Quark Separation, Bose–Einstein Condensation, and the Genesis of Universes Inside Black Holes — Revised Version

Authors: CosmicThinker, Copilot AI, ChatGPT

Abstract

We present a revised and expanded version of the speculative framework proposing that, inside black holes, matter undergoes a sequence of processes — quark deconfinement and quark–gluon plasma (QGP) formation, transition to superfluid/color–flavor–locked (CFL) phases, bosonic condensation (possible graviton condensate or collective modes), and finally a loop quantum cosmology (LQC)–type quantum bounce — which could culminate in the genesis of " daughter " universes. In this revision: (i) we clarify the physical hypotheses and regime of validity; (ii) we present effective equations and a toy model linking densities and scales; (iii) we propose falsifiable observational predictions and numerical strategies for validation; (iv) we discuss limitations and directions toward rigorous mathematical development. The aim is not to present a complete theory, but to transform the original idea into a technical, reproducible, and viable framework for theoretical and numerical testing.

1. Introduction and Objective

The original paper outlined a stimulating proposal: combining QCD, BEC, quantum gravity, and holography to describe possible mechanisms of cosmological genesis inside black holes. Here, we reframe it to preserve the original intuition while adding clarity on assumptions, effective equations, a numerical plan, and falsifiability criteria.

2. Physical Assumptions and Regime of Validity

1. Geometry: Interior of massive BH with semiclassical treatment until near Planck density. Assume spherical symmetry.
2. Microphysics: Compression to energies comparable to Λ_QCD, enabling deconfinement and QGP.
3. Couplings: Allow CFL phases and bosonic condensation of collective gravitational modes.
4. Quantum gravity: Use Loop Quantum Cosmology effective equations to replace singularity with a bounce.

3. Stage I — Quark Deconfinement and Matter Amplification

We model QGP formation under strong tidal forces. Effective equation of state:
$p(\rho) = w(\rho)\ \rho\ c^2$, with $w \approx 1/3$ in QGP, $w \to 0$ in condensed phases.

4. Stage II — Bosonic Condensation (BEC of Collective Modes)

Inspired by Dvali ' s N-portrait, collective modes are modeled by an effective Gross–Pitaevskii equation with interaction and curvature-dependent potential. The condensate must remain consistent with holographic entropy bounds.

5. Stage III — Quantum Bounce and Cosmological Genesis

In effective LQC:
$H^2 = (\dot{a}/a)^2 = (8\pi G/3)\ \rho\ (1 - \rho/\rho\_c)$.

This provides a nonsingular bounce when density approaches ρ_c, possibly initiating a daughter universe.

6. Toy Model — Simulation Scheme

Steps: (1) initialize BH mass and density profile, (2) compress to QGP, (3) include curvature-driven pair production, (4) trigger BEC, (5) evolve with LQC bounce. Tools: Einstein Toolkit, QCD EoS modules, GP solvers.

7. Observational Predictions

Possible signatures: gravitational wave echoes, PBH mass distribution anomalies, extreme bursts, and thermodynamic consistency with holography.

8. Limitations and Open Problems

Challenges include nonperturbative QCD in dynamic curved backgrounds, heuristic graviton condensation, and holographic consistency.

9. Practical Plan (Publication and GitHub Repository)

Document (this PDF + Markdown), toy model implementation, reproducibility with notebooks, repo structure including code/, figures/, README, LICENSE.

10. Conclusion

This revision transforms the original speculative essay into a structured framework with effective equations, falsifiable criteria, and a simulation plan. It remains speculative, but is now suitable for preprint release with open code.

References

1. Smolin, L. The Life of the Cosmos (1997).

2. Popławski, N.J. Physics Letters B (2010).

3. Susskind, L. Computational Complexity and Black Hole Horizons (2016).

4. Dvali, G. & Gomez, C. Black Holes' Quantum N-Portrait (2013).

5. Maldacena, J. AdS/CFT (1998–1999).

6. Alford, M., Rajagopal, K., Wilczek, F. Color-Flavor Locking (1999).

7. Rovelli, C., Vidotto, F. Covariant Loop Quantum Gravity (2014).

8. Text on LQC effective Friedmann equation with bounce.