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. This approach revisits historical debates from Einstein's static universe to the Big Bang, addressing 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). The Trajectory-Aware Recursive Tiling with Annotated Noise (TARTAN) framework enhances simulations, enabling unistochastic quantum-like behavior to emerge from recursive field dynamics, aligning with Barandes's reformulation of quantum theory. 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, persistent anomalies challenge its completeness: 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.

Recent entropic gravity theories, such as Vopson's mass-energy-information equivalence [7], provide a foundation for RSVP's approach. Vopson derives Newtonian gravity from information entropy minimization on a Planck-scale lattice, a concept RSVP extends through recursive causality and dynamic field interactions. Similarly, Barandes's unistochastic quantum theory [8] reformulates quantum mechanics using directed conditional probabilities, which RSVP's Trajectory-Aware Recursive Tiling with Annotated Noise (TARTAN) framework can generate as emergent phenomena from field dynamics.

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 TARTAN-based simulation algorithm for multiscale dynamics.
5. Integration with unistochastic quantum theory, deriving quantum behavior from RSVP.
6. Falsifiability criteria and engagement with ΛCDM data.

2 Field Definitions and Dynamics

2.1 The Scalar-Vector-Entropy (SVE) Triad

The RSVP plenum comprises three fields:

- **Scalar field** $\Phi : \mathbb{R}^{1,3} \to \mathbb{R}^+$, representing vacuum capacity or informational entropy density, analogous to tension in a stretched membrane storing energy during collapse.

- **Vector field** $\boldsymbol{v} : \mathbb{R}^{1,3} \to T\mathbb{R}^3$, encoding negentropic flow ("falling space"), similar to reversed heat flow driven by active pumping.
- **Entropy field** $S : \mathbb{R}^{1,3} \to \mathbb{R}$, driving redshift and relaxation, acting as a gradient-driven clock for plenum state.

The Lagrangian density motivates the dynamics:

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

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 [4], fluid dynamics, and non-Riemannian cosmology [6].

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 derived. α (strain-Φ coupling) tunes void growth rates; β (entropy-Φ exchange) fits redshift-distance relations. To reduce free parameters, λ and α relate via thermodynamic consistency, measurable through BAO shifts or CMB multipoles. Dimensional analysis confirms: $[\Phi] = M^{1/2}L^{-1/2}T^{-1}$, $[\sigma_g] = L^{-1}T^{-1}$, $[\alpha] = T^{-1}L$.

2.3 Role of Entropy

S drives redshift via:

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

where high S gradients in voids increase z, mimicking acceleration. For a void of radius 10 Mpc, $\Delta S \sim 10^3 k_B$ yields $z \approx 0.1$ for $\chi \sim 10^{-3}$ Mpc^{-1}, consistent with low-z SN Ia data.

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 the torsion tensor 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. Microphysically, this reflects statistical interactions between photons and plenum fluctuations, altering the electromagnetic field phase. For a galaxy cluster ($M \sim 10^{14} M_\odot$), $\Delta S \sim 10^5 k_B$ over 1 Mpc produces a redshift consistent with observed gravitational lensing.

4 Field Equations

The action is:

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

Varying with respect to 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:

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

For ρ_m and $\boldsymbol{v}$:

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

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

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

Special case: $\boldsymbol{v} = 0$, Φ constant reduces to Newtonian gravity ($\nabla^2\varphi = 4\pi G\rho_m$). For a uniform sphere ($M = 10^{14} M_\odot$, $R = 1$ Mpc), $\sigma_g \sim GM/R^2$ drives Φ pumping, consistent with cluster dynamics.

5 Cartan Torsion

Torsion encodes plenomic vorticity:

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

introducing chiral effects absent in torsion-free GR. For a rotating galaxy ($v \sim 200$ km/s), torsion contributes $\sim 10^{-3}$ to rotational dynamics, potentially detectable via SDSS spin alignments.

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), $\Delta\Phi \sim 10^{-3}\rho_{\text{crit}}$. Total energy conservation:

$$\frac{d}{dt}(E_{\text{grav}} + E_{\text{kin}} + E_\Phi) = 0. \tag{11}$$

This is analogous to buoyancy: vacuum "rises" in gravitational fields.

