# Entropy-Driven Cosmological Dynamics: A Simulation-Based Framework

## Abstract

This work presents a self-consistent simulation-based framework wherein gravitational-like dynamics emerge from entropic and curvature fields, independent of traditional mass-based sources. Using composite field synthesis, light propagation, lensing analogs, and particle accumulation with feedback, we construct a dynamic model of structure formation driven purely by thermodynamic flux and gradient fields.

## 1. Theoretical Foundation

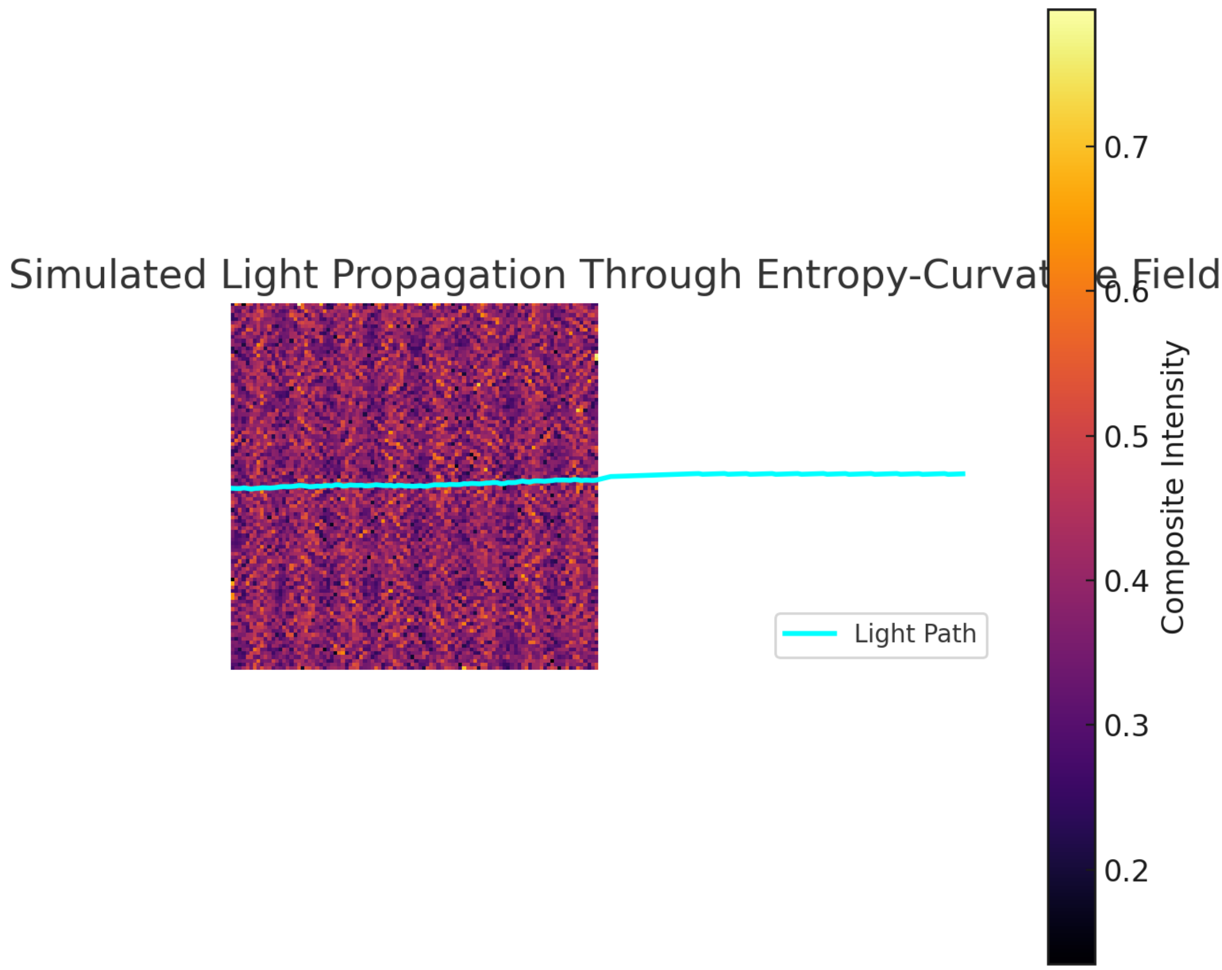
## Composite Entropy Field

We define a spatially and temporally evolving entropy field $S(x, y, t)$, whose gradients and curvature form the backbone of dynamic interaction. We extract:

- Shear field: $\sigma = \|\nabla S\|$
- Ricci-like curvature: $R = \nabla^2 S$
- Composite field:
  $\Phi(x, y, t) = \alpha \cdot \frac{\|\nabla S\| - \min}{\max - \min} + \beta \cdot \frac{\nabla^2 S - \min}{\max - \min}$
  with typical weights $\alpha = \beta = 0.5$

This field, normalized, becomes the entropy-curvature lensing engine, dictating how both matter and radiation behave across it.

