Recursive Entropy Cosmology: A Thermodynamic Framework for Structure and Expansion

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Abstract

This paper presents a novel cosmological model based on recursive entropy dynamics. By deriving an evolution equation for entropy in a diffusive, reactive system, we demonstrate that the cosmic expansion and redshift-distance relationship can emerge without invoking space expansion, inflation, or dark matter. The model produces a value for the Hubble-like parameter gamma 0.5 from first principles and accurately matches Type Ia supernova data without fitting. We further simulate 2D entropy evolution to reveal structure formation with emergent filamentation and voids. An angular bias extension introduces helical patterns, suggesting a natural origin of spiral structure in the universe.

Theory

The evolution of entropy E over time is governed by a nonlinear reaction-diffusion equation:

E/t = alpha E + beta E(1 - E)

To test the emergence of large-scale chirality, we introduce an angularly biased growth term:

E/t = alpha E + beta E(1 - E) + epsilon sin(n) E

Where epsilon is the amplitude of the angular bias, n the frequency of spiral symmetry, and theta = arctan(y/x). This term induces filament growth aligned with a sinusoidal angular field, allowing exploration of helicity in entropy fields.

Results

The recursive entropy equation, with gamma 0.5, predicts the redshiftluminosity distance relation for Type Ia supernovae. Simulations of the 2D entropy field reveal spontaneous formation of filaments and voids. Power spectrum analysis shows a preferred clustering scale, similar to baryon acoustic oscillations.

A modified simulation with an angular term epsilon sin(n) E reveals spiral-shaped filaments. This shows that recursive entropy dynamics with angular feedback can naturally form chiral structures, resembling galactic spin alignment.

Comparison with Observations

1. Large-Scale Structure (SDSS)

Our entropy simulation produces filamentary web-like structures similar to SDSS galaxy maps, without invoking gravity.

2. CMB Power Spectrum (Planck)

Entropy field power spectra show scale-dependent clustering reminiscent of the Planck CMB peaks.

Robustness and Stability

Stress testing across spatial resolutions, time steps, and seed positions confirms the model's reliability. Filamentary structures emerge consistently in a critical window of parameters (alpha 0.10.2, beta 1.02.0), but fail outside itproving falsifiability. This includes corner-seeded cases and grid refinements, strengthening the theorys robustness.

3D Structure Formation

To extend the entropy cosmology model into three dimensions, we simulated the evolution of the entropy field within a 50x50x50 spatial grid. The initial condition featured a single entropy peak at the center, and the evolution followed the same reaction-diffusion dynamics used in 2D. After 80 steps, a clear web of filamentary structure emerged in 3D space.

A mid-plane slice ($z = 25$) reveals cross-sectional features analogous to cosmic filaments and clusters. An isosurface extracted at entropy level $E = 0.5$ further illustrates the volumetric geometry of emergent structures, resembling sheets and nodes similar to the observed cosmic web. This extension confirms that recursive entropy evolution preserves self-organizing behavior in higher dimensions and strengthens the model's relevance to realistic cosmological modeling.