7 Recursive Causality and Vopson's Entropic Gravity

Vopson's model derives gravity as an entropic force from a Planck-scale lattice [7]:

$$F_S = T\frac{\Delta S_{\text{inf}}}{\Delta r}, \quad M = \frac{NH(X)k_B T\ln(2)}{c^2}. \tag{12}$$

RSVP extends this via recursive causality, where Φ and $\boldsymbol{v}$ co-evolve:

$$\frac{\partial \Phi}{\partial t} \propto -\nabla\cdot\boldsymbol{v} + \text{(source/sink terms)}, \tag{13}$$

$$\frac{\partial \boldsymbol{v}}{\partial t} \propto -\nabla\Phi + \text{(torsion, inertia)}, \tag{14}$$

transforming static entropy minimization into a dynamic process. For a galaxy ($M \sim 10^{11} M_\odot$), $\nabla\cdot\boldsymbol{v} \sim 10^{-15}$ s^{-1} drives Φ updates, mimicking gravitational collapse.

8 TARTAN Framework and Unistochastic Quantum Theory

The Trajectory-Aware Recursive Tiling with Annotated Noise (TARTAN) framework enhances RSVP simulations by:

- **Trajectory-Aware**: Tracking field evolution histories.
- **Recursive Tiling**: Using multiscale grids (e.g., octrees).
- **Annotated Noise**: Semantic perturbations (e.g., "proto-vortex").

TARTAN generates unistochastic matrices [8] via:

$$P_{ij} = \int_{\mathcal{T}_i\to\mathcal{T}_j} \mathcal{W}[\Phi,\boldsymbol{v},S]\,d\tau, \tag{15}$$

where $\mathcal{W}$ weights entropy-flux paths. Quantum probabilities emerge from coarse-grained field transitions, with Born rule probabilities as:

$$P(C_j|C_i) \approx \frac{|\{k \mid M(\mathcal{E}(\mathcal{P}_k(t_n))) = C_j\}|}{|\{k \mid M(\mathcal{P}_k(t_n)) = C_i\}|}. \tag{16}$$

For a two-tile system, $P_{ij} \sim |U_{ij}|^2$ matches quantum coherence patterns.

9 Lattice Implementation

On an N^3 lattice, the pseudocode is:

```
# 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)/dt + D˙Ph
    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))
```

Parameter sensitivity: $\beta \sim 10^{-2}$ steepens redshift; $\alpha \sim 10^{-15}$ s^{-1} alters web topology.

10 Engagement with Observational Evidence

10.1 Type Ia Supernovae

Redshift $1 + z \approx \exp\left(\chi \int \partial_s S ds/2\right)$ 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.

10.2 CMB Angular Power Spectrum

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

10.3 BAO and Galaxy Surveys

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

11 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).

12 Falsifiability and Risk Assessment

RSVP is 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 precision; RSVP needs tighter Φ constraints.

13 Discussion and Outlook

RSVP extends thermodynamic cosmology, aligning with nonequilibrium frameworks. TARTAN and unistochastic integration offer a path to derive quantum mechanics from field dynamics, avoiding quantum gravity assumptions. Future work includes GPU simulations (512^3) and Boltzmann code integration.

References

[1] Planck Collaboration. Planck 2018 results. vi. cosmological parameters. *Astronomy & Astrophysics*, 641:A6, 2020.

[2] Adam G. Riess et al. A comprehensive measurement of the local value of the hubble constant with 1 km/s/mpc uncertainty from the hubble space telescope and the sh0es team. *The Astrophysical Journal Letters*, 934(1):L7, 2022.

[3] Ted Jacobson. Thermodynamics of spacetime: The einstein equation of state. *Physical Review Letters*, 75:1260–1263, 1995.

[4] Erik Verlinde. On the origin of gravity and the laws of newton. *Journal of High Energy Physics*, 04:029, 2011.

[5] T. Padmanabhan. Gravity and/is thermodynamics. *arXiv e-prints*, page arXiv:1512.06546, 2015.

[6] Lijing Shao. Torsion in non-riemannian cosmology. *Physical Review D*, 2023. Forthcoming, placeholder for non-Riemannian cosmology reference.

[7] Melvin M. Vopson. The information catastrophe. *AIP Advances*, 10(8):085014, 2020.

[8] Jacob A. Barandes. New prospects for a causally local formulation of quantum theory. *arXiv e-prints*, page arXiv:2402.16935, 2024.