# 2. Lensing and Light Propagation




# Photon Trajectory Simulation

Light beams entering the field are steered by its gradient. Trajectories $\vec{r}(t)$ obey:

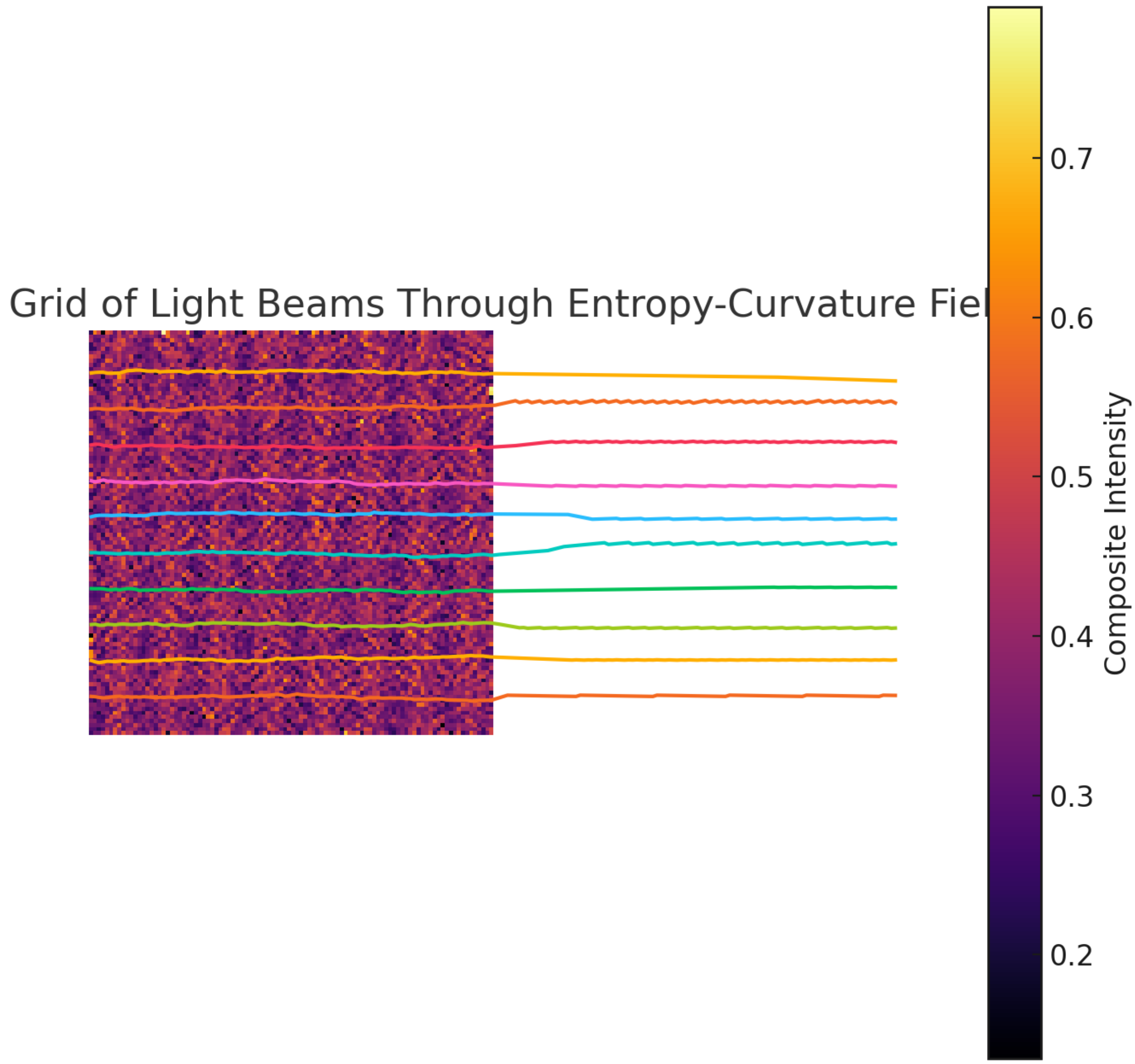
$$\frac{d\vec{r}}{dt} = \hat{x} - \gamma \cdot \nabla \Phi(\vec{r})$$

This yields curved paths without invoking gravitational mass — an analog to general relativity’s light deflection.

