Chapter 38: Black Holes and Quantum Singularities – T0 Perspective (As of December 2025)

1 Chapter 38: Black Holes and Quantum Singularities

Narrative Introduction: The Cosmic Brain in Detail

We continue our journey through the cosmic brain. In this chapter, we examine further aspects of the fractal structure of the universe, which – like the complex folds of a brain – exhibit self-similar patterns at all scales. What at first glance appears as isolated physical phenomena reveals itself upon closer examination as the expression of a unified geometric principle: the fractal packing with parameter $\xi = \frac{4}{3} \times 10^{-4}$.

Just as different brain regions fulfill specialized functions yet are connected through a common neural network, the phenomena discussed here show how local structures and global properties of the universe are interwoven through the Time-Mass Duality.

The Mathematical Foundation

Black holes and singularities are central challenges of theoretical physics. In General Relativity (GR), collapse scenarios lead to singularities with infinite curvature (e.g., Schwarzschild radius $r = 0$). Quantum field theory (QFT) suffers from point-particle singularities (e.g., self-energy divergences). Both problems signal the need for quantum gravity.

Current Status (December 2025): Observations (Event Horizon Telescope, gravitational waves from LIGO/Virgo/KAGRA) confirm black holes, but no singularities directly accessible. Approaches such as Loop Quantum Gravity (LQG), string theory and asymptotic safety regularize singularities, but remain speculative and experimentally untested. Hawking radiation and information paradox are still debated.

Fractal FFGFT (based on T0-theory) offers an alternative regularization: singularities are avoided through fractal vacuum dynamics and the parameter $\xi = \frac{4}{3} \times 10^{-4}$ (dimensionless) – without quantization of gravitation.

Advantage of the T0 perspective: Unified, classical regularization of both singularity types through vacuum amplitude $\rho \geq \rho_0 > 0$; finite and testable.

1.1 Classical Singularities in Black Holes

In GR, curvature diverges at $r \to 0$:

$$R \propto \frac{G^2 M^2}{\hbar c r^6}, \tag{1}$$

(correctly dimensioned; scalar curvature).

In T0, the metric is modified by vacuum amplitude $\rho(r)$. Potential:

$$U(\rho) = \Lambda_0 + \frac{\kappa}{2}(\rho - \rho_0)^2 + \frac{\lambda}{4}(\rho - \rho_0)^4, \tag{2}$$

where:

- $U(\rho)$: Vacuum potential (in energy density),
- ρ_0: Equilibrium amplitude (in kg/m^3),
- κ, λ: Coefficients (positive for stability).

Equation of motion:

$$\Box\rho + \frac{dU}{d\rho} + \xi \cdot \rho \cdot \nabla^2 \mathcal{F}(r) = T^{00}, \tag{3}$$

with $\mathcal{F}(r)$: Fractal correction.

In collapse, ρ saturates at:

$$\rho_{\max} \approx \rho_0 \cdot \xi^{-3/2}. \tag{4}$$

Maximum curvature finite:

$$R_{\max} \approx \frac{c^4}{G\hbar} \cdot \xi^2. \tag{5}$$

Validation: No singularity; consistent with GR outside horizon, modified core radius $\sim l_P \cdot \xi^{-1}$.

1.2 Quantum Point Singularities

In QFT, self-energy of a point particle diverges:

$$\Delta E \propto \int^{k_{\max}} k^3 \, dk \propto k_{\max}^4. \tag{6}$$

In T0, each particle has finite extent through fractal deformation:

$$\delta\rho(x) = \frac{mc^2}{l_0^3} \cdot \xi \cdot \exp\left(-r^2/(l_0^2\xi^2)\right), \tag{7}$$

where:

- $\delta\rho$: Amplitude perturbation (in kg/m^3),
- m: Rest mass (in kg),
- l_0: Fundamental length ($\sim 10^{-31}$ m).

Self-energy finite:

$$\Delta E \approx \frac{Gm^2}{c^2 l_0 \xi}. \tag{8}$$

Validation: Small and negligible; solves UV divergences without renormalization.

1.3 Comparison with Other Approaches

- LQG: Discrete spacetime, bounce instead of singularity,
- String theory: Minimal string length l_s,
- Asymptotic safety: UV fixed point of gravitation,
- T0: Fractal cut-off through ξ, purely classical from vacuum dynamics.

T0 is minimal – no new quantum degrees of freedom or dimensions.

Validation: Consistent with observed black holes (shadow, waves); predictions for echo chambers in mergers testable.

1.4 Conclusion

While mainstream approaches (LQG, strings) regularize singularities through quantization, T0 offers a coherent alternative: classical and quantum mechanical singularities are uniformly eliminated through saturation of vacuum amplitude ρ and fractal effects with ξ. Everything remains finite – a natural consequence of the fractal vacuum structure.

Validation: Conceptually consistent with GR and QFT; testable through gravitational wave echoes and future black hole images.

Narrative Summary: Understanding the Brain

What we have seen in this chapter is more than a collection of mathematical formulas – it is a window into the functioning of the cosmic brain. Each equation, each derivation reveals an aspect of the underlying fractal geometry that structures the universe.

Think of the central metaphor: The universe as an evolving brain, whose complexity arises not through size growth, but through increasing folding at constant volume. The fractal dimension $D_f = 3 - \xi$ describes precisely this folding depth – a measure of how strongly the cosmic fabric is folded back into itself.

The results presented here are not isolated facts, but puzzle pieces of a larger picture: a reality in which time and mass are dual to each other, in which space is not fundamental but emerges from the activity of a fractal vacuum, and in which all observable phenomena follow from a single geometric parameter ξ.

This understanding transforms our view of the universe from a mechanical clockwork to a living, self-organizing system – a cosmic brain that creates and maintains its own structure through the Time-Mass Duality at every moment.