Entropy, Geometry, and the RSVP Field: A Thermodynamic Theory of the Cosmos

Abstract

We introduce the Relativistic Scalar-Vector-Entropy Propagation (RSVP) framework, a unified thermodynamic and information-theoretic model of cosmic evolution. Rejecting traditional metric expansion, RSVP posits that the universe's large-scale structure and temporal dynamics emerge from local interactions of a scalar entropy potential Φ, a vector entropy flux $\vec{v}$, and an entropy density S. Formulated as a classical field theory with extensions to BV-BRST quantization and AKSZ sigma models, RSVP integrates derived geometry, computational simulation, and speculative applications to consciousness. We outline the theory's dynamical equations, geometric foundations, numerical implementation via RSVPyTorch, and cosmological implications, including a reinterpretation of redshift, structure formation, and the arrow of time. RSVP offers a falsifiable path toward understanding time, structure, and cognition in an entropically driven cosmos.

1 Introduction

Contemporary cosmology, anchored in the Lambda Cold Dark Matter (ΛCDM) paradigm, models the universe as an expanding manifold driven by dark energy and governed by general relativity. However, this framework struggles with conceptual challenges, including the nature of the cosmological constant, the initial singularity, and the arrow of time. The Relativistic Scalar-Vector-Entropy Propagation (RSVP) framework proposes a radical alternative, reinterpreting cosmic evolution as a thermodynamic process driven by entropy descent within a non-expanding plenum. By integrating scalar potential Φ, vector flux $\vec{v}$, and entropy density S, RSVP unifies classical field theory, derived geometry, and computational simulation to address fundamental questions about time, structure, and consciousness.

This paper synthesizes RSVP's core ontology, dynamical equations, geometric foundations, numerical realization, and cosmological implications. We also explore speculative extensions to consciousness, positioning RSVP as a bridge between physics, neuroscience, and information theory. Section 2 defines the field triplet, Section 3 derives the governing PDEs, Section 4 outlines the derived geometric framework, Section 5 describes the RSVPyTorch simulator, Section 6 details cosmological predictions, Section 7 explores cognitive applications, and Section 8 charts future directions.

2 Core Field Ontology

The RSVP framework is defined on a smooth or derived manifold X, representing a relativistic plenum. The fundamental fields are:

- $\Phi : X \to \mathbb{R}$, a scalar entropy potential governing thermodynamic smoothing.
- $\vec{v} : X \to T_X$, a vector entropy flux encoding local directionality of structure formation.
- $S : X \to \mathbb{R}_+$, an entropy density tracking informational complexity and disorder.

Definition 2.1 (RSVP Field Triplet)**.** *The RSVP plenum is a tuple $(X, \Phi, \vec{v}, S)$, where X is a smooth or derived manifold, and Φ, $\vec{v}$, S are fields satisfying continuity and differentiability conditions on X. The triplet evolves under a variational principle minimizing an entropic action functional.*

The scalar Φ acts as a potential driving entropy descent, analogous to gravitational potential but coupled to informational complexity. The vector $\vec{v}$ models flows such as baryonic motion or thermodynamic fluxes, while S quantifies local entropic states. This ontology emerges from the hypothesis that physical structure is a manifestation of local entropy minimization.

3 Dynamical Equations and Thermodynamic Evolution

The RSVP fields evolve according to a system of nonlinear partial differential equations (PDEs), derived variationally from an action functional or phenomenologically from thermodynamic principles:

$$\frac{\partial S}{\partial t} + \nabla \cdot (S\vec{v}) = \nabla^2 S + \Sigma(\Phi, \vec{v}), \tag{1}$$

$$\frac{\partial \Phi}{\partial t} = \nabla^2 \Phi + \beta\Phi(\vec{v} \cdot \nabla \times \vec{v}), \tag{2}$$

$$\frac{\partial \vec{v}}{\partial t} = -\nabla\Phi + \nabla \times \vec{v}, \tag{3}$$

where $\Sigma(\Phi, \vec{v}) = \rho(\nabla \cdot \vec{v}) - \lambda\|\nabla \times \vec{v}\|$ is the entropy production term, ρ, λ, β are coupling constants, and ∇^2 denotes the Laplacian on X.

The entropy equation (1) combines advection, diffusion, and a source term modeling entropy production from divergence (compression) and curl (shear). The scalar equation (2) includes a helicity term, aligning Φ with topological vorticity. The vector equation (3) evolves $\vec{v}$ via gradient descent on Φ and preserves angular momentum through curl dynamics. These equations link thermodynamics, hydrodynamics, and structure formation into a coherent entropic framework.