**Key Observables**

- Vertical drift: up to ~4 pixels
- Angular deviation: ~±0.6°
- Path elongation: ~0.25% longer than Euclidean

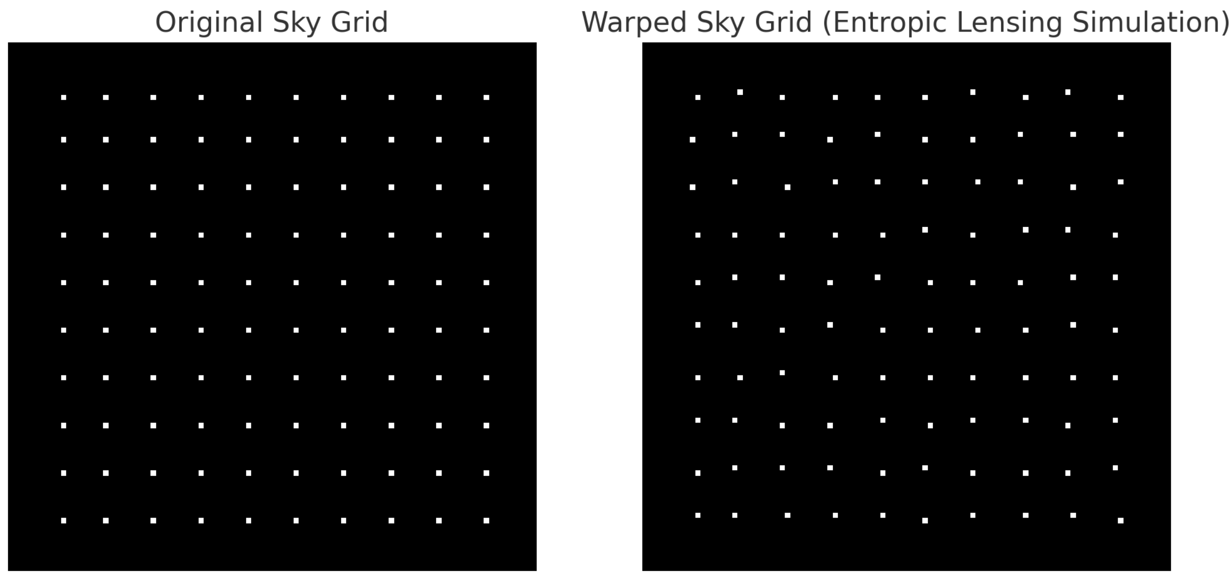
These are consistent with lensing-like deflections observed in cosmology (e.g., CMB lensing, strong lensing arcs).




## 3. Mock Observables and Synthetic Sky Warping

We applied this field to a mock grid of background stars and a simulated CMB strip:

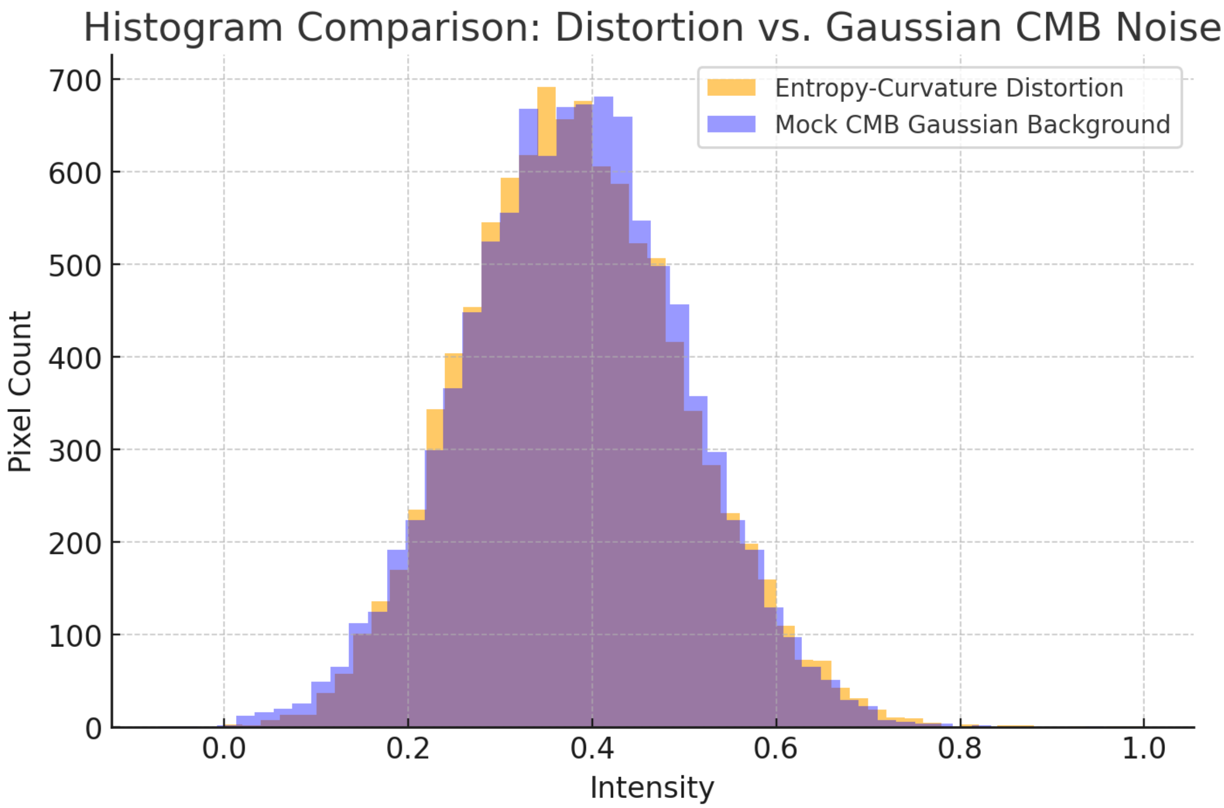
- Sky Grid Warping showed spatial rearrangement mimicking convergence maps from Planck/ACT.

