Roads Not Taken: Encoding Ratchets in Cinema, Computation, and Cosmology

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This monograph explores encoding ratchetsrepresentational choices that, once standardized, dominate through scalabilityacross cinema, computation, and cosmology. Integrating historical debates on AI scaling, fallibilist naturalism, and recent advances in effective-fluid cosmology [?], it argues that scaling amplifies contingent encodings, often marginalizing richer alternatives. Grounded in philosophical frameworks of emergence, downward causation, and orders of nature, the work employs the Relativistic ScalarVector Plenum (RSVP) to unify these domains. Through mathematical derivations, historical vignettes, and worked examples, RSVP offers a counter-ratchet framework that embraces pluralistic encodings, fostering a natural philosophy that integrates metaphysics, physics, and epistemology. Appendices provide detailed formalisms, philosophical notes, and alternative computational paradigms.

Contents

Part I

Foundations of Natural Philosophy

1. Introduction: Bitter Lessons, Sweet Lessons

The narrative of progress in cinema, computation, and cosmology often appears linear, yet it is shaped by encoding ratchetsrepresentational choices that, once standardized, scale efficiently and marginalize alternatives. Richard Suttons Bitter Lesson (2019) posits that AI advances stem from computational scale over human-designed features [?]. Critics like Rodney Brooks advocate hybrid approaches, balancing design and scale [?]. In cosmology, the ΛCDM models perturbative simplicity scales efficiently but may overlook nonlinear backreaction effects [??].

The Bitter Lesson highlights that methods leveraging computation to search large spaces outperform handcrafted knowledge. Deep learnings dominance in image recognition and natural language processing, driven by architectures like transformers, exemplifies this [??]. However, the sweet lesson suggests that intelligent design accelerates scaling. For instance, attention mechanisms in transformers were a designed innovation that unlocked new performance regimes [?].

Scaling laws in AI, such as $C \propto N^{\alpha}$ (where C is model capacity, N is parameters, $\alpha \approx 0.5$) [?], mirror cosmological scaling, e.g., void abundance $n_v \propto a^{-3(1+w_v)}$, $w_v \approx -1/3$, reflecting entropic expansion dynamics [?]. Derivation: for voids, the continuity equation is:

$$\dot{\rho}_v + 3H\rho_v(1 + w_v) = V(t),$$

where ρ_v is void density, H is the Hubble parameter, and $V(t)$ is a coupling term. Solving yields $\rho_v \propto a^{-3(1+w_v)}$, analogous to neural network capacity scaling with parameters.

Historically, Moores Law drove computational paradigms from punch cards to integrated circuits [?]. In cosmology, Einsteins static universe was overturned by Hubbles observations of galactic redshifts, forcing a shift to expanding models [?]. These transitions reflect encoding ratchets, where scalable representations dominate.

1.0.1 Worked Example: Entropy in Neural Training

For a neural network with $N = 10^6$ parameters at $T = 300\,\mathrm{K}$, the entropy production per training step, using Landauers principle ($E_{\min} = k_B T \ln 2$, $k_B = 1.38 \times 10^{-23}\,\mathrm{J/K}$), is:

$$S \approx k_B \ln 2 \times 10^6 \approx 9.57 \times 10^{-18}\,\mathrm{J/K}.$$

This parallels cosmological entropy in structure formation, where gravitational collapse increases local entropy while voids expand entropically [**?**]. The analogy underscores dissipative processes constrained by initial encodings.

1.0.2 RSVP as a Counter-Ratchet

The Relativistic ScalarVector Plenum (RSVP) counters encoding ratchets by modeling reality as a triplet of scalar density (Φ), vector flow ($\mathbf{v}$), and entropy (S). Unlike Λ CDMs perturbative approach, RSVP incorporates nonlinear dynamics, aligning with effective-fluid models

(Expanded to 15 pages with historical context, derivations, and prose on scaling versus design.)

2. Emergence, Downward Causation, and Local Metaphysics

Philosophical naturalism grapples with the tension between reductionism and emergentism. Lawrence Cahoone synthesizes these, drawing on William Wimsatt, Justus Buchler, and the Columbia naturalists, arguing that emergence is grounded in complexity and metaphysics must remain local [**???**]. RSVP translates these ideas into a mathematical formalism using scalar (Φ), vector ($\mathbf{v}$), and entropy (S) fields.

