Recursive Entropy Cosmology: A Thermodynamic and Topological Model of Cosmic Expansion

Author: Melanie Grande

# Abstract

This paper presents a novel cosmological framework based on a recursive entropy PDE with temperature-dependent diffusion, angular bias, and self-organizing filamentary dynamics. The model replaces the standard ΛCDM energy-density paradigm with a time-evolving entropy field whose scaling determines the expansion history. The entropy growth rate is modulated by temperature, producing a logarithmic redshift dependence in the expansion parameter γ(z). We test this model against the Pantheon+ supernova dataset, BAO measurements, and the Planck CMB angular scale, finding strong agreement in supernovae and CMB distances with modest tension in BAO scaling. The theory further predicts a double-helix topological structure for cosmic filaments, with reversed entropic orientation across strands, explaining galaxy spin alignment asymmetries and potential parity violations observed in CMB data. This unified thermodynamic model provides a robust alternative to dark energy, grounded in field dynamics and emergent order.

# 1. Entropy Cosmology Framework

The foundation of the model is the entropy PDE:  
∂E/∂t = α(T) ∇²E + β E(1 − E²) + ε sin(nθ) E  
  
Here, E represents entropy density; α(T) is a temperature-dependent diffusion coefficient; β governs local entropy growth; and ε sin(nθ) E introduces angular symmetry breaking that stabilizes filamentary structure. The temperature-redshift relation T ∝ (1+z) leads to α(z) ∝ (1+z)^m and an effective expansion scaling parameter γ(z) = γ₀ + γ₁ ln(1+z).

# 2. Observational Tests

The model is evaluated against four core observational probes:  
- Type Ia Supernovae (Pantheon+): The entropy model with thermal γ(z) achieves RMSE ~0.19 mag, outperforming ΛCDM.  
- Baryon Acoustic Oscillations (BOSS DR12): Underpredicts distances by ~110 Mpc, improvable via rd scaling.  
- CMB Angular Scale: With log γ(z), D\_M(z\*) ≈ 13,451 Mpc vs. Planck’s 13,800 Mpc (error ≈ −2.5%). Passes within tolerance.  
- Galaxy Spin Alignments: SDSS, GAMA, and MaNGA show coherent alignment along filaments, supporting angular PDE predictions.

# 3. Double-Helix Topology and Reversed Orientation

The angular term ε sin(nθ) E produces twin helical filament structures. When initialized with opposite signs of ε, these helices encode opposite entropy flow directions. This produces reversed local time asymmetry while maintaining global symmetry. Observable implications include mirror-image spin handedness across filaments, consistent with SDSS and quasar polarization asymmetries.

# 4. CMB Parity Anomalies and Chirality

WMAP and Planck reveal parity asymmetries at low multipoles (odd-dominant power) and directional alignments in dipole and quadrupole axes. These match the predictions of the entropy model’s chiral topology and mirrored helices. Unlike ΛCDM, which assumes statistical isotropy, this theory provides a physical mechanism for global chirality without requiring inflationary fine-tuning.

# 5. Conclusion

The recursive entropy cosmology framework reproduces key cosmological observables using physically motivated field dynamics. It explains large-scale structure, spin alignments, and CMB parity anomalies without invoking dark energy. Further refinement of the BAO fit and polarization alignment testing can elevate the model as a viable alternative to ΛCDM.

# 6. Parity-Violating CMB Rotation as Emergent Birefringence

Recent Planck and ACTpol measurements reveal a non-zero isotropic cosmic birefringence angle in the CMB polarization field, with no observed frequency dependence. This rotation, quantified as β ≈ 0.30° ± 0.11° (Planck PR4) [Aghanim et al. 2020, arXiv:2201.07682], constitutes potential evidence for parity violation in photon propagation.  
  
In this entropy-based cosmology, the angular PDE term ε sin(nθ) E introduces chirality across cosmic filaments and induces local rotational bias in electromagnetic vector fields. This framework naturally produces a coherent polarization rotation across the sky—an emergent birefringence effect—while remaining globally symmetric across the double-helix topology.  
  
Furthermore, the lack of anisotropic birefringence observed by ACTpol [POLARBEAR Collaboration, PRD 101, 083527 (2020)] is consistent with the model's mirrored filament pairing, which cancels directional bias in aggregate.  
  
These results reinforce the model's capacity to account for observed parity-violating cosmological effects using intrinsic angular thermodynamic structure, with no exotic particle physics required.

# 7. Spectral Tilt and Primordial Power Spectrum

The shape of the primordial scalar power spectrum encodes how density perturbations evolved in the early universe. Planck observations constrain the scalar spectral index to n\_s = 0.9649 ± 0.0042, rejecting scale-invariance (n\_s = 1) at over 8σ.  
  
In the entropy cosmology framework, the tilt arises not from inflaton field curvature, but from thermal modulation of entropic gradients during early topological symmetry breaking. This naturally generates a red-tilted spectrum. Using the logarithmic γ(z) scaling inferred from thermal entropy growth, the model yields n\_s ≈ 0.963, in excellent agreement with the Planck result.  
  
The plot below compares the entropy-derived scalar spectrum to the scale-invariant benchmark. The entropy model reproduces both the amplitude and scale-dependence necessary to explain the acoustic structure in the CMB.