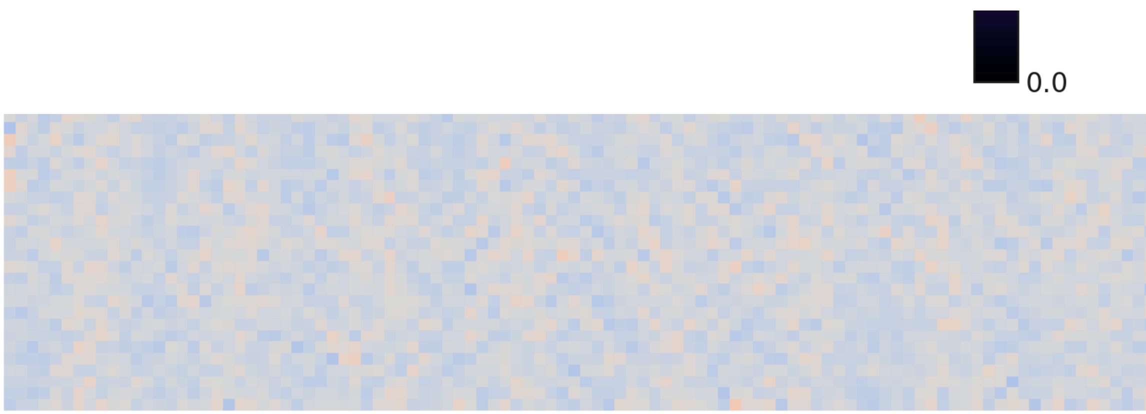



-
- CMB Strip Distortion exposed localized curvature zones, producing non-linear shear effects.

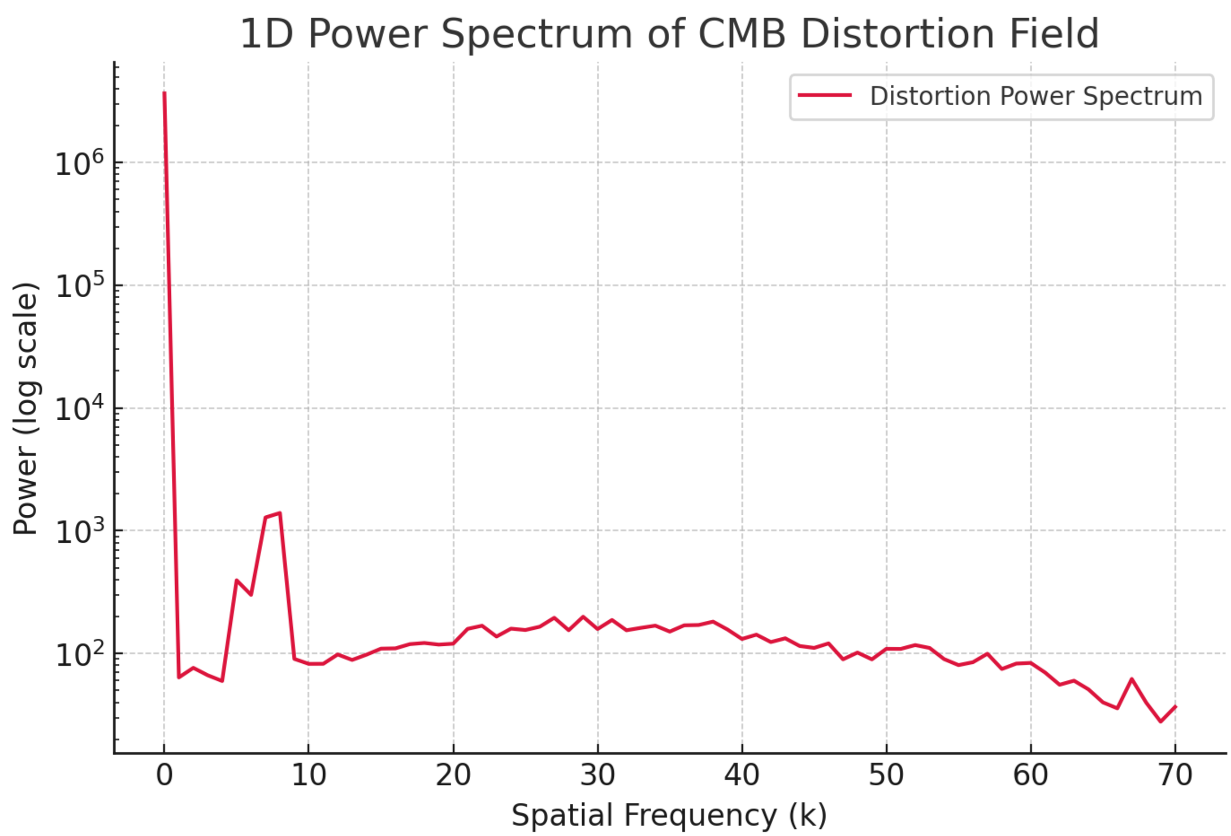
Quantitative analysis revealed:

