Two Modes of Selection: Collapse vs Constraint Redistribution in Quantum Collapse Geometry

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Abstract

Recent analyses of geometry-induced quantum phenomena reveal two structurally distinct mechanisms by which stable spectral and dynamical structure emerges under constraint[1]. In one class of systems, instability leads to collapse-like behavior, producing localized invariant sectors such as resonant states and singular attractors. In another, constraint deformation induces asymmetric redistribution of spectral structure without explicit collapse events, yielding nonuniform scaling and unconventional thermodynamic behavior.

Within the framework of Quantum Collapse Geometry (QCG), we show that both mechanisms are unified as distinct realizations of selection under constraint. The first corresponds to collapse-dominant dynamics, in which instability drives configurations toward admissible invariant sectors. The second corresponds to constraint-driven redistribution, in which admissibility structure is deformed continuously, reshaping invariant sectors without singular collapse.

This distinction clarifies how collapse-selection manifests across physical systems, and establishes a dual-mode framework in which observable structure arises either through elimination of instability or redistribution of admissible persistence under constraint.

1 Introduction

Across physical systems, stable structure emerges through restriction of possible configurations under constraint. Within Quantum Collapse Geometry (QCG), this process is expressed as:

$$\Sigma \xrightarrow{\Phi} \mathrm{Fix}(\Phi) \xrightarrow{P} \mathcal{O},$$

where Σ is a relational configuration space, Φ a collapse-selection operator, and P a descriptive projection.

Previous work has identified collapse-like behavior arising from geometric constraint, producing resonant spectral structure and localized invariant sectors. More recent results demonstrate that geometry can also induce nonuniform spectral scaling through asymmetric level coupling, without requiring collapse-like instability.

The purpose of this note is to unify these observations within a single structural framework by identifying two distinct modes of selection under constraint:

1. collapse-dominant selection,
2. constraint-driven redistribution.

2 Collapse Classes and Invariant Structure

Let Σ denote a relational configuration space and let

$$\Phi : \Sigma \to \Sigma$$

be a collapse-selection operator.

The invariant sector is defined as:

$$\mathrm{Fix}(\Phi) = \{x \in \Sigma \mid \Phi(x) = x\}.$$

Observable structure arises through projection:

$$P : \Sigma \to \mathcal{O}.$$

Within this framework:

- admissibility defines which configurations persist,
- collapse eliminates incompatible configurations,
- invariant sectors define observable structure.

Different physical systems correspond to different collapse classes, defined by families of admissible dynamics and constraint structures.

3 Mode I: Collapse-Dominant Selection

3.1 Mechanism

In collapse-dominant systems:

$$\text{constraint} \to \text{instability} \to \text{collapse} \to \text{invariant sector}.$$

with instability corresponding to violation of admissibility under the constraint structure.

Configurations violating admissibility are dynamically suppressed, producing:

- singular behavior,
- resonant structures,
- attractor basins,
- accumulation points.

3.2 Example: Geometry-Induced Collapse

In curved-space quantum systems, inverse-square potentials induce collapse-like dynamics:

- inward spiraling trajectories,
- infinite resonant states,
- logarithmic spectral oscillations.

These correspond to collapse toward admissibility boundaries and formation of metastable invariant sectors.

3.3 QCG Interpretation

Collapse-dominant systems exhibit:

- explicit collapse trajectories in configuration space,
- formation of localized invariant sectors,
- strong selection through instability elimination.

4 Mode II: Constraint-Driven Redistribution

4.1 Mechanism

In redistribution-dominant systems:

$$\text{constraint deformation} \rightarrow \text{admissibility redistribution} \rightarrow \text{reweighted invariant sectors.}$$

Configurations are not eliminated but reweighted under changing constraints.

4.2 Example: Geometry-Induced Asymmetric Level Coupling

In systems undergoing size-invariant shape transformations:

- ground-state energy and energy gap evolve in opposite directions,
- spectral structure shifts nonuniformly,
- thermodynamic behavior deviates from classical expectations.

These effects arise without singular collapse.

4.3 QCG Interpretation

Let γ be a control parameter. Then:

$$\Phi_\gamma : \Sigma \rightarrow \Sigma$$

where γ parametrizes a deformation of admissibility constraints rather than an independent dynamical input.

defines a deformation of admissibility structure.

The invariant sector transforms as:

$$\mathrm{Fix}(\Phi_\gamma) \neq \mathrm{Fix}(\Phi),$$

through redistribution rather than collapse.

Observable structure becomes:

$$P(\mathrm{Fix}(\Phi_\gamma)).$$

5 Unified Interpretation

Both modes arise from:

$$\text{Configuration Space} \rightarrow \text{Constraint} \rightarrow \text{Selection} \rightarrow \text{Persistence.}$$

5.1 Structural Distinction

Feature	Collapse-Dominant	Constraint Redistribution
Driver	Instability	Constraint deformation
Selection	Elimination	Reweighting
Dynamics	Collapse trajectories	Smooth deformation
Signature	Resonances, singularities	Asymmetric scaling
Invariant sector	Formed via collapse	Reshaped continuously

6 Projection and Descriptive Structure

Observables arise through:

$$P : \Sigma \to \mathcal{O}.$$

In redistribution systems, descriptive quantities may behave non-intuitively because projection acts on a reweighted invariant sector.

This explains phenomena such as:

- spontaneous transitions to lower entropy states,
- nonuniform thermodynamic behavior.

These effects arise from projection of constraint-deformed admissibility structure.

7 Relation to Invariant Families

Invariant families provide the appropriate abstraction across collapse classes.

- Collapse-dominant systems isolate invariant sectors through instability,
- Redistribution systems reshape invariant families through constraint deformation.

Physical law corresponds to invariant relational structure preserved across admissible collapse dynamics.

8 Conclusion

We identify two distinct modes of selection under constraint:

1. collapse-dominant selection,
2. constraint-driven redistribution.

Both arise naturally within the collapse-selection ontology of QCG and represent complementary mechanisms of structure formation.

Collapse-selection determines which configurations persist, while constraint deformation determines how invariant structure is distributed within admissible sectors and subsequently observed under projection.

Positioning Within the QCG Program

This note extends the collapse-class framework by distinguishing two modes of admissibility-driven selection. It complements prior work on invariant families, transition kernels, and admissibility transport, and clarifies how different physical systems instantiate selection under constraint.

Forward Outlook

This dual-mode framework provides a basis for identifying collapse-class behavior across physical systems and distinguishing between instability-driven selection and constraint-driven redistribution in future applications.

References

[1] Alhun Aydin. "Geometry-induced asymmetric level coupling". In: *Physical Review E* 112.1 (2025), p. 014121.