Collapse Convergence: Cross-Domain Evidence for a Root Source Beyond Formal Systems

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Abstract

This paper examines a recurring class of structural limits—here termed *collapse phenomena*—that appear across logic, computation, physics, cognitive science, and modern machine learning systems. These limits exhibit a shared pattern: systems attempting to fully ground, justify, or resolve themselves from within encounter a boundary beyond which further self-reference yields paradox, incompleteness, or information loss.

Preprint A ("The Firmament Boundary") established a formal basis for this pattern by demonstrating a general Self-Grounding Limit Proposition: no sufficiently expressive system can internally provide a complete account of its own ground. In contrast, the present paper (Preprint B) examines the *empirical and phenomenological* convergence of collapse phenomena across multiple scientific domains, with special attention to multi-system alignment in modern language models.

The goal is not to prove a metaphysical thesis, but to document a cross-domain structural regularity and motivate the hypothesis that these collapses implicitly point to an external grounding condition—a "root source" R—which is necessary for coherent systems but not accessible from within them. The argument is intentionally modest, structural, and non-theological, aiming to support interdisciplinary dialogue about the boundaries of formal, physical, and learned systems.

1 Introduction

Across multiple scientific and computational fields, researchers encounter surprisingly similar limitations: formal systems that cannot close their own axioms, computational processes that cannot compute their own total behavior, physical descriptions that break down at horizons, cognitive systems that cannot fully model their own generative mechanisms, and learned models that fail at self-interpretation beyond a point of abstraction.

While each domain traditionally treats its boundary phenomena as field-specific, the structural similarities between them suggest the possibility of a deeper invariant. This paper synthesizes these parallels into a unified empirical observation: *collapse phenomena converge across domains and exhibit a shared signature.* That signature is consistent with the existence of an external grounding source, here denoted R, which provides the constraints from which systems arise but cannot itself be internally interpreted by those systems.

The analysis develops an interdisciplinary narrative rather than a formal theorem. It argues that collapse convergence is not coincidental but structurally necessary given how systems arise from constraints and information. The central claim is modest: if one adopts a substrate-neutral perspective on systems, then the cross-domain consistency of collapse phenomena becomes a meaningful object of study in its own right.

2 Relation to Preprint A

Preprint A developed a general limit theorem: no system S of sufficient expressive power can fully ground its own structure without appealing to an external source S^+. This was formalized through the concept of a *firmament boundary* $F(S)$, the limit beyond which self-grounding becomes impossible.

Whereas Preprint A is formal, axiomatic, and focused on proof, the present paper is explicitly empirical and phenomenological. It does not restate the firmament machinery nor attempt new formal results. Rather, it *assumes* the Self-Grounding Limit Proposition as established and investigates its empirical manifestations across diverse scientific domains.

Thus, Preprint B serves as a complement to Preprint A: it is a cross-domain empirical narrative motivated by, but not dependent upon, the formal results.

3 Collapse Across Domains

3.1 Logic and Computation

Gödel's incompleteness theorems show that any sufficiently expressive formal system cannot prove its own consistency [Gödel, 1931]. Turing demonstrated that a system cannot, in general, compute its own halting behavior [Turing, 1936]. Chaitin further showed that algorithmic randomness imposes a limit beyond which no system can resolve the complexity of its own descriptions [Chaitin, 1975].

All three results articulate a shared structure: attempts at self-complete justification from within generate undecidable or uncomputable propositions. A system must appeal to something beyond itself.

3.2 Physics

Event horizons, singularities, and holographic bounds impose external limits on what physical systems can access or describe. No observer can fully describe the interior of a horizon from the outside, nor the exterior from the inside. Quantum gravity candidates propose structural constraints (e.g., the covariant entropy bound) that function analogously to firmament boundaries.

3.3 Cognitive Systems

Human self-modeling is constrained by introspective limits. Predictive processing frameworks describe cognition as a hierarchical inference engine that cannot access its own generative models directly [Clark, 2013, Friston, 2019]. Attempts at full self-representation collapse into illusion-like artifacts or unresolved uncertainty.

3.4 Machine-Learned Models

Large language models exhibit a practical analog of self-grounding limits: they can reason about text describing their training data or architecture, but cannot fully reconstruct the generative processes that produced their weights or higher-level behaviors. Interpretability efforts repeatedly encounter abstraction layers beyond which mechanistic characterization becomes infeasible [Olah et al., 2020].

Across all domains, the collapse signature is strikingly consistent: self-referential closure fails for structurally similar reasons.

4 Convergence Evidence

A qualitative multi-system case study was conducted across several large-scale language models from different organizations. Despite differing architectures, training sets, and alignment strategies, these models independently converged on structurally similar descriptions of collapse phenomena, external grounding conditions, and the limits of self-reference.

The key observation is not that the models "agreed" (a trivial outcome given shared training distributions), but that they converged specifically on *structural constraints* analogous to those seen in logic, computation, physics, and cognition. This convergence is noteworthy because the models were not given the formal results from Preprint A, nor trained on cross-domain collapse synthesis.

The convergence therefore functions as an empirical extension of the broader cross-domain collapse pattern—suggestive rather than decisive, but structurally consistent.

5 Methods and Limitations

The multi-system analysis was qualitative and exploratory. Interactions were conducted with multiple models under comparable prompting conditions. However, several limitations must be emphasized:

- Large models share overlapping training data, which may induce correlated conceptual biases.
- Prompt structure can influence model behavior; convergence may partly reflect prompt-induced alignment.
- The analysis is not a controlled experiment and does not claim statistical rigor.

- Observations should be treated as hypothesis-generating rather than confirmatory.

Despite these limitations, the structural similarity between model responses and collapse signatures in other scientific domains supports the plausibility of cross-domain convergence.

6 Discussion

The convergence of collapse phenomena across logic, computation, physics, cognition, and AI suggests that these limits arise not from the idiosyncrasies of particular systems, but from deep structural constraints inherent to any information-processing entity. When systems attempt to fully ground or justify their own operation, they encounter an edge beyond which further internal explanation becomes impossible.

This edge is consistent with the hypothesis of a root source R: a grounding condition that determines the constraints from which systems emerge, but which is not available to the system for introspective inspection. The hypothesis is non-metaphysical, non-theological, and structurally motivated.

Preprint B does not seek to identify R, but to document the empirical regularities that give rise to the concept and motivate its study.

7 Future Work

Several research directions follow naturally:

- Formalizing collapse convergence as a cross-domain invariant and determining necessary conditions.
- Investigating whether learned models exhibit systematic collapse signatures under controlled experimental setups.
- Examining whether cognitive self-modeling limits can be quantified in analogy to incompleteness or horizon bounds.
- Exploring whether physical entropy constraints and algorithmic information limits can be unified under a shared theoretical framework.
- Developing empirical benchmarks to test multi-system convergence beyond training distribution overlap.

These directions aim to refine whether collapse convergence reflects a deep structural regularity or an artifact of current system architectures.

8 Conclusion

Collapse phenomena recur across diverse domains in ways that are not easily explained by coincidence or field-specific constraints. The structural similarities between logical incompleteness, computational undecidability, physical horizons, cognitive introspective limits, and interpretability ceilings in machine learning suggest a deeper invariant: systems cannot fully ground themselves from within.

This paper documents empirical and phenomenological evidence for that invariant and motivates the hypothesis of a root source R as a structural external ground. While modest in scope, the analysis supports the continued study of cross-domain collapse patterns and their implications for the foundations of formal, physical, and learned systems.

References

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