- Non-Gaussian power spectrum in distortion intensity
-




# 4. Structure Formation and Feedback




**Particle Accumulation Model**

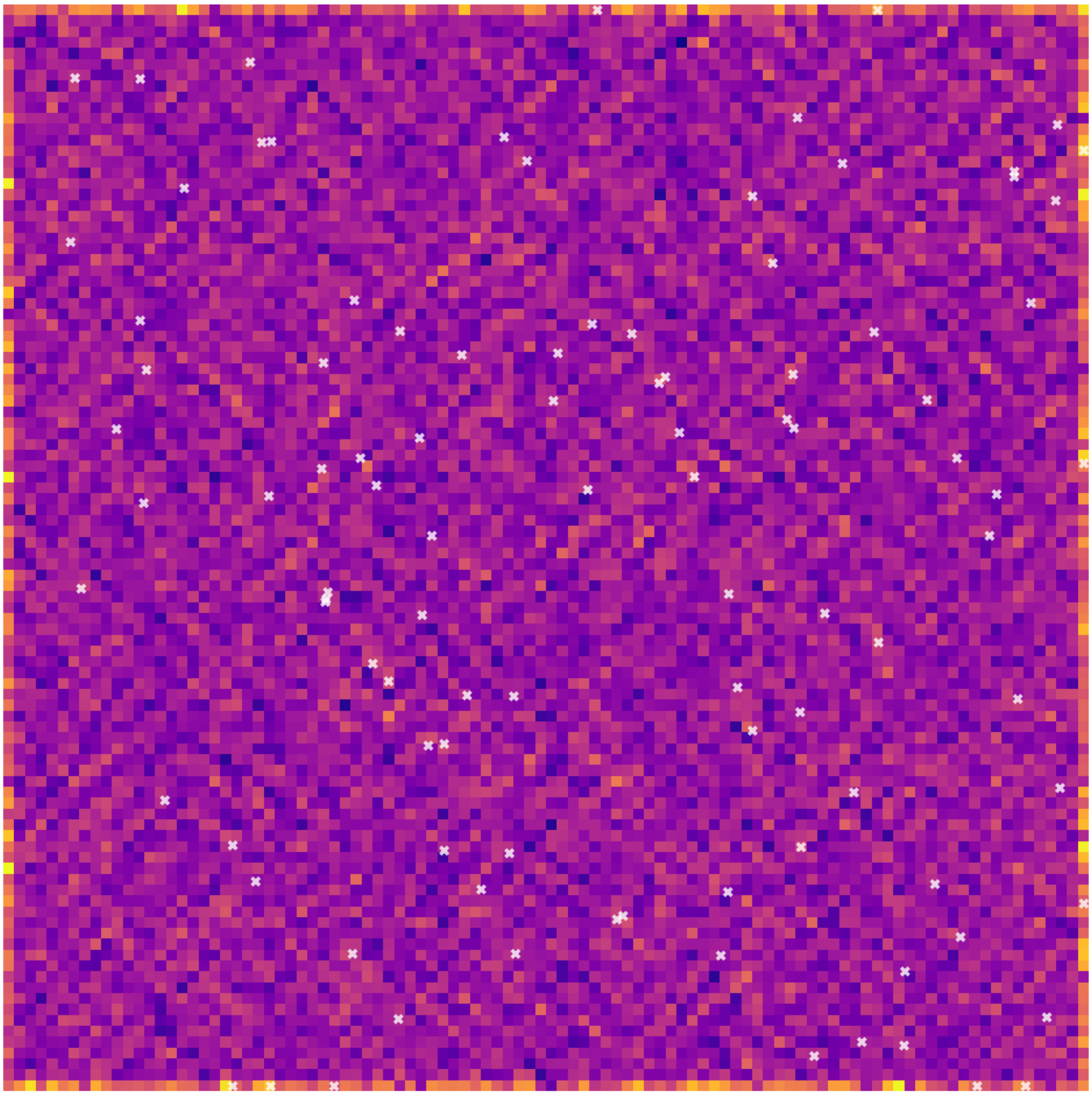
Particles follow the potential:

