Quantum Collapse Gravity Series – Paper 7

Collapse Geometry Layer: The Phase-Resolved Structure Beneath Spacetime

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Abstract

In this continuation of the Quantum Collapse Gravity (QCG) framework, we introduce the **Collapse Geometry Layer (CGL)**: a unifying structure that formalizes how classical spacetime arises from recursive phase resolution of quantum states. This paper builds directly on prior QCG works which model curvature as emergent from collapse events, gauge constraints, and harmonic symmetry. Here, we show that the transformation from probabilistic wavefunction dynamics to classical geometry can be understood as a passage from e^{ix}-based complex phase evolution to $e^{i\pi}$-based discrete symmetry anchoring. We interpret spacetime geometry not as a fundamental manifold, but as the *informational residue* of collapse coherence.

1 Introduction

This paper forms the seventh installment in the Quantum Collapse Gravity series, following:

- Paper 1: Collapse as a source of emergent gravity
- Paper 2: Gauge-constrained modifications to General Relativity
- Paper 3: Transformation theory under collapse conservation
- Paper 4: Harmonic entropy and emergent structure
- Paper 5: Prime structure emergence from collapse constraints
- Paper 6: Quasicrystalline emergence via Penrose tiling and collapse

In this paper, we seek to integrate and formalize a new structural interpretation of collapse: as the *transition boundary* between pure phase evolution and classical reference frames.

2 Mathematical Framework

We define the core mathematical structures, operators, and quantities used throughout this paper. Let all functions and fields be defined on a Lorentzian spacetime with metric tensor $g^{\mu\nu}$, and assume units where $\hbar = c = 1$.

2.1 1. Quantum States and Phase Fields

- $\psi(x,t) = A(x,t)e^{i\phi(x,t)}$: A generic wavefunction with amplitude A and local phase field $\phi(x,t) \in \mathbb{R}$.
- $\phi(x,t)$: Phase field, interpreted as the rotational degree of freedom in complex Hilbert space.
- $\mathcal{H}$: Complex Hilbert space in which quantum states evolve.

2.2 2. Operator Formalism

- $\mathcal{U}(x) = e^{ix}$: Unitary evolution operator representing phase-encoded superposition prior to collapse.
- $\mathcal{C}(\psi) = e^{i\pi}$: Collapse operator that fixes phase into a symmetry-locked state, corresponding to topological constraint.
- $\mathcal{P}(e^{i\pi}) \in \mathbb{R}$: Projection operator mapping collapsed phase states into real-valued classical observables.

2.3 3. Collapse Condition Functional

- $\Phi[\psi] = |\nabla\phi(x,t)|^2 - \left|\langle\psi|\hat{O}|\psi\rangle\right|^2$: Functional that defines the collapse condition based on phase gradient tension.
- $\Phi[\hat{\Psi}] = g^{\mu\nu}\partial_\mu\phi\,\partial_\nu\phi - \left|\langle 0|\hat{\Psi}^\dagger(x)\hat{O}\hat{\Psi}(x)|0\rangle\right|^2$: Covariant field-theoretic extension of the collapse condition.
- $\hat{O}$: Hermitian operator representing an observable quantity (e.g., position, momentum, energy).
- ϵ: Collapse threshold constant beyond which classical projection is enforced.

2.4 4. Topological Collapse Geometry

- $G \in \{\mathrm{SU}(2), \mathrm{SO}(3), \ldots\}$: Symmetry group over which quantum states evolve.
- $J = \frac{\partial(x',y',z')}{\partial(x,y,z)}$: Jacobian matrix of the local phase-space transformation.
- Collapse occurs when: $\mathrm{rank}(J) < \dim(G)$: A topological degeneracy analogous to gimbal lock.

2.5 5. Recursive Collapse Lattice

- $C_n = (x_n, \phi_n, \rho_C(x_n))$: A discrete collapse node with location, resolved phase, and local collapse density.
- $\rho_C(x) = \sum_n \delta^4(x - x_n) + \sum_{m \neq n} f_{mn}(\phi_m, \phi_n)$: Collapse density field consisting of node deltas and phase-interference contributions.
- $f_{mn}(\phi_m, \phi_n)$: Interference kernel encoding resonant or repulsive behavior between phase states; properties may include symmetry or entropy-minimizing characteristics.

3 Conceptual Framework

3.1 The Two Worlds of Phase

- e^{ix}: Continuous, probabilistic, evolving phase field — describes **unitary evolution**, coherence, and wavefunction behavior.
- $e^{i\pi}$: Fixed, discrete, resolved phase anchor — represents **collapse**, topological fix-points, and symmetry invariants.

These represent two ontological layers:

- Generative: the wavefunction landscape of becoming
- Collapsed: the symmetry-locked, real-valued structure of being

3.2 Euler's Identity as Collapse Symmetry

Euler's identity:

$$e^{i\pi} + 1 = 0$$

demonstrates that even the deepest symmetry can resolve to zero — not by destruction, but by *perfect cancellation*. This is treated as a symbolic analogue of collapse: rotationally balanced phase reaching a symmetric attractor that terminates interference.

4 The Collapse Geometry Layer

4.1 Collapse as Projection

We propose that classical spacetime is a projected artifact of recursive quantum collapse. Collapse selects stable, phase-locked configurations that form the reference frame from which geometry emerges.

