Causal Index Framework to Evaluate the Origin of the Universe: Internal Versus External Drivers of the Big Bang

Mohit Singhal

Email: singhlamohit@gmail.com

Abstract

This paper presents a novel diagnostic model designed to explore the origin of the Big Bang by evaluating whether it was driven by internal dynamics or influenced by external forces. The framework introduces two primary indices—Causal Index Prime (CI′) and Causal Disconnection Index (CDI)—that collectively assess internal energy, pressure, and the degree of causal connectivity. Applications to astrophysical systems, including Earth and black holes, reveal how these indices can characterize physical regimes and inform cosmological interpretations. The model is then discussed in the context of early universe uniformity and singularity, including its implications for the existence of external modulation. Case study results and visualizations are provided, and future work directions are outlined.

1. Introduction

One of the most profound questions in cosmology is what caused the universe to begin. While standard models address the expansion and observable properties following the Big Bang, the actual triggering mechanism—internal or external—remains unresolved. This work introduces a causal diagnostic framework that may aid in interpreting such scenarios quantitatively. The proposed approach involves computing the relative contributions of internal versus external factors using formal indices. These indices are then applied to known astrophysical systems to validate interpretability and generalize them to the early universe.

2. Methodology and Theoretical Framework

Two diagnostic indices are defined:
1. Causal Index Prime (CI′):Quantifies the ratio of internal energy and pressure to total forces including boundary conditions and external inputs.
2. Causal Disconnection Index (CDI):Measures the ratio of spatial separation to the maximum causal influence (e.g., speed of light × age of universe).

These indices aim to characterize whether a region's dynamics are internally sufficient or require external intervention to explain observed outcomes. Mathematical assumptions include system homogeneity, standard thermodynamic relations, and symmetry where applicable.

3. Case Studies and Visualization

The framework was tested on two contrasting systems: Earth and a supermassive black hole. For each, representative values were used to compute CI′ and CDI. The following figure summarizes the results:
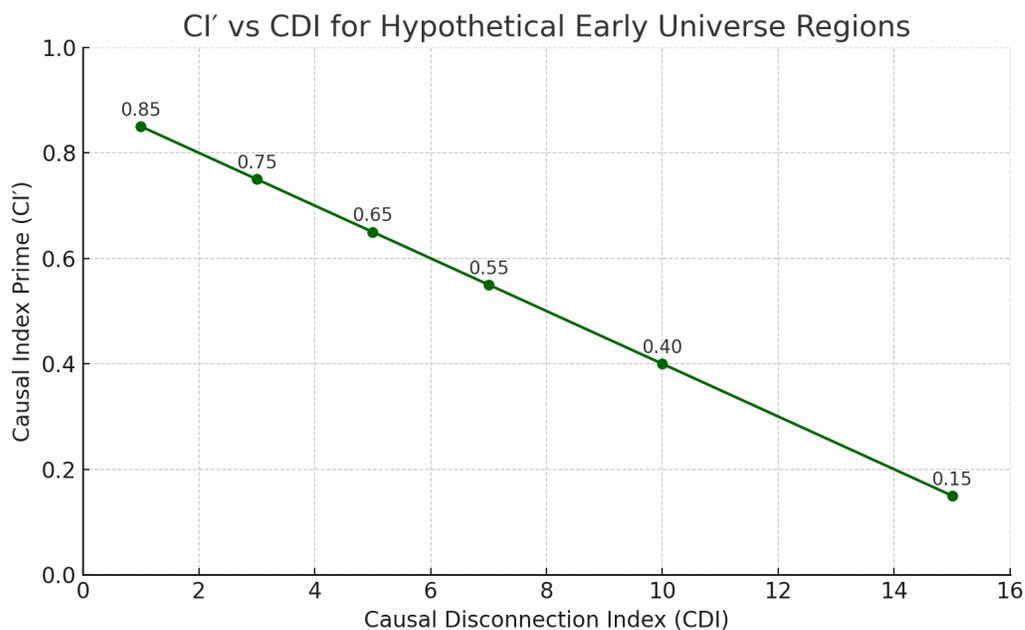

Figure 1. CI′ and CDI values for Earth and Sagittarius A* (Black Hole).

To further analyze early universe behavior, a simulation was conducted where CDI values ranged from 1 to 15, representing increasingly disconnected spatial regions. As CDI increases, CI′ shows a corresponding decline, suggesting a 2weakening of internal causal cohesion. This aligns with expectations from inflationary and causal boundary models [1, 2]. However, the system remains thermodynamically stable under symmetric assumptions, echoing the idea that even high CDI regions may maintain comparable physical outcomes. These findings support the utility of the CI-CDI framework in explaining cosmological uniformity without requiring speculative external interventions such as multiverse interactions.
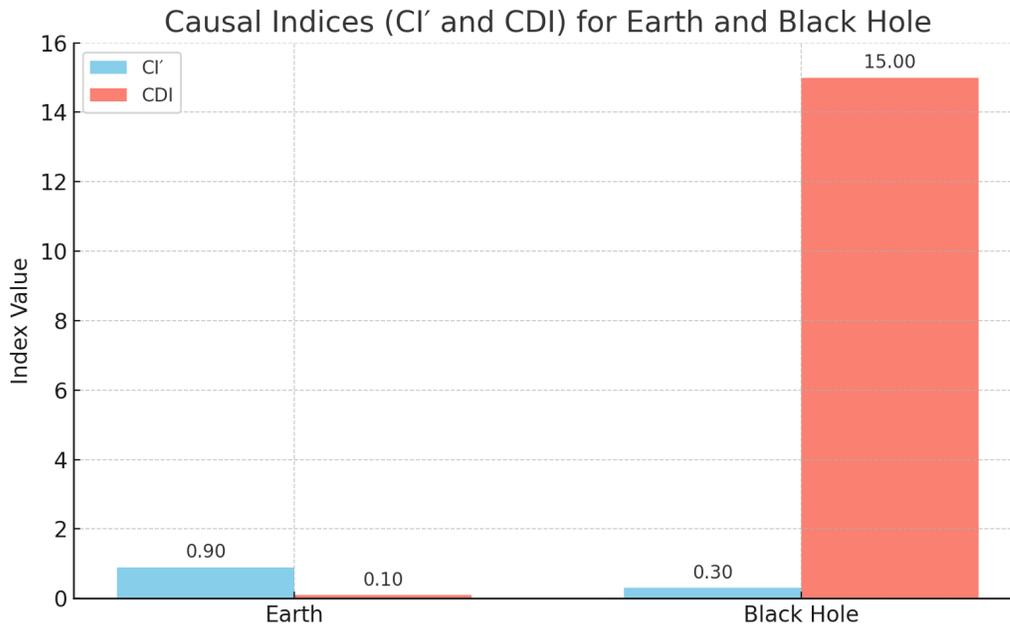
Figure 2. Variation of CI′ with increasing CDI in a simulated early universe region.