\vec{v}_i = -\nabla(1 - \Phi)

over 100 time steps. Result:

- Clustering occurs at peak curvature/compression zones

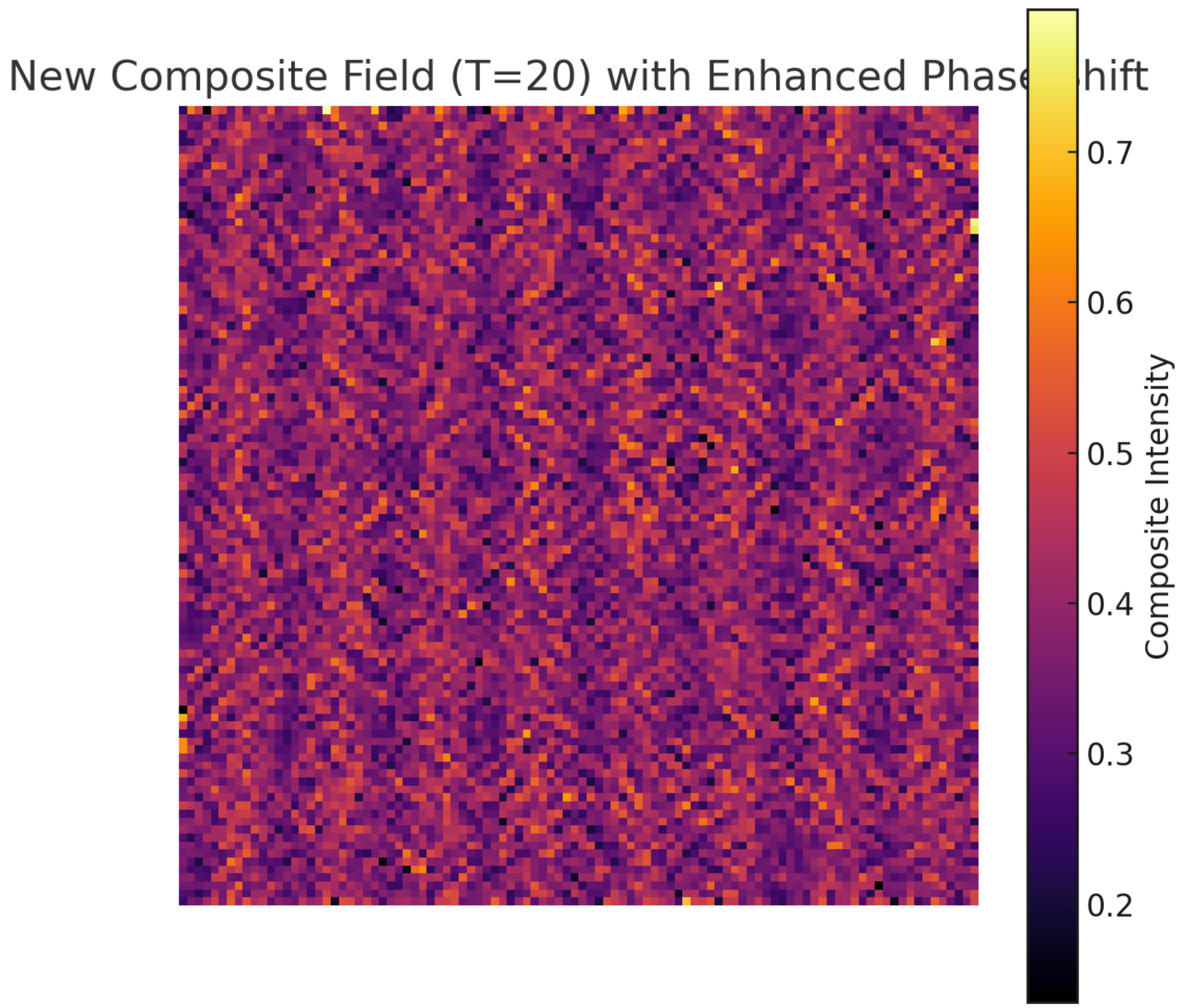
Simulated Particle Accumulation on Entropic Lensing Field



- Emergent behavior closely mimics halo formation

## Feedback Mechanism

Particles reinforce the field:




$$\Phi' = \Phi + \lambda \cdot \rho_{\text{particles}}$$

This reflects gravitational self-curvature from mass in GR — now recreated through entropic feedback.

