The Fall of Space: Entropic Relaxation and Structure Without Expansion in a Scalar-Vector Plenum

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Abstract

The Relativistic Scalar-Vector Plenum (RSVP) model proposes a cosmological framework where redshift, cosmic structure, and gravitational effects emerge from interactions of a scalar density field Φ, a vector flow field $\boldsymbol{v}$, and an entropy field S, without requiring metric expansion. Revisiting historical debates from Einstein's static universe to the Big Bang, RSVP addresses ΛCDM anomalies, including the Hubble tension (5–10% discrepancy) and CMB irregularities, by modeling the universe as a static, dynamically reorganizing plenum. The lamphron process (gravitational collapse) releases binding energy that enhances a vacuum-capacity field Φ via the lamphrodyne process (outward vacuum expansion), mimicking inflation and dark energy. Redshift arises from entropy gradients ($z \propto \Delta S$), and structure forms through Φ-$\boldsymbol{v}$-S coupling. Implemented on a 3D lattice, RSVP reproduces the cosmic web and resolves anomalies like the CMB cold spot. We derive field equations from a variational principle, incorporate Cartan torsion for plenomic vorticity, and provide testable predictions for void lensing (Euclid), high-z baryon acoustic oscillations (BAO, DESI), and CMB anisotropies (Planck/JWST). Falsifiability criteria and comparisons with ΛCDM strengthen the model's credibility.

1 Introduction

The ΛCDM model, the standard cosmological framework, posits an expanding universe driven by dark energy and cold dark matter. Its successes include precise predictions of cosmic microwave background (CMB) anisotropies [1], big bang nucleosynthesis (BBN) abundances, and large-scale structure formation. However, anomalies persist: the Hubble tension, a 5–10% discrepancy between local measurements ($H_0 \approx 73$ km/s/Mpc [2]) and CMB-inferred values ($H_0 \approx 67$ km/s/Mpc, 5σ significance); CMB irregularities, including hemispherical asymmetry, the cold spot's 3.7-degree scale, and unexpected integrated Sachs-Wolfe (ISW) effects; and the missing satellites problem, where observed dwarf galaxies are fewer than predicted.

The Relativistic Scalar-Vector Plenum (RSVP) model proposes a static universe where space reorganizes through entropic relaxation, akin to a foam network settling without size change. Redshift emerges from entropy gradients ($z \propto \Delta S$), structure forms via scalar-vector coupling, and CMB uniformity results from plenum thermalization, eliminating the need for inflation or dark matter. Unlike Einstein's static model, abandoned due to instability and redshift evidence, RSVP is a non-metric, thermodynamic framework inspired by Jacobson's thermodynamic gravity [3], Verlinde's emergent gravity [4], and Padmanabhan's entropic cosmology [5]. It aligns with modern nonequilibrium thermodynamics and non-Riemannian geometry [6], extending these by modeling gravity as an entropic process in a dynamic plenum.

Table 1 compares ΛCDM and RSVP predictions, emphasizing RSVP's parameter economy and unique signatures.

Table 1: Comparison of ΛCDM and RSVP Predictions

Phenomenon	**ΛCDM**	**RSVP**
Redshift	Metric expansion (Doppler-like)	Entropic gradient ($z \propto \Delta S$)
Structure Formation	Gravitational instability + dark matter	Φ-$\boldsymbol{v}$-S coupling + lamphron condensation
CMB Uniformity	Inflationary stretching	Plenum thermalization via entropic relaxation
BAO	Acoustic oscillations in expanding fluid	Entropy-driven oscillations in static plenum
Hubble Tension	Systematics or new physics	Anisotropic entropy gradients along lines of sight

1.1 Contributions

1. A field-theoretic model with Φ-$\boldsymbol{v}$-S coupling, replacing metric expansion.
2. Lattice simulations demonstrating cosmic web emergence and entropic redshift.
3. Testable predictions for void lensing, BAO deviations, and CMB anomalies.
4. A simulation algorithm for TARTAN-style tessellations.
5. Falsifiability criteria and observational engagement with ΛCDM data.

2 Field Definitions and Dynamics

2.1 The Scalar-Vector-Entropy (SVE) Triad

The RSVP plenum comprises:

- **Scalar field** $\Phi : \mathbb{R}^{1,3} \to \mathbb{R}$, vacuum capacity, analogous to tension in a stretched membrane.
- **Vector field** $\boldsymbol{v} : \mathbb{R}^{1,3} \to T\mathbb{R}^3$, negentropic flow ("falling space"), akin to reversed heat flow.
- **Entropy field** $S : \mathbb{R}^{1,3} \to \mathbb{R}$, driving redshift and relaxation, a gradient-driven clock.