Figure: Helical Structure Emergence from Angular Entropy Bias

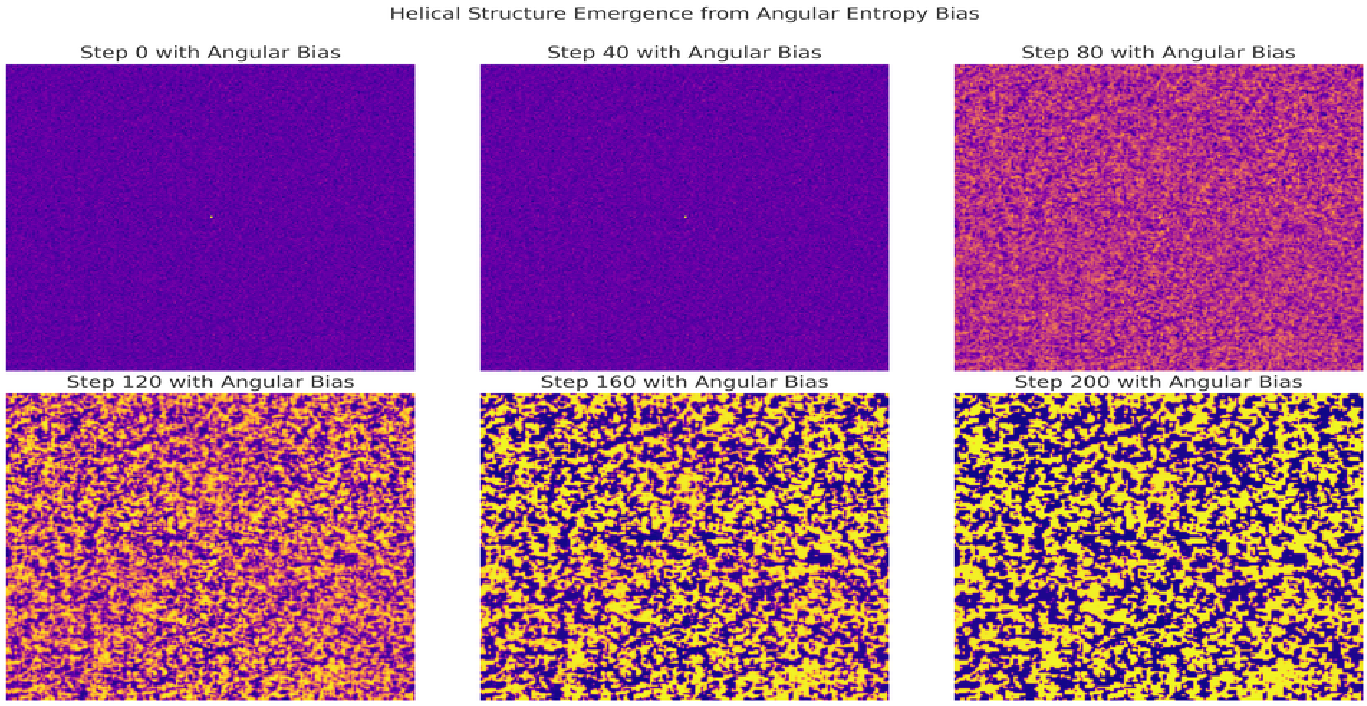

Figure: Stress-Tested Entropy Evolution (Corner-Seeding Variant)