4.2 Collapse Curvature

Curvature becomes a function of collapse density:

- Flat space = uniform collapse frequency
- Curved space = locally variant collapse density

4.3 Transformation Limit and Gödel Boundary

Transformations are not mappings over a pre-existing continuum, but reparametrizations of collapsed phase topology. The inability to fully encode pre-collapse phase history defines a Gödelian limit — a hard boundary beyond which no complete self-description exists.

5 Topological Collapse Mechanism (TCM)

Collapse is modeled as a topological singularity in the configuration manifold of quantum phase space — analogous to **gimbal lock**.

Let the system evolve in a group manifold G (e.g., SU(2), SO(3)). Collapse occurs when:

$$\text{rank}(J) < \dim(G)$$

where $J = \frac{\partial(x', y', z')}{\partial(x, y, z)}$ is the Jacobian of the phase space transformation.

6 Collapse Condition Functional $\Phi[\psi]$

Collapse occurs when the internal phase gradient cannot be sustained:

$$\Phi[\psi] = |\nabla \phi(x,t)|^2 - \left| \langle \psi | \hat{O} | \psi \rangle \right|^2$$

Collapse is triggered when:

$$\Phi[\psi] \geq \epsilon$$

7 Operator Transitions: $e^{ix} \to e^{i\pi} \to \mathbb{R}$

Evolution Operator $\mathcal{U}(x) = e^{ix}$

Encodes unitary evolution of the wavefunction.

Collapse Operator $\mathcal{C}(\psi) = e^{i\pi}$

Applies symmetry constraints to lock the phase configuration.

Projection Operator $\mathcal{P}(e^{i\pi}) \in \mathbb{R}$

Projects the collapsed state into observable classical space.

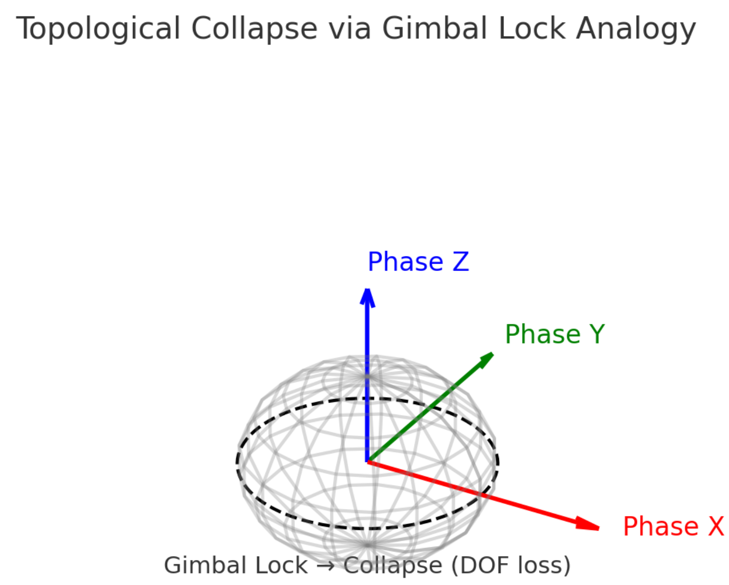

Figure 1: Topological Collapse via Gimbal Lock Analogy

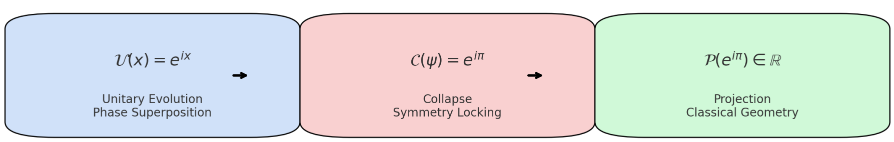

Figure 2: Operator Chain from Phase to Geometry

8 Field-Theoretic Embedding of $\Phi[\hat{\Psi}]$

Generalized to curved spacetime:

$$\Phi[\hat{\Psi}] = g^{\mu\nu}\partial_\mu\phi(x)\partial_\nu\phi(x) - \left|\langle 0|\hat{\Psi}^\dagger(x)\hat{O}\hat{\Psi}(x)|0\rangle\right|^2$$

Collapse condition remains:

$$\Phi[\hat{\Psi}] \geq \epsilon$$

9 Recursive Phase Lattice

Define collapse node:

$$C_n = (x_n, \phi_n, \rho_C(x_n))$$

Collapse density evolves via:

$$\rho_C(x) = \sum_n \delta^4(x - x_n) + \sum_{m \neq n} f_{mn}(\phi_m, \phi_n)$$

This models spacetime emergence as quasiperiodic phase alignment.

10 Comparison with Previous QCG Papers

- **Paper 1:** Collapse = source of gravity curvature
- **Paper 2:** Gauge constraint = topological restriction
- **Paper 3:** Coordinate conservation = symmetry of collapse mapping
- **Paper 4:** Harmonic entropy = phase minimization logic
- **Papers 5/6:** Penrose tiling and prime collapse = recursive interference lattice

11 Conclusion

The Collapse Geometry Layer recasts spacetime as a shadow — a residue of recursive phase collapse. With a defined collapse condition $\Phi[\psi]$, a topological constraint mechanism, and a recursive lattice of interference, this paper completes the formal architecture needed to unify QFT, GR, and emergent structure under one coherent quantum gravity framework.

References

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