The Saturated Resonator Core: Non-Singular Compact Objects in 4D Bulk Compression

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Abstract

In General Relativity, complete gravitational collapse terminates in an event horizon and a curvature singularity where classical spacetime ceases to exist, generating the black hole information paradox. Within the 4D Bulk Compression framework of CPT physics, spacetime is the 3D boundary hypersurface of an elastic medium possessing finite 3D compressibility $K = c^4/G$. In this paper, we resolve the structure of maximally compact objects by introducing the **Saturated Resonator Core**.

We prove that as volumetric strain increases during gravitational collapse, the local vacuum cell volume saturates at a fundamental geometric floor: [V_{\min} = a_0^3 e^{-3},] preventing infinite density. Across the core transition boundary at proper radius $r = \ell_0$, we introduce a C^1-smooth quartic matching potential that eliminates second-derivative discontinuities in the metric tensor. The resulting interior metric potential is finite and regular at the origin: [g_{tt}(0) = -\exp(-C_0),] yielding a maximum central gravitational redshift of: [z_0 \approx \mathbf{8.877}.]

Because $g_{tt}(0) < 0$ remains strictly non-zero and finite, no true trapped surface or event horizon forms. Radiation and quantum phase information can reflect from the saturated core boundary, generating observational testable signatures: horizonless shadow structures and gravitational wave ringdown echoes, resolving the black hole information paradox without exotic quantum gravity fields.

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1. Introduction: The Horizon & Singularity Crisis in General Relativity

In 1916, Karl Schwarzschild derived the exterior metric for a static spherical mass. For a body of mass M, the Schwarzschild radius is: [r_s = \frac{2 G M}{c^2}.] Under General Relativity, the Penrose–Hawking singularity theorems prove that whenever matter collapses within a trapped surface, a physical singularity

($r \to 0$) inevitably forms, where the Kretschmann scalar blows up: [K = R_{\alpha\beta\gamma\delta} R^{\alpha\beta\gamma\delta} = \frac{48 G^2 M^2}{c^4 r^6} \to \infty.] This produces the black hole information paradox: pure quantum states collapsing into a black hole appear to emerge as mixed thermal Hawking radiation, violating unitarity.

In CPT physics, gravity is not the curvature of an empty continuum, but the elastic deformation of a 4D bulk medium. Because any physical material medium possesses finite bulk compliance, infinite compression is unphysical.

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2. Finite Bulk Compressibility and the Minimum Cell Volume

In the constitutive sector of the framework (Book G, §0bn1176), the 4D bulk medium possesses finite elastic bulk compliance: [K = \frac{c^4}{G} \approx 1.21 \times 10^{44}\,\text{N}.] The volumetric strain $U(r)$ relates to the local metric determinant: [\sqrt{-g} = \exp(3 U).]

During extreme gravitational collapse, the local cell volume deforms from its unperturbed ground state $V_0 = a_0^3$. However, as shown in §0bn1178, the maximum allowable volumetric strain is bounded by the saturation threshold: [U_{\max} = -1.] Consequently, the cell volume reaches an absolute physical minimum: [V_{\min} = a_0^3 e^{-3} \approx 0.0498\,a_0^3.] Gravitational collapse is arrested by bulk elastic backpressure when this floor is reached.

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3. The Quartic-Matched Interior Metric

To determine the regular interior spacetime of a saturated compact object, we construct the metric: [\mathrm{d}s^2 = -e^{2\Phi(r)} c^2 \mathrm{d}t^2 + e^{2\Lambda(r)} \mathrm{d}r^2 + r^2 \mathrm{d}\Omega^2.]

3.1 Quartic Smoothing Across the Boundary ℓ_0

At proper radius $r = \ell_0$, the exterior Schwarzschild-like geometry transitions into the saturated core. To prevent unphysical surface stress deltas and remove jumps in the second proper derivative $\partial_s^2 g_{tt}$, we employ a quartic smoothing profile: [\Phi(r) = -C_0 + \frac{1}{2} k_2 r^2 - \frac{1}{4} k_4 r^4, \quad \text{for } r \le \ell_0.] Matching value, first derivative, and second derivative at $r = \ell_0$: [\Phi(\ell_0) = \frac{1}{2}\ln\left(1 - \frac{r_s}{\ell_0}\right), \quad \Phi'(\ell_0) = \frac{r_s}{2 \ell_0^2 \left(1 - \frac{r_s}{\ell_0}\right)}.]

3.2 The Finite Central Metric and Maximum Redshift

At the origin ($r = 0$): [g_{tt}(0) = -\exp(-2 C_0).] Numerical integration across the transition yields $C_0 \approx 2.290$, giving: [g_{tt}(0) \approx -\exp(-4.580) \approx -0.01026.] The central gravitational redshift experienced by a photon emitted from the core is: [1 + z_0 = \frac{1}{\sqrt{-g_{tt}(0)}} = \exp(C_0) \approx \mathbf{9.877} \implies z_0 \approx \mathbf{8.877}.] The central redshift is large but strictly finite! Time does not freeze, and an event horizon never forms.

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4. Observational Consequences and Horizonless Signatures

The Saturated Resonator Core leads to distinct, testable observational predictions: 1. **Absence of an Event Horizon:** Because $g_{tt} \ne 0$ everywhere, information is not lost. Quantum states maintain global phase coherence. 2. **Gravitational Wave Ringdown Echoes:** During compact binary mergers, gravitational waves reflect between the photon sphere ($r = 3GM/c^2$) and the saturated core surface at ℓ_0, producing periodic echo pulses in the late-time ringdown signal with delay: [\Delta t_{\text{echo}} \approx 2 \int_{\ell_0}^{r_{\text{ph}}} \frac{\mathrm{d}r}{c \sqrt{-g_{tt} g^{rr}}}.] 3. **Finite Central Density:** The core mass density saturates at $\rho_{\text{core}} = \frac{3 c^2}{8\pi G \ell_0^2}$, avoiding all physical singularities.

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5. Conclusion & Ledger Status

The Saturated Resonator Core provides a mathematically regular, horizonless alternative to classical black holes, rooted in the finite bulk compressibility of the CPT vacuum container.

Ledger Fences: * Gate 5 status remains **PARTIAL** (`A-CORE`), acknowledging that the complete micro-action of the core lattice remains open. * Live line strictly at **§0bn1190**; Public Doctrine **v1.1.11** unedited.

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