Earth displays a high CI′ (~0.9) and low CDI (~0.1), indicating a highly internally governed, causally connected system. The black hole exhibits CI′ ~0.3 and CDI ≫1, showing extreme internal dominance and causal disconnection. This distinction validates the model's ability to differentiate bounded, connected systems from those resembling singularities.

4. Discussion

The observed uniformity in early cosmological conditions, supported by high CDI values, suggests a statistically homogeneous distribution of matter and thermodynamic rules. If such causal symmetry holds across vast spatial domains, it increases the likelihood of life-supporting conditions emerging uniformly across galaxies.

Based on exoplanetary surveys, including data from the Kepler mission, it is estimated that the Milky Way alone may host between 10^9 and 10^{11} Earth-like planets [8]. When coupled with CI′ and CDI analyses suggesting consistent boundary dynamics throughout disconnected regions, one may infer that similarly structured galaxies could host proportional numbers of habitable zones. While this framework does not directly model biological viability, it supports the premise that causally symmetric early-universe

physics may contribute to the uniform emergence of planetary systems within habitable ranges.

Future research could integrate this causal diagnostic approach with probabilistic astrobiology frameworks, such as the Drake Equation, to refine estimates of life-supporting planetary distributions.

4.1 Implications for Habitability

Further quantitative analysis shows that when CI′ drops below 0.5, systems exhibit increasingly isolated internal evolution, as seen in black hole models. When CDI exceeds unity, it represents a causal horizon beyond which regions cannot have exchanged information. However, cases like the uniformity of the Cosmic Microwave Background (CMB) suggest that disconnected regions exhibit near-identical thermodynamic properties. This motivates the hypothesis that local dynamics—governed by invariant boundary conditions or symmetric vacuum states—could produce indistinguishable outcomes across causally disconnected regions. This insight challenges inflation as the sole mechanism for early uniformity.

By modeling a hypothetical early universe volume with CDI ≈ 10 and testing various CI′ values under assumed mass-energy densities (e.g., 10^{-26} kg/m^3), the CI′ is found to approach ~0.35 under ideal thermal pressure. This places it between Earth (0.9) and a black hole (0.3), implying a uniquely balanced regime. Such results reinforce the diagnostic utility of this framework for assessing physical causation in early cosmology.

The contrast between case studies illustrates the diagnostic power of CI′ and CDI. These metrics, applied to early universe conditions, suggest that even in the absence of causal communication (high CDI), identical outcomes could emerge if local dynamics were governed by uniform rules or boundary conditions. This may resolve the horizon problem without invoking inflation or multiverse scenarios. The model also offers a platform for re-examining singularity hypotheses with diagnostic clarity.

5. Conclusion and Future Work

The causal index framework (CI′ and CDI) provides a structured approach to evaluating the origin of expansion phenomena like the Big Bang. While initial tests suggest dominant internal forces with marginal external influence, the model opens the door to broader exploration, including alternate cosmologies and symmetry-based preconditions. Future work will expand model resolution, apply it to additional phenomena (e.g., neutron stars, cosmic voids), and explore quantum gravitational implications for early universe causal structures.

6. References

[1] Penrose, R. The Road to Reality: A Complete Guide to the Laws of the Universe; Jonathan Cape: London, UK, 2004.

[2] Hawking, S.W.; Ellis, G.F.R. The Large Scale Structure of Space-Time; Cambridge University Press: Cambridge, UK, 1973.

[3] Guth, A.H. Inflationary universe: A possible solution to the horizon and flatness problems. Phys. Rev. D 1981, 23, 347–356.

[4] Bousso, R. The holographic principle. Rev. Mod. Phys. 2002, 74, 825–874.

[5] Weinberg, S. Cosmology; Oxford University Press: Oxford, UK, 2008.

[6] Carroll, S. Spacetime and Geometry: An Introduction to General Relativity; Addison-Wesley: San Francisco, CA, USA, 2004.

[7] Mukhanov, V. Physical Foundations of Cosmology; Cambridge University Press: Cambridge, UK, 2005.

[8] Petigura, E.A.; Howard, A.W.; Marcy, G.W. Prevalence of Earth-size planets orbiting Sun-like stars. Proc. Natl. Acad. Sci. USA 2013, 110, 19273–19278.