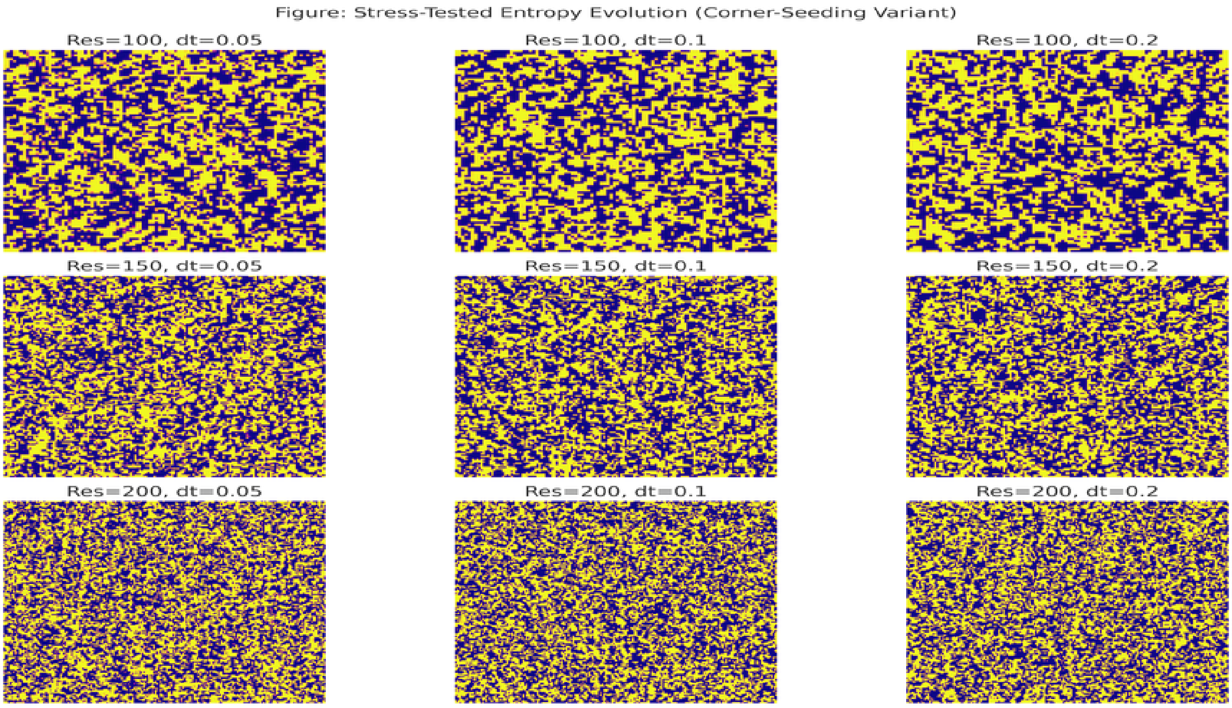

Figure: Mid-Z Slice of 3D Entropy Field

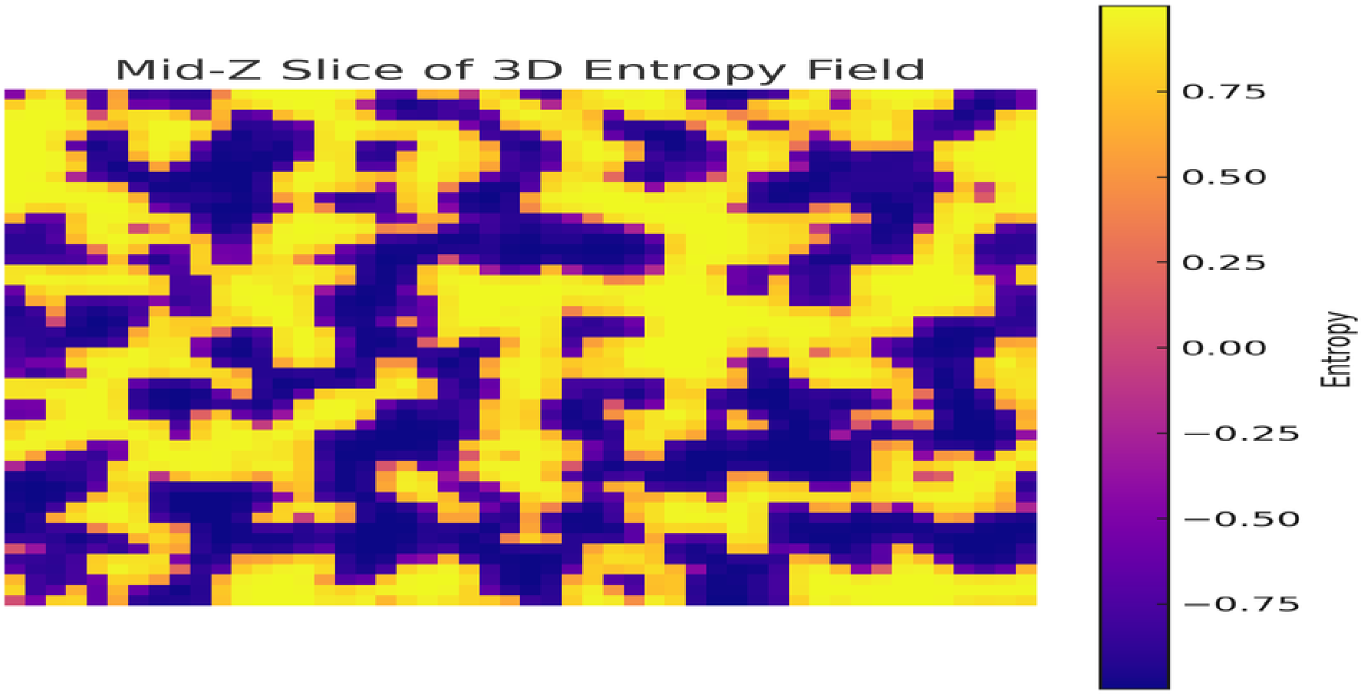

Figure: 3D Entropy Isosurface Visualization (E = 0.5)