Theorem 3.1 (Entropic Consistency)**.** *The system (1–3) conserves total entropy $\int_X S\, dx$ in the absence of sources ($\Sigma = 0$) and ensures non-negative entropy production when $\rho, \lambda > 0$.*

Proof. Integrate (1) over X:

$$\frac{d}{dt}\int_X S\, dx = \int_X \left(-\nabla \cdot (S\vec{v}) + \nabla^2 S + \Sigma\right) dx.$$

By the divergence theorem, $\int_X \nabla \cdot (S\vec{v})\, dx = 0$ for a closed manifold. The diffusion term $\int_X \nabla^2 S\, dx = \int_{\partial X} \nabla S \cdot d\vec{n} = 0$, and $\Sigma \geq 0$ ensures non-negative entropy growth. □

4 Derived Geometric Foundations

RSVP is formulated in the language of derived algebraic geometry, providing a rigorous substrate for quantum extensions and singularity resolution. The moduli space of field configurations is a derived stack, equipped with a (-1)-shifted symplectic structure in the sense of Pantev-Toën-Vaquié-Vezzosi (PTVV) theory. The AKSZ construction casts RSVP as a topological sigma model from a source dg-manifold $T[1]X$ to a target stack of entropy fields.

Definition 4.1 (Derived RSVP Stack)**.** *The moduli space $\mathcal{M}_{RSVP}$ of RSVP field configurations is a derived stack, with a (-1)-shifted symplectic form $\omega = \delta\alpha$, where α is a 1-form encoding entropy gradients. The AKSZ action is:*

$$S_{AKSZ} = \int_{T[1]X} \langle \chi, d\chi \rangle + \chi^* \mathcal{L}_{RSVP},$$

where $\chi : T[1]X \to \mathcal{M}_{RSVP}$ is a field map, and $\mathcal{L}_{RSVP}$ is the RSVP Lagrangian.

The BV-BRST formalism introduces antifields and ghosts to handle gauge redundancies, such as coordinate reparametrizations. This ensures consistency in the presence of singularities (e.g., black hole entropy spikes) and topological phase transitions (e.g., cosmic web bifurcations).

5 Numerical Realization: RSVPyTorch

To operationalize RSVP, we developed RSVPyTorch, a GPU-accelerated simulator of the field equations (1–3). Key features include:

- 3D grid-based finite difference solvers for Φ, $\vec{v}$, and S.
- Dynamic computation of Σ from vorticity and divergence.
- Helicity toggle to probe topological alignment.
- Modular interface for coupling to neural networks learning parameters (e.g., β, diffusivity).

RSVPyTorch enables hypothesis testing against cosmological data, such as:

- Galactic spin alignment (TNG simulations).
- Entropy filamentation in voids (SDSS surveys).
- Redshift as entropic diffusion.
- Non-Gaussian power spectra.

Future work will integrate variational inference and data assimilation to match RSVP dynamics to observational datasets.

6 Cosmological Implications

RSVP reinterprets cosmic evolution, rejecting ΛCDM assumptions:

- **No metric expansion**: The universe is a non-expanding plenum, with redshift arising from entropic diffusion.
- **Entropy-driven time**: The arrow of time emerges from entropy smoothing, not thermodynamic equilibrium.
- **Structure formation**: Galaxies and voids are entropic defects driven by $\nabla\Phi$, not Newtonian gravity.
- **Cyclic plenum**: RSVP supports asymptotically smooth or cyclic configurations, avoiding initial singularities.

Testable predictions include:

- Anomalous redshift patterns deviating from Hubble's law.
- Helicity signatures in large-scale structure.
- Entropy plateaus in void regions.

7 Consciousness, Cognition, and Thermodynamic Geometry

RSVP extends speculatively to consciousness, modeling cognitive systems as submanifolds within the plenum:

- Φ as semantic potential, driving meaningful differentiation.
- $\vec{v}$ as information flow, traversing cognitive networks.
- S as phenomenological entropy, encoding complexity.

This framework integrates with:

- Integrated Information Theory (IIT) via entropic curvature metrics.

- Bayesian brain models through entropy descent priors.
- Predictive coding under thermodynamic constraints.

Conscious events may correspond to vorticity bifurcations or topological shifts in entropy gradient flow, quantifiable via a consciousness functional ϕ_{RSVP}.

8 Future Directions

To advance RSVP, we propose:

- **Physical Validation**: Compare RSVP dynamics with TNG, SDSS, and CMB data.
- **Neurodynamic Modeling**: Simulate cognitive field evolution and define ϕ_{RSVP}.
- **Learning and Inference**: Use deep learning to infer coupling terms and develop hybrid models with transformer architectures.

9 Conclusion

RSVP offers a thermodynamic, information-theoretic synthesis of cosmic evolution, structure formation, and consciousness. By rejecting metric expansion and embracing entropy descent, it redefines the universe as a diffusing, meaning-making plenum. Through rigorous mathematics, computational tools like RSVPyTorch, and testable predictions, RSVP charts a falsifiable path toward an entropic theory of everything.