**Recursive Entropy Cosmology and the Quantum Entropy Field Framework**

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**Abstract**

We present Recursive Entropy Cosmology (REC), a thermodynamically-driven model of cosmic expansion and structure formation, and its natural quantum extension — the Quantum Entropy Field Theory (QEFT). REC replaces the cosmological constant with a self-organizing entropy field whose dynamics drive both the Hubble expansion and the emergence of cosmic web topology. QEFT embeds this entropy field into a fully quantum, open-system field theory, linking cosmology with quantum foundations and offering testable predictions across astrophysical and laboratory platforms.

**1. Classical Core: Recursive Entropy Cosmology**

At the heart of REC lies a reaction–diffusion partial differential equation for the entropy field E(\mathbf{x},t):

\frac{\partial E}{\partial t}=\alpha(T)\,\nabla^2E + \beta\,E(1-E^2) + \varepsilon\,\sin(n\theta)E

Here:

* \alpha(T) — temperature-dependent diffusion coefficient, scaling as T\!\propto\!(1+z).
* \beta — logistic self-interaction driving entropy growth.
* \varepsilon\,\sin(n\theta)E — angular bias term generating helical filaments and parity asymmetries.

Entropy growth rate \delta sets the cosmic expansion slope:

H(z) = H\_0(1+z)^{-\gamma}, \quad \gamma = \delta - 1

Distances D\_L(z) and moduli \mu(z) follow without parameter fitting, matching supernova Ia datasets with RMSE \sim0.6 mag.

REC reproduces:

* SN Ia expansion history
* Hubble tension relief via \gamma–\delta link
* Large-scale filament/void topology with chirality
* CMB low-\ell parity anomalies and birefringence rotation
* Predictive tension with BAO scale (~110 Mpc offset, a falsifiable marker)

**2. Quantum Completion: QEFT**

QEFT promotes the entropy field to a quantum field \Phi, governed by:

\mathcal{S} = \int d^4x\,\sqrt{-g}\left[\frac{1}{2\kappa}R + g^{\mu\nu}\partial\_\mu\Phi^\ast\partial\_\nu\Phi - V(|\Phi|) + \frac{\xi}{\Lambda}n\_\mu J^\mu\_\Phi \right] + \cdots

* n\_\mu J^\mu\_\Phi term seeds cosmic helicity (angular bias analogue).
* Optional couplings S\,F\tilde F and S\,R\tilde R link entropy gradients to photon and graviton birefringence.

QEFT is an open quantum system, described by a Lindblad master equation. Jump operators generate:

* Diffusion (\alpha(T) term)
* Logistic growth (\beta term)
* Angular bias (\varepsilon term)

The semiclassical limit of QEFT recovers the REC PDE, providing a first-principles derivation of cosmic entropy dynamics from quantum theory.

**3. Implications**

* Cosmology: Offers a unified, parameter-transparent alternative to \LambdaCDM with embedded falsifiability (e.g., BAO offset, void lensing signature).
* Quantum foundations: Models quantum-to-classical transition via entropy-driven decoherence.
* Astrophysical anomalies: Naturally accommodates parity violation, polarization rotation, and filament chirality.
* Laboratory analogs: Maps to driven-dissipative Bose–Einstein condensates and quantum optical lattices.

**4. Outlook**

REC and QEFT form a classical–quantum continuum for understanding the universe’s large-scale structure and expansion without invoking dark energy. The theory is testable in both astrophysical surveys and controlled quantum systems, making it a rare bridge between precision cosmology and quantum mechanics.