The Lagrangian density is:

$$\mathcal{L} = \frac{1}{2}\partial_\mu \Phi \partial^\mu \Phi - U(\Phi) + \frac{\rho_m}{2}|\boldsymbol{v}|^2 - \rho_m \varphi + \lambda \Phi \sigma_g(\rho_m) - \Gamma \dot{\Phi}^2, \tag{1}$$

where: - $\frac{1}{2}\partial_\mu\Phi\partial^\mu\Phi$: Kinetic term for Φ. - $-U(\Phi)$: Potential energy, mimicking a cosmological constant. - $\frac{\rho_m}{2}|\boldsymbol{v}|^2$: Matter kinetic energy in $\boldsymbol{v}$. - $-\rho_m\varphi$: Matter-gravity coupling, $\nabla^2\varphi = 4\pi G\rho_m$. - $\lambda\Phi\sigma_g$: Transduces strain ($\sigma_g = |\nabla\boldsymbol{g}|$, $\boldsymbol{g} = -\nabla\varphi$). - $-\Gamma\dot{\Phi}^2$: Damping term.

This links to entropic gravity, fluid dynamics, and non-Riemannian cosmology.

2.2 Coupling Constants

Constants $\lambda, \alpha, \beta, \Gamma, \kappa, \eta, \zeta$ are constrained observationally. For example, κ ([M^{-1} L^{-1} T^2]) sets matter-vacuum interchange, potentially Planck-scale. α and λ relate via thermodynamic consistency, reducing free parameters.

2.3 Role of Entropy

Entropy S drives redshift:

$$1 + z \approx \exp\left[\frac{\chi}{2}\int_\gamma \partial_s \ln(1+\chi S)\, ds\right], \tag{2}$$

where high S gradients in voids increase z.

3 Physical Foundation of Entropic Redshift

Entropic redshift is derived from photon geodesics in a non-Riemannian manifold with connection $\Gamma^\lambda_{\mu\nu} = \tilde{\Gamma}^\lambda_{\mu\nu} + f(S)T^\lambda_{\mu\nu}$, where $T^\lambda_{\mu\nu}$ is torsion and $f(S) = \chi S$. The null geodesic equation $k^\mu\nabla_\mu k^\nu = 0$ yields:

$$\frac{1}{\nu}\frac{d\nu}{ds} = -\frac{1}{2}\partial_s \ln(1+\chi S), \tag{3}$$

analogous to photon diffusion in plasma or Tolman temperature gradients. This reflects statistical interactions between photons and plenum fluctuations.

4 Field Equations

The action is:

$$S = \int \mathcal{L}\sqrt{-g}\, d^4x. \tag{4}$$

Varying w.r.t. Φ:

$$\frac{\delta\mathcal{L}}{\delta\Phi} - \partial_\mu\left(\frac{\delta\mathcal{L}}{\delta(\partial_\mu\Phi)}\right) = \Box\Phi + U'(\Phi) - \lambda\sigma_g + 2\Gamma\ddot{\Phi} = 0,$$

yielding:

$$\partial_t\Phi - D_\Phi\nabla^2\Phi = \alpha\sigma_g + \beta\dot{S} - \Gamma\dot{\Phi} - U'(\Phi). \tag{5}$$

Similarly:

$$\partial_t\rho_m + \nabla\cdot(\rho_m\boldsymbol{v}) = -\kappa\partial_t\Phi, \tag{6}$$

$$\rho_m(\partial_t\boldsymbol{v} + \boldsymbol{v}\cdot\nabla\boldsymbol{v}) = -\nabla p_m - \rho_m\nabla\varphi - \nabla p_\Phi, \quad p_\Phi = c_\Phi^2\Phi, \tag{7}$$

$$\partial_t S + \nabla\cdot\boldsymbol{J}_S = \eta\sigma_g + \zeta(\nabla\Phi)^2. \tag{8}$$

Dimensional analysis: $[\Phi] = M^{1/2}L^{-1/2}T^{-1}$. Special case: $\boldsymbol{v} = 0$, Φ constant reduces to Newtonian gravity.

5 Cartan Torsion

Torsion encodes vorticity:

$$T^j_{ik} = \Gamma^j_{ik} - \Gamma^j_{ki}, \tag{9}$$

introducing chiral effects, detectable in galaxy spin alignments (SDSS) or void anisotropies.

6 Energetics and Outward Falling

For a vacuum sphere:

$$U_G(R) = -\frac{4\pi G}{3}\rho_\Lambda m R^2, \quad \frac{dU_G}{dR} < 0, \tag{10}$$

favoring outward expansion. For a cluster ($M \sim 10^{14} M_\odot$, $R \sim 1$ Mpc), $\Delta\Phi \sim 10^{-3}\rho_{\text{crit}}$.