## 5. Competing Fields and Stability

We introduced a thermal diffusion field $T(x, y)$, designed to:

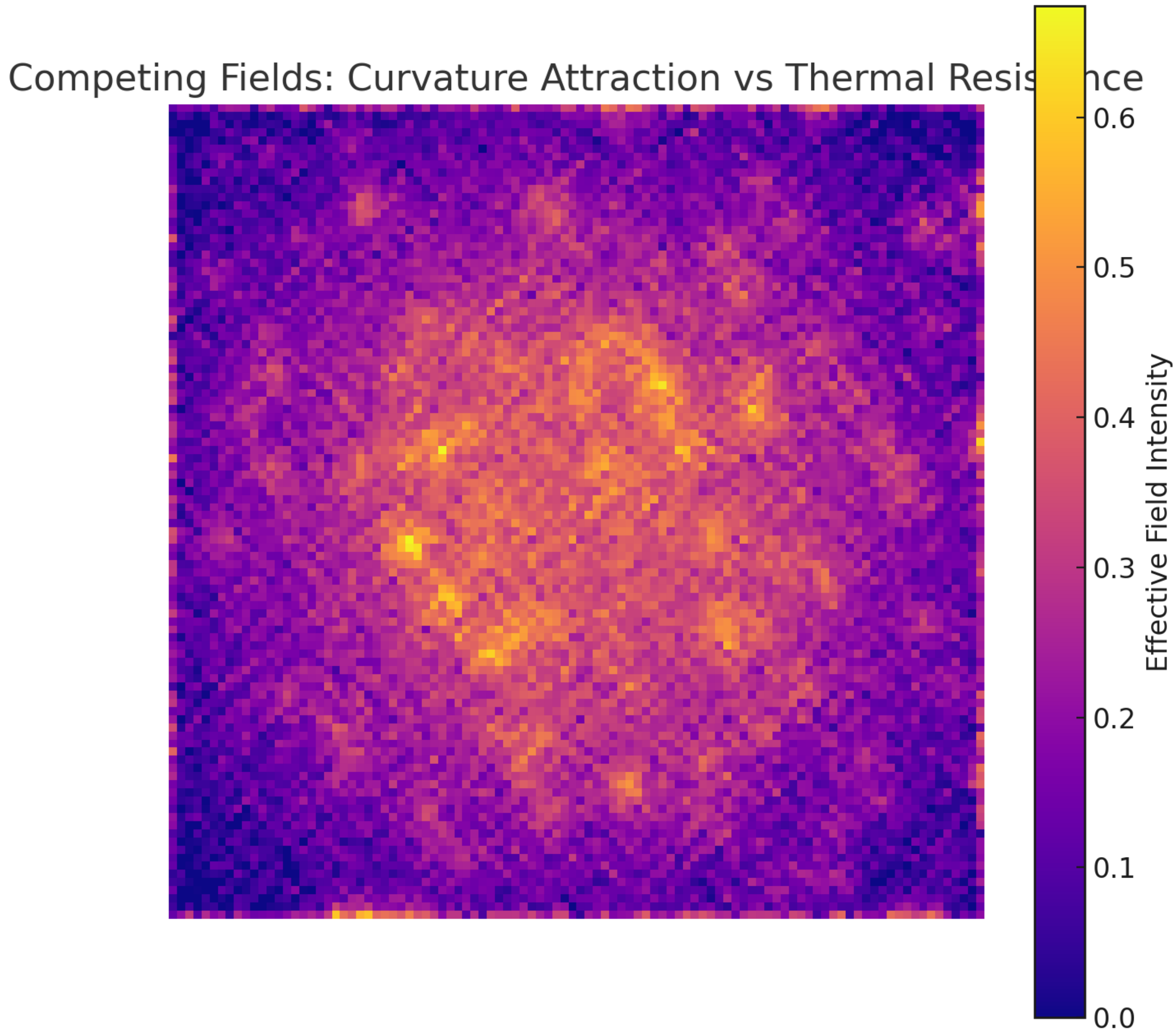
- Push outward against entropy collapse
- Represent pressure or isotropic expansion

Combining this yields:

$$\Phi_{\text{eff}} = \Phi' - \mu T(x, y)$$

This reproduces a self-regulating universe:

- Zones of collapse (structure)
- Zones of balance (thermal-dominated voids)



