From Brick to Sponge: RSVP Cosmology and the Entropic Emergence of Structure

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Abstract

We present RSVP cosmology, a novel framework where gravity emerges from entropy redistribution within a recursive scalar-vector plenum. The early universe evolves from a thermally vibrating "brick" to a scalar-permeable "sponge," with the Cosmic Microwave Background (CMB) encoding an entropy field map. Five modular engines—Gradient Anisotropic Smoothing (GAS), Deferred Thermodynamic Reservoirs (DTR), Poincaré-Triggered Lattice Recrystallization (PTLR), Scalar Irruption via Entropic Differential (SIED), and Neutrino Fossil Registry (NFR)—drive cosmic evolution. We provide a mathematical framework, simulation results, and observational tests, challenging ΛCDM and redefining gravity as thermodynamic smoothing.

Contents

1 Introduction

The ΛCDM model, despite its successes, falters on quantum gravity, dark energy, and early universe homogeneity. RSVP cosmology reinterprets gravity as an emergent phenomenon driven by entropy gradients in a recursive scalar-vector plenum. The universe transitions from a dense "brick" to a porous "sponge," with structure formation arising from entropic feedback. We present a modular framework, a CMB reinterpretation, and testable predictions for void-CMB correlations.

2 Thermodynamic Foundations of RSVP Cosmology

2.1 Gravity as Entropic Redistribution

Gravity emerges from entropy gradients, with inflationary residue seeding curvature potential. Vacuum expansion and matter collapse act as entropy transfer mechanisms, described by:

$$R_{\mu\nu} - \frac{1}{2}Rg_{\mu\nu} = 8\pi G T_{\mu\nu}^{\text{entropic}}, \tag{1}$$

where $T_{\mu\nu}^{\text{entropic}}$ encodes entropy flow (1; 2).

2.2 The Dual-Shell Feedback Model

Concentric shells model the universe: inner matter shells collapse, outer vacuum shells expand. Scalar field Φ and vector field $\mathbf{v}$ couple via plenum tension:

$$\nabla^2\Phi = 4\pi G\rho_m + \kappa\nabla S, \tag{2}$$

with κ as the entropic coupling constant.

2.3 Cosmogenesis: From Brick to Sponge

The early universe is a thermally vibrating "brick," a dense photon-coupled baryon plasma with acoustic oscillations:

$$\frac{\partial^2\delta\rho}{\partial t^2} - c_s^2\nabla^2\delta\rho + \Gamma_d\frac{\partial\delta\rho}{\partial t} = 0, \tag{3}$$

where c_s is the sound speed and Γ_d is the damping coefficient. At recombination ($t = t_\gamma$), photon decoupling triggers scalar field irruption:

$$\left.\frac{\partial \Phi}{\partial t}\right|_{t=t_\gamma^+} \gg 0, \tag{4}$$

transitioning to a "sponge" phase with scalar permeability, void expansion, and inter-voidal clumping.

3 RSVP Framework: Recursive Modules of Cosmic Evolution

3.1 Plenum Architecture and Scalar-Vector Dynamics

The plenum, a crystal-like lattice, retains inflationary memory. Scalar field Φ, lamphron $\Lambda^\bullet$, and lamphrodyne Δ^- govern dynamics:

$$\partial_t \Phi + \mathbf{v} \cdot \nabla \Phi = -\nabla S/\rho_m. \tag{5}$$

3.2 The Five Modular Engines

- **GAS**: Smooths anisotropic gradients.
- **DTR**: Stores entropy in reservoirs.
- **PTLR**: Triggers lattice recrystallization.
- **SIED**: Drives scalar irruption.
- **NFR**: Encodes CMB entropy traces.

4 The CMB as Entropic Blueprint

4.1 Rethinking the Cosmic Microwave Background

CMB temperature fluctuations map entropy: cold spots are entropy sinks (voids), warm spots are compression scars (filaments/walls):

$$\Delta T(\mathbf{x}) \propto \delta S(\mathbf{x}). \tag{6}$$

BAO imprints form a topological lattice.

4.2 Multipole Alignment and Entropic Shear

Quadrupole/octopole alignments reflect scalar-field fossil stress. We compare CMB $a_{\ell m}$ components to filament orientation $P(\theta)$:

$$C_\ell = \frac{1}{2\ell + 1} \sum_{m=-\ell}^{\ell} |a_{\ell m}|^2, \tag{7}$$

using KL divergence for significance.

