Toward a Continuous Formulation of Collapse-Selection Dynamics

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Abstract

Previous notes introduced collapse-selection dynamics as a discrete operator acting on relational configurations. These constructions demonstrated interference structure, measurement outcomes, statistical behavior, and admissibility structure in minimal systems. In this note, we extend the collapse operator to a continuous setting by defining it over a phase field. We show that, in the local limit, the collapse operator induces behavior consistent with a smoothing flow that reduces phase variation, yielding dynamics analogous to diffusion or relaxation processes. This provides a minimal step toward a field-level formulation of collapse-selection dynamics.

1 Introduction

In previous notes, the collapse operator Φ was defined on discrete relational configurations and shown to drive systems toward stable fixed-point sectors through local interaction rules.

A natural question is whether this structure admits a continuous formulation. Specifically:

> How does collapse-selection dynamics act on a continuous field of relational configurations?

The aim of this note is to define a continuous version of the collapse operator and examine its local behavior.

2 Continuous Phase Field

We consider a phase field:

$$\theta(x,t), \quad x \in \mathbb{R}^n \tag{1}$$

where θ represents a relational phase-like variable defined over space.

3 Continuous Collapse Operator

We define a continuous analog of the collapse operator:

$$\Phi[\theta](x) = \arg\left(\int K(x,x')e^{i\theta(x')}\,dx'\right) \tag{2}$$

where $K(x,x')$ is a kernel representing local coupling between configurations.

The specific form of $K(x,x')$ is not fixed and may encode interaction range or weighting of neighboring configurations.

3.1 Local Interaction

We assume that $K(x, x')$ is localized, such that the integral is dominated by contributions from a neighborhood of x.

Thus, the operator Φ acts as a local averaging rule over nearby phases.

4 Local Expansion

To understand the behavior of Φ, we consider a local expansion of the field around x:

$$\theta(x') \approx \theta(x) + (x' - x) \cdot \nabla\theta(x) + \frac{1}{2}(x' - x)^T H(x)(x' - x) \tag{3}$$

where $H(x)$ is the Hessian of θ.

Substituting into the collapse operator and assuming a symmetric kernel K, the first-order term vanishes, and the leading correction arises from second-order contributions. This expansion suggests that local curvature of the phase field governs the leading-order behavior of the collapse operator.

5 Effective Dynamics

Under repeated application of Φ, the field evolves in a manner consistent with reduction of local phase variation.

In the small neighborhood limit, this behavior can be approximated by:

$$\partial_t\theta \text{ is consistent with } \nabla^2\theta \tag{4}$$

This corresponds to a diffusion-like or smoothing process.

6 Interpretation as Field Dynamics

The continuous collapse operator induces a local smoothing flow on the phase field:

- regions of high phase variation are reduced,
- the field evolves toward configurations of lower gradient,
- stable configurations correspond to low-variation or constant-phase states.

This provides a physically interpretable picture of collapse as a relaxation process in a field.

7 Relation to Known Dynamics

The resulting dynamics resemble several known processes:

- diffusion equations,
- phase ordering dynamics,
- relaxation toward equilibrium configurations.

This suggests that the collapse operator shares structural features with familiar classes of field evolution, though no specific identification is made here.

8 Finite Invariance in the Continuum

In previous notes, collapse was constrained by finite invariance, limiting resolution of distinctions.

In the continuous setting, this corresponds to:

- finite spatial resolution,
- coarse-graining scale,
- limits on distinguishability of field variations.

As a result, collapse dynamics do not necessarily produce perfectly uniform fields, but rather structured configurations at finite resolution.

9 Interpretation

9.1 Collapse as Smoothing Flow

In the continuum limit, the collapse operator admits interpretation as a local smoothing flow on relational phase fields, analogous to diffusion or relaxation dynamics.

9.2 Relation to Discrete Model

The continuous formulation recovers the qualitative behavior of the discrete collapse operator, replacing discrete averaging with spatial integration.

9.3 Scope

This construction does not constitute a full field theory. It provides only a minimal extension of the collapse operator to continuous systems.

10 Limitations and Open Questions

This construction is intentionally minimal and leaves several open questions:

- whether a fully consistent field-theoretic formulation can be derived,
- how collapse dynamics interact with known physical laws,
- whether additional structure is required to recover quantum behavior in continuous systems.

Future work will explore these questions.

11 Conclusion

We have extended the collapse operator to a continuous phase field and shown that, in the local limit, it induces a smoothing flow analogous to diffusion. This provides a minimal step toward a field-level formulation of collapse-selection dynamics and suggests that the abstract collapse operator may admit a natural interpretation in terms of local field interactions.