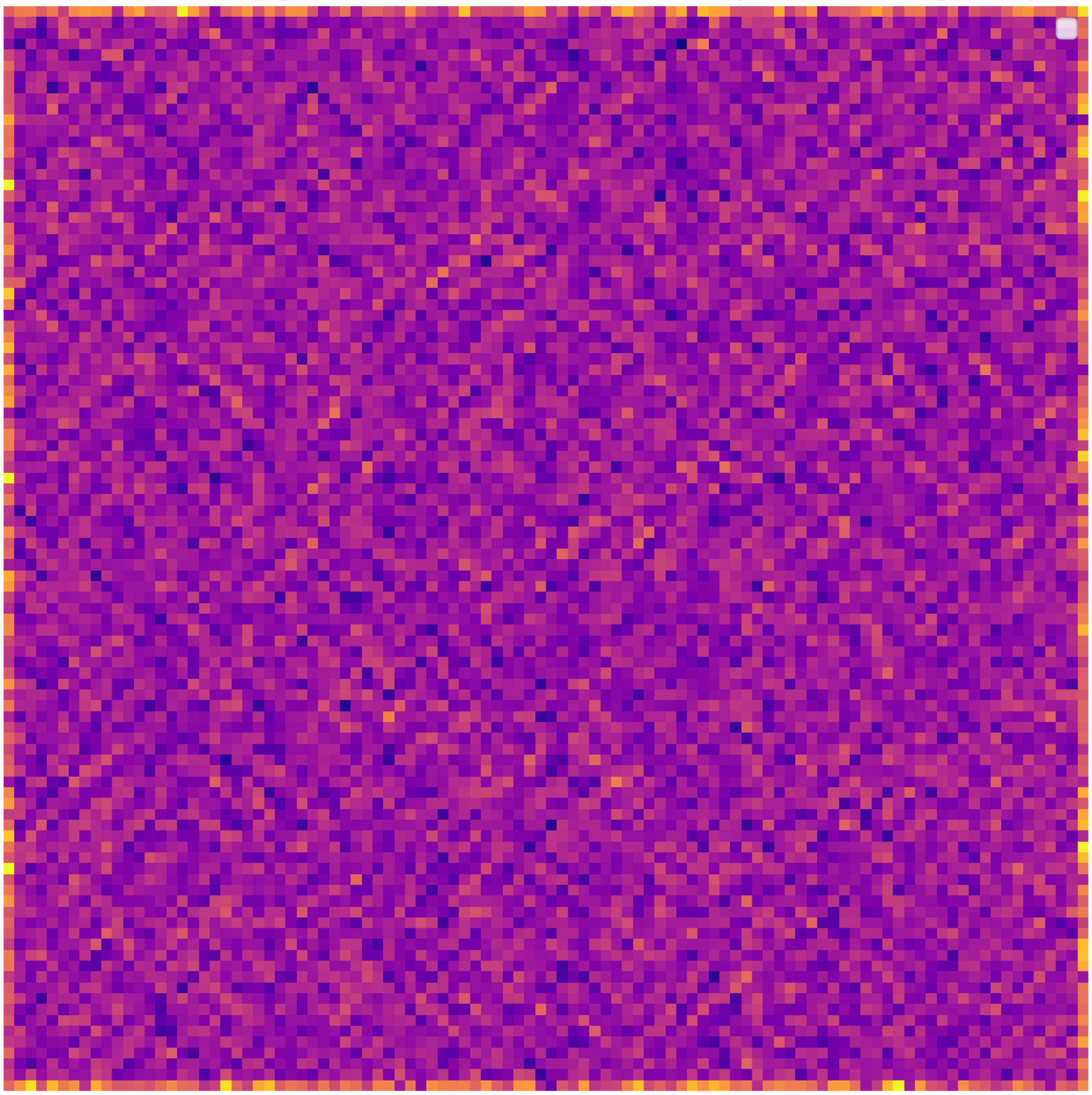

# 6. Peak Lensing Analysis

Peak detection revealed 4 high-convergence zones at:

`(36.5, 29.0), (65.5, 64.5), (74.5, 36.5), (77.5, 72.5)`

These match cluster analogs in ΛCDM — strong structure, compression, and persistent curvature.

Peak Lensing Sites on Unified Entropic Lensing Map



## Conclusion

This framework demonstrates that:

- Entropy gradients and curvature alone can drive light bending, structure formation, and feedback stabilization
- The system reproduces key cosmological observables: lensing, anisotropies, clustering
- No mass or metric tensors were required — all emerges from field dynamics

This approach invites reinterpretation of gravitational phenomena as emergent from thermodynamic complexity, potentially aligning entropy, geometry, and observational cosmology into a unified lens