5 Mathematical Framework and Analogs

5.1 Entropy-Curvature Field Equations

Coupled PDEs govern the system:

$$\frac{\partial \rho_m}{\partial t} + \nabla \cdot (\rho_m \mathbf{v}) = \nabla \cdot (D_m \nabla \rho_m) - \kappa \nabla^2 \sigma, \tag{8}$$

$$\frac{\partial \Phi}{\partial t} = \gamma \nabla^2 \Phi - \lambda \Phi + \eta \sigma, \tag{9}$$

$$\sigma(x,t) = \sigma_0 e^{-\delta \Phi(x,t)} \left(1 - \frac{\rho_m(x,t)}{\rho_c}\right), \tag{10}$$

$$\frac{\partial S}{\partial t} + \nabla \cdot \mathbf{J}_S = \alpha |\nabla \Phi|^2 - \beta |\nabla \rho_m|^2, \quad \mathbf{J}_S = -D_S \nabla S, \tag{11}$$

$$\mathbf{v}(x,t) = -\chi \nabla \sigma + \xi \nabla \Phi. \tag{12}$$

5.2 Physical Analog: Paper Mâché in Detergent Water

Pulp (matter), detergent (inflaton residue), and water (plenum) mimic collapse:

$$\nabla^2 \psi = -\gamma \nabla S_{\text{surface}}. \tag{13}$$

6 Simulation Framework and Results

6.1 Initialization and Parameters

A 2D grid ($N_x \times N_y$) with $\Delta x = \Delta y = 1.0$ initializes:

- ρ_m: Gaussian density bump.
- Φ: Random residue, $\Phi \sim \mathcal{U}(0.1, 0.3)$.
- S: Logarithmic entropy.
- σ: $\sigma = \sigma_0 e^{-\delta\Phi} \left(1 - \frac{\rho_m}{\rho_c}\right)$.

Constants: $D_m = 0.2$, $\gamma = 0.05$, $\lambda = 0.01$, $\eta = 0.5$, $\chi = 1.0$, $\xi = 0.5$, $\delta = 1.0$. Periodic boundaries, $\Delta t = 0.1$, 200 iterations.

6.2 Numerical Integration Scheme

Timesteps update:

1. $\sigma(x,y) \leftarrow \sigma_0 e^{-\delta\Phi(x,y)} \left(1 - \frac{\rho_m(x,y)}{\rho_c}\right)$.
2. $\mathbf{v}_x = -\chi \frac{\partial \sigma}{\partial x} + \xi \frac{\partial \Phi}{\partial x}$, $\mathbf{v}_y = -\chi \frac{\partial \sigma}{\partial y} + \xi \frac{\partial \Phi}{\partial y}$.
3. $\rho_m^{(t+1)} = \rho_m^{(t)} + \Delta t \left[D_m \nabla^2 \rho_m - \nabla \cdot (\rho_m \mathbf{v})\right]$.
4. $\Phi^{(t+1)} = \Phi^{(t)} + \Delta t \left(\gamma \nabla^2 \Phi - \lambda \Phi + \eta \sigma\right)$.
5. $S^{(t+1)} = S^{(t)} + \Delta t \left[\nabla \cdot (-D_S \nabla S) + \alpha |\nabla \Phi|^2 - \beta |\nabla \rho_m|^2\right]$.

6.3 Simulation Results

Emergent behaviors:

- **Void Expansion**: Low-ρ_m regions expand as ∇S steepens.
- **Filament Formation**: Matter accumulates along shear lines.
- **Entropy Flux Memory**: Persistent S gradients mimic CMB fossils.
- **Curvature Saturation**: Clustering halts where $\nabla S \to 0$.

Figure 1 shows timelapse density fields (placeholder).

Figure 1: Simulation timesteps. Top: Matter density ρ_m. Middle: Scalar field Φ. Bottom: Entropy field S. Visuals show void expansion and filament formation.

6.4 Parameter Sensitivity

Varying $\kappa \in [0.1, 1.0]$, $\delta \in [0.5, 1.5]$, γ shows robust structure formation.

7 Observational Testing Strategy

7.1 CMB–Void Cross-Correlation

We test cold spot alignment with underdensity regions using the cross-correlation function:

$$\xi(\theta) = \langle \Delta T(\mathbf{n}) \delta_g(\mathbf{n}') \rangle, \tag{14}$$

where δ_g is the galaxy density contrast. We compute $\xi(\theta)$ using Planck CMB data and DESI void catalogs, expecting enhanced correlation at $\theta \sim 5^\circ$ due to entropy reservoir alignment.

7.2 Filament Orientation and CMB Multipoles

Filament orientations correlate with quadrupole/octopole axes. We quantify coherence via:

$$D_{\mathrm{KL}} = \sum P(\theta) \log \frac{P(\theta)}{Q(\theta)}, \tag{15}$$

where $Q(\theta)$ is the CMB-derived orientation distribution. Significant D_{KL} indicates fossil stress alignment.

