Geometry-Induced Collapse as an Admissibility-Driven Transition Kernel:

A QCG Interpretation of Curvature-Induced Resonant Structure

Stephen Garner

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Abstract

Recent work has demonstrated that quantum particles constrained to curved geometries can exhibit collapse-like behavior, including infinite resonant states and logarithmic oscillations in the local density of states (LDOS)[1]. These phenomena arise from an effective inverse-square geometric potential induced by curvature.

In this note, we reinterpret these results within the framework of Quantum Collapse Geometry (QCG), showing that the observed dynamics constitute a concrete realization of a transition kernel defined over admissible relational configurations. The geometric potential is identified with an admissibility functional, the collapse states correspond to invariant sectors under collapse-selection dynamics, and the LDOS emerges as the spectral response of a collapse-induced kernel.

This perspective situates geometry-induced collapse as a special case of admissibility-driven selection, providing a bridge between curved-space quantum mechanics and the broader collapse-selection ontology of QCG.

1 Introduction

Quantum systems constrained to curved geometries can exhibit behavior that departs qualitatively from their flat-space counterparts. In particular, recent work has shown that motion on a truncated conic surface induces an effective inverse-square potential capable of generating collapse-like quantum states characterized by infinite resonances and oscillatory local density of states (LDOS).

These states resemble the phenomenon of atomic collapse, yet arise without Coulomb impurities or relativistic effects, suggesting that collapse-like behavior can emerge purely from geometric constraint.

The purpose of this note is to reinterpret these results within the framework of Quantum Collapse Geometry (QCG). Rather than treating collapse as a consequence of a specific potential, we identify the underlying structure as an instance of admissibility-driven selection acting on a constrained configuration space.

In this view, geometry does not induce collapse as an external mechanism, but defines a class of admissibility conditions under which collapse-selection dynamics generate invariant structure.

2 Configuration Space and Sector Structure

We consider a quantum particle constrained to a truncated conic surface characterized by parameters:

- sector angle $\alpha \in (0, 1)$,
- radial coordinate $\rho \geq \rho_0$,
- angular momentum $l \in \mathbb{Z}$.

The system defines a structured configuration space:

$$\mathcal{C}_{\alpha,l} = \{\text{radial configurations admissible under } \alpha, l, \rho_0\}.$$

This space naturally decomposes into sectors:

$$\mathcal{C} = \{C_{\text{bound}}, C_{\text{collapse}}, C_{\text{scatter}}, C_{\rho_0}, C_{\infty}\}.$$

These sectors correspond respectively to:

- bound states,
- collapse-like scattering states,
- conventional scattering states,
- boundary configurations,
- asymptotic configurations.

3 Geometric Potential as Admissibility Functional

The effective radial potential takes the form:

$$U_G(\rho) = \frac{\hbar^2}{2M} \frac{\tilde{\nu}^2}{\rho^2}.$$

We reinterpret this as an admissibility functional:

$$\Phi_{\alpha,l}(\rho) \text{ is induced by } U_G(\rho).$$

Under this interpretation:

- attractive potential $\Rightarrow$ admissibility basin,
- repulsive potential $\Rightarrow$ exclusion of configurations.

In particular:

- $l = 0$ yields an attractive sector (collapse-accessible),
- $l \neq 0$ yields repulsive sectors (conventional scattering).

Thus, geometry defines which configurations persist under iteration rather than simply how they evolve.

4 Finite Boundary and Collapse Regulation

The truncation condition:

$$\psi(\rho_0) = 0$$

removes the singularity at the conic apex.

In QCG terms, ρ_0 defines a finite admissibility boundary:

- preventing singular collapse,
- enforcing finite resolution,
- ensuring bounded persistence structure.

This realizes finite invariance at the level of physical configuration space.

5 Transition Structure and Kernel Representation

The classical trajectories of the system correspond to repeated transitions:

$$C_\infty \to C_{\text{collapse}} \to C_{\rho_0} \to C_{\text{collapse}} \to C_\infty.$$

These transitions define a kernel of the form:

$$T_{\alpha\beta}(E) = A_{\alpha\beta}(E) \exp[-\Gamma_{\alpha\beta}(E)] \exp(i\Theta_{\alpha\beta}(E)).$$

Here:

- $A_{\alpha\beta}$ measures accessibility of collapse channels,
- $\Gamma_{\alpha\beta}$ encodes escape (collapse leakage),
- $\Theta_{\alpha\beta}$ captures phase accumulation.

These transitions correspond to admissible pathways in configuration space rather than trajectories in a fixed geometric background.

This provides a direct physical realization of the QCG transition kernel.

6 Logarithmic Phase Structure

Near zero energy, the wavefunction exhibits oscillatory behavior of the form:

$$\sin(\tilde{\alpha} \ln E).$$

This corresponds to a phase term:

$$\Theta(E) \sim \tilde{\alpha} \ln E.$$

This logarithmic scaling implies:

- scale invariance,
- limit-cycle behavior,
- absence of a preferred energy scale.

These features identify the collapse states as belonging to a scale-invariant invariant family.

7 LDOS as Spectral Response

The local density of states is given by:

$$N(\epsilon, r) = \sum_l n_l(\epsilon, r).$$

where ϵ denotes the dimensionless energy corresponding to E. We reinterpret this as a spectral response:

$$N(\epsilon, r) \longleftrightarrow S_{\text{QCG}}(E).$$

The decomposition:

$$N = N_{\text{collapse}} + N_{\text{scatter}}$$

corresponds to:

- collapse-stable sectors,
- smooth background contributions.

The infinite oscillations in LDOS reflect:

$$|K_{\text{collapse}}(E)|^2,$$

the kernel contribution from collapse sectors.

8 Infinite Resonance Structure

The system exhibits an infinite set of resonant states:

$$E_n \to 0.$$

This corresponds to:

$$K(E) \sim \sum_n \frac{g_n^2}{E - E_n + i\Gamma_n}.$$

These states form a scale-invariant tower of metastable configurations.

9 Classical Interpretation

Classically, trajectories spiral inward toward the conic apex, reflect at ρ_0, and escape outward.

In QCG terms:

- inward motion = flow toward admissibility basin,
- reflection = boundary constraint,
- escape = collapse leakage.

Thus, classical motion traces admissibility gradients in configuration space.

10 Positioning Within the QCG Program

This note serves as a structural bridge within the QCG framework, connecting:

- B1: invariant structure as generative basis,
- B14: admissibility transport as a condition for observability,
- B10: transition kernel formulation.

The conic system provides a concrete realization of a collapse-induced admissibility landscape in which invariant families and spectral structure arise naturally from geometric constraint.

Forward Outlook. This perspective extends to large language models, where collapse-geometry transfer governs learning dynamics, and to ethics, where autonomy and responsibility emerge from admissibility and information transport across descriptive layers.

11 Conclusion

Geometry-induced collapse can be understood as a manifestation of admissibility-driven selection rather than as a consequence of geometry alone.

The curved surface defines a collapse class, within which invariant structure emerges through selection under constraint. The resulting spectral behavior provides a direct physical realization of the QCG transition kernel.

In this sense, geometry does not generate collapse, but specifies a constraint class within which collapse-selection dynamics produce observable structure.

References

[1] Li-Li Ye et al. "Geometry-induced wave-function collapse". In: *Physical Review A* 106.2 (Aug. 2022). ISSN: 2469-9934. DOI: 10.1103/physreva.106.022207. URL: http://dx.doi.org/10.1103/PhysRevA.106.022207.