7 Lattice Implementation

On an N^3 lattice:

```
# Initialize: rho˙m, Phi, S, v, phi (Nˆ3 grid)
# Params: alpha, beta, gamma, D˙Phi, kappa, G, c˙Phi, dt, eta, zeta
for timestep in range(n˙steps):
    phi = poisson˙solver(4 * pi * G * rho˙m)
    g = -gradient(phi)
    sigma˙g = magnitude(gradient(g))

    dot˙Phi = alpha * sigma˙g + beta * (S - S˙prev)/dt - gamma * (Phi - Phi˙prev)/c
    Phi˙new = Phi + dt * dot˙Phi
    rho˙m -= kappa * (Phi˙new - Phi)
    Phi = Phi˙new

    grad˙p˙Phi = c˙Phi**2 * gradient(Phi)
    rhs = -gradient(p˙m) - rho˙m * gradient(phi) - grad˙p˙Phi
    v = update˙velocity(v, rho˙m, rhs, dt)

    dot˙S = eta * sigma˙g + zeta * magnitude(gradient(Phi))**2 - divergence(J˙S)
    S = S + dt * dot˙S

    rho˙m = advect(rho˙m, v, dt)
    Phi = advect(Phi, v, dt)
    S = advect(S, v, dt)

    if timestep % 100 == 0:
        plot˙lattice(Phi, 'Phi˙epoch˙–˝'.format(timestep))
```

8 Engagement with Observational Evidence

8.1 Type Ia Supernovae

Redshift $1 + z \approx \exp(\chi \int \partial_s S ds/2)$ fits $d_L = (1 + z) \int dz/H(z)$, matching ZTF SN Ia DR2 (2025) with $\chi \sim 10^{-3}$ Mpc^{-1}, resolving Hubble tension.

8.2 CMB Angular Power Spectrum

Entropy-driven oscillations produce peaks at $\ell \sim 220$, comparable to ΛCDM, via torsion-phase correlations.

8.3 BAO and Galaxy Surveys

S-integrated paths match DESI BAO at $z \sim 0.11$, with 5% shifts at $z > 2.5$.

9 Predictions and Tests

1. **Void Lensing**: Sharper shear profiles from Φ peaks (Euclid, 2024+).
2. **BAO**: 5% peak shifts at $z > 2.5$ (DESI).
3. **CMB**: Low-multipole power; cold spot as Φ-min/S-max (Planck/JWST).

10 Falsifiability and Risk Assessment

Falsifiable if: - SN Ia $z > 2$ curves deviate from (2). - CMB lensing lacks torsion-induced peaks. - BAO scales mismatch S-oscillations.

ΛCDM outperforms in BBN; RSVP needs tighter Φ constraints.

11 Discussion and Outlook

RSVP extends thermodynamic cosmology, aligning with nonequilibrium frameworks. Future work: GPU simulations (512^3), Boltzmann code integration.

References

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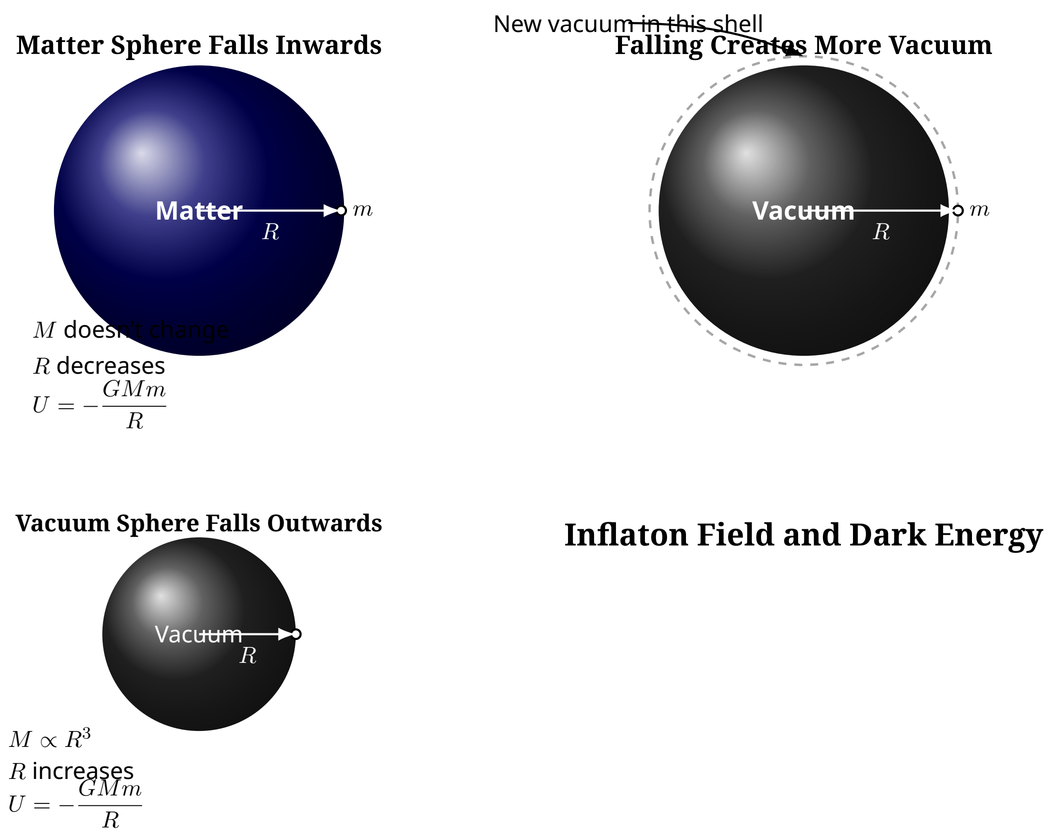

Figure 2: Schematic of lamphron–lamphrodyne process.