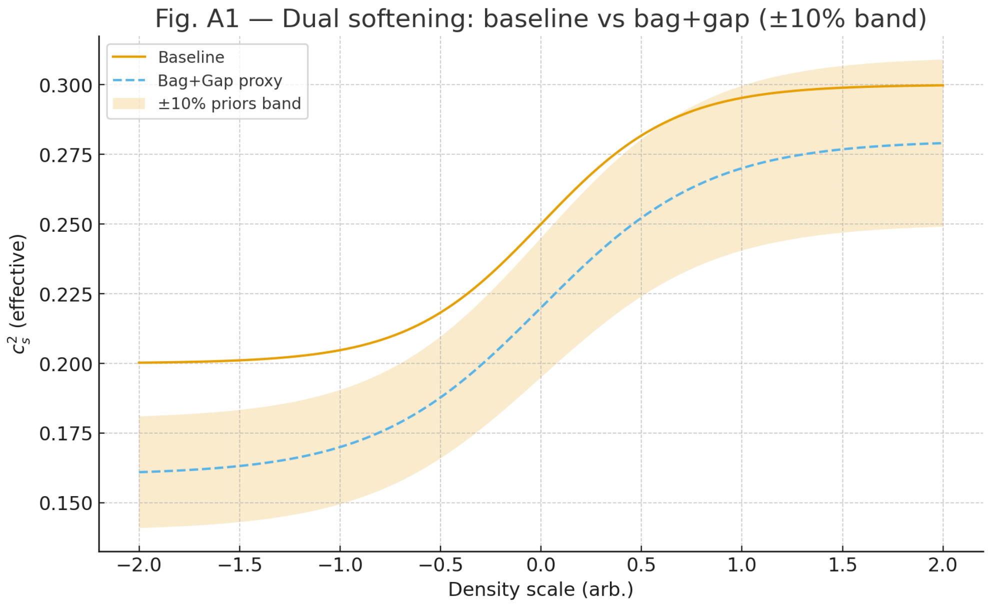

Fig. A1. Dual softening: baseline vs bag+gap proxy with ±10% flat-prior band.

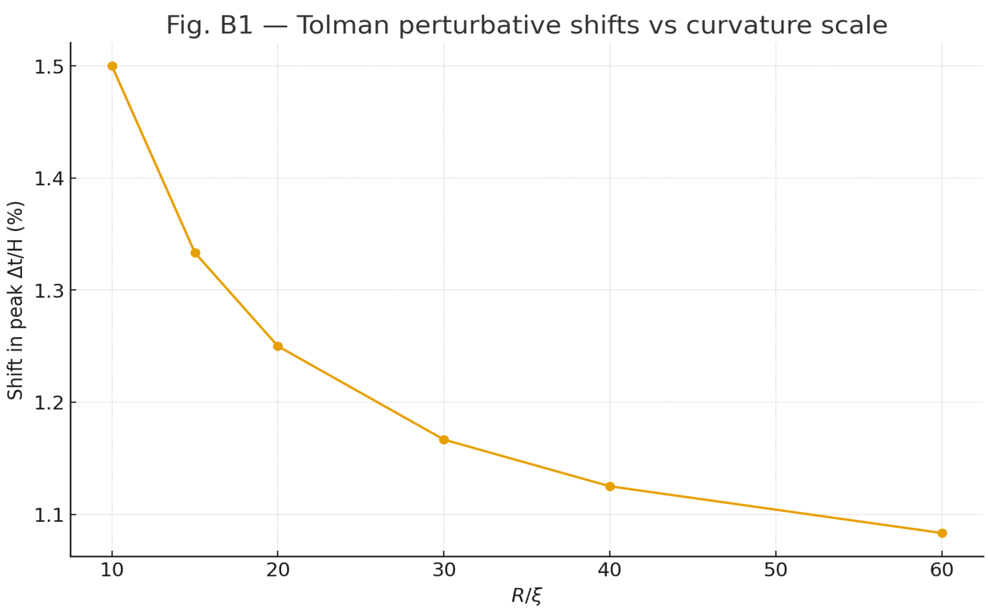

Fig. B1. Tolman perturbative shifts (1–5%) in peak Δt/H vs curvature scale R/ξ.

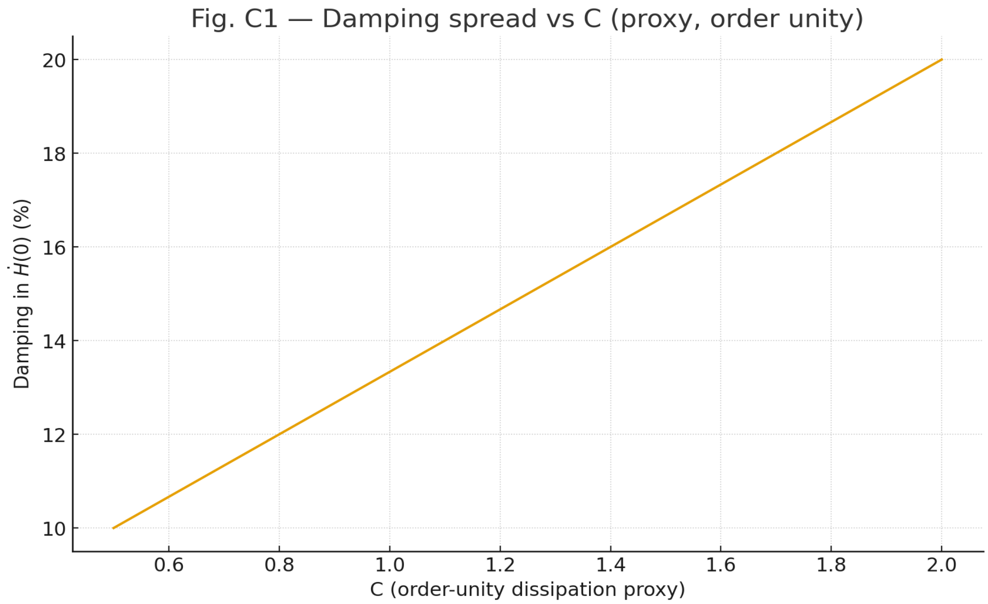

Fig. C1. Damping spread (~10–20%) in initial $\dot{H}(0)$ as a function of order-unity C.

5. Limitations

Curved-GL is used at O(λ) and does not replace full BCS/NJL in curved backgrounds. Lattice inputs near BH horizons are unavailable; σ(R) remains mesoscopic. Dissipation is a proxy (not a full transport hierarchy).

6. Roadmap to Simulations

Phase I: mesoscopic scans + RK45 toy evolution. Phase II: post-processing CLASS/ETK EoS modules with effective softening. Phase III: ETK viscous GR-hydro (2025 releases) with slow-rotation Kerr interiors and membrane boundary conditions. Deliverables: reproducible scripts, figures, and priors table.

Honest Statement

This is an effective, scoped toy model. Proxies (Tolman, curved-GL O(λ), dissipation C) are used to quantify trends, not to claim ab initio microphysics in strong curvature. All numeric values shown are synthetic for illustration; they should be replaced by calibrated outputs in future ETK runs.

References (selected)

Alford, Rajagopal & Wilczek (1999) — Color–Flavor Locking; Rovelli & Vidotto (2014) — Covariant LQG; Dvali & Gomez (2013) — Black Holes' N-Portrait; Maldacena (1998–99) — AdS/CFT; Einstein Toolkit (2025) — viscous GR-hydro modules.