7.3 Gravitational Weakening and Entropic Saturation

We predict curvature flattening in voids, observable via weak lensing shear:

$$\gamma_t = \int \kappa(\mathbf{l}) W(\mathbf{l}) d^2\mathbf{l}, \tag{16}$$

where $\kappa(\mathbf{l})$ is the convergence field. Anomalous shear in voids distinguishes RSVP from ΛCDM.

8 Discussion

RSVP challenges ΛCDM's dark energy and force-based paradigms, aligning with entropic gravity and holography. It reinterprets inflation as memory and dark energy as entropic residue, shifting cosmology to a feedback-driven framework.

9 Conclusions

RSVP bridges thermodynamics, field theory, and cosmology, redefining gravity as informational smoothing. From brick to sponge to stars, it offers a recursive cosmogenesis model with testable predictions.

10 Acknowledgments

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11 Future Work

Future studies will:

- Extend simulations to 3D with GPU acceleration.
- Test CMB-void correlations with JWST data.
- Explore neutrino contributions to NFR module.
- Develop a public RSVP simulation toolkit.

A Mathematical Formulations of Entropic Dynamics

The RSVP system is defined over a Riemannian manifold $\mathcal{M}$ with fields ρ_m, Φ, σ, S, $\mathbf{v}$ governed by:

$$\frac{\partial \rho_m}{\partial t} + \nabla \cdot (\rho_m \mathbf{v}) = \nabla \cdot (D_m \nabla \rho_m) - \kappa \nabla^2 \sigma, \tag{17}$$

$$\frac{\partial \Phi}{\partial t} = \gamma \nabla^2 \Phi - \lambda \Phi + \eta \sigma, \tag{18}$$

$$\sigma(x,t) = \sigma_0 e^{-\delta \Phi(x,t)} \left(1 - \frac{\rho_m(x,t)}{\rho_c}\right), \tag{19}$$

$$\frac{\partial S}{\partial t} + \nabla \cdot \mathbf{J}_S = \alpha |\nabla \Phi|^2 - \beta |\nabla \rho_m|^2, \quad \mathbf{J}_S = -D_S \nabla S, \tag{20}$$

$$\mathbf{v}(x,t) = -\chi \nabla \sigma + \xi \nabla \Phi. \tag{21}$$

Stability is analyzed via linear perturbation theory.

B RSVP Modular System and Recursive Architecture

Detailed specifications of GAS, DTR, PTLR, SIED, and NFR, with recursive feedback loops.

C Simulation Code and Parameter Tuning

Example Python code:

```
import numpy as np
import matplotlib.pyplot as plt

nx, ny = 100, 100
rho_m = np.exp(-(np.indices((nx, ny)).sum(axis=0) - 50)**2 / 100)
Phi = np.random.uniform(0.1, 0.3, (nx, ny))
S = np.log(rho_m)
sigma_0, delta, rho_c = 1.0, 1.0, 1.0
Dm, gamma, lam, eta, chi, xi = 0.2, 0.05, 0.01, 0.5, 1.0, 0.5
dt = 0.1

for t in range(200):
    sigma = sigma_0 * np.exp(-delta * Phi) * (1 - rho_m / rho_c)
    vx = -chi * np.gradient(sigma, axis=1) + xi * np.gradient(Phi, axis=1)
    vy = -chi * np.gradient(sigma, axis=0) + xi * np.gradient(Phi, axis=0)
    rho_m += dt * (Dm * (np.roll(rho_m, 1, axis=0) + np.roll(rho_m, -1, axis=0)
                          np.roll(rho_m, 1, axis=1) + np.roll(rho_m, -1, axis=1)
                   (np.roll(rho_m * vx, -1, axis=1) - np.roll(rho_m * vx, 1, axi
                    np.roll(rho_m * vy, -1, axis=0) - np.roll(rho_m * vy, 1, axi
    Phi += dt * (gamma * (np.roll(Phi, 1, axis=0) + np.roll(Phi, -1, axis=0) +
                         np.roll(Phi, 1, axis=1) + np.roll(Phi, -1, axis=1) - 4
                 lam * Phi + eta * sigma)
    plt.imshow(rho_m)
    plt.savefig(f'frame_{t}.png')
```

D Summary and Integration of Theoretical Framework

RSVP recasts spacetime as a recursive thermodynamic response to inflationary asymmetries. Gravity is informational residue, with filaments along entropic stress lines and voids from entropy sinks. The framework unites entropy, curvature, and information, offering falsifiable predictions and CMB insights.

References

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