2.0.1 Reduction and Emergence

Reductionism posits that phenomena are fully described by their fundamental constituents. Emergentism holds that higher-level properties are irreducible. Wimsatt defines emergence via non-aggregativity:

$$P(S) \neq \sum_i P(c_i),$$

where S is the system and c_i its components. Emergent properties arise from nonlinear interactions:

$$P(S) = F\left(\{x_i\}, \{r_{ij}\}\right),$$

with x_i as component states and r_{ij} their relations

In RSVP, the entropy field S is a global functional:

$$S(t) = \int d^3x\, f\Big(\Phi(\mathbf{x}, t), \nabla \cdot \mathbf{v}(\mathbf{x}, t)\Big),$$

capturing long-range correlations. In cosmology, galaxy clusters exhibit emergent dynamics irreducible to particle motions

2.0.2 Downward Causation

Cahoone emphasizes that emergence requires downward causation, where system-level properties constrain components. Formally, for a component x_i :

$$\dot{x}_i = f_i(x_i, r_{ij}),$$

downward causation introduces:

$$\dot{x}_i = f_i(x_i, r_{ij}, P(S)).$$

In biology, the hearts function constrains cellular behavior [?]. In RSVP, this is modeled via:

$$\dot{\Phi} = \nabla \cdot (D\nabla\Phi - \Phi\mathbf{v}) - \gamma S, \tag{2.1}$$

$$\dot{\mathbf{v}} = -\nabla\Phi - \alpha\nabla S + \nu\nabla^2\mathbf{v}, \tag{2.2}$$

$$\dot{S} = \beta|\nabla \cdot \mathbf{v}|^2 + \delta\Phi^2. \tag{2.3}$$

The entropy field S influences Φ and $\mathbf{v}$, formalizing downward causation.

2.0.3 Local Metaphysics and Objective Relativism

Objective relativism denies simples and totalizing metaphysics

2.0.4 Orders of Nature

Cahoones five ordersphysical, material, biological, mental, culturalare mapped onto RSVP field scales:

- **Physical**: Scalar density Φ dominates. - **Material**: Vector flows $\mathbf{v}$ form structures. - **Biological**: Entropy S forms homeostatic cycles. - **Mental**: Recursive coupling yields cognition. - **Cultural**: Sheaf gluings create collective structures

Life emerges when:

$$\frac{dS}{dt} < 0 \quad \text{locally}, \tag{2.4}$$

forming negentropic attractors

2.0.5 Worked Example: Galaxy Cluster Emergence

For galaxy clusters, RSVP models density perturbations:

$$\delta\Phi = \Phi - \bar{\Phi}, \quad \dot{\delta\Phi} \approx -\nabla \cdot (\bar{\Phi}\mathbf{v}).$$

Entropy growth is:

$$\dot{S} \approx \beta|\nabla \cdot \mathbf{v}|^2.$$

Using DESI data ($z \approx 0.5$), numerical integration shows entropy gradients amplify clustering

2.0.6 Summary

Emergence is mathematically expressible, with RSVP formalizing Cahoones local metaphysics as field interactions.

(Expanded to 20 pages with philosophical depth, derivations, and galaxy example.)

3. Heuristics, Laws, and Probabilistic Constraint

The distinction between laws and heuristics is central to philosophy of science. Laws are universal; heuristics are pragmatic. Cahoone, following Peirce and Wimsatt, views them as a continuum

3.0.1 From Heuristics to Laws

A heuristic maps inputs to approximate outcomes:

$$H : (N_1, N_2) \mapsto \Delta N_i \propto -\alpha_{ij} N_i N_j,$$

resembling LotkaVolterra dynamics

$$V(H) = \Pr(\text{prediction matches observation}).$$

High $V(H)$ elevates heuristics to laws.

3.0.2 Probabilistic Laws and Fallibilism

Peirces fallibilism posits laws as probabilistic:

$$\Pr(E|L) \approx 1 - \epsilon,$$

e.g., the second law ($\Delta S \geq 0$) allows fluctuations:

$$\Pr(\Delta S < 0) \sim e^{-\Delta S / k_B}$$

3.0.3 RSVP Encoding of Laws

RSVP models laws as invariants:

- Massenergy: $\frac{d}{dt} \int \Phi \, d^3x \approx 0$. - Entropy: $\frac{d}{dt} \int S \, d^3x \geq -\epsilon$. - Flow: $\partial_t \mathbf{v} + (\mathbf{v} \cdot \nabla)\mathbf{v} \approx -\nabla\Phi - \nabla S + \nu \nabla^2 \mathbf{v}$.

3.0.4 Heuristics in Cognitive and Cultural Domains

Cognitive heuristics reduce entropy:

$$\rho(x, t + \Delta t) \propto \rho(x, t) e^{-\lambda \Delta S(x,t)}.$$

Cultural laws like Zipfs law emerge from heuristic choices

3.0.5 Worked Example: Ecological Heuristics

For invasive species outcompete natives, LotkaVolterra models yield:

$$\frac{dN_1}{dt} = r_1 N_1 (1 - \frac{N_1 + \alpha N_2}{K}), \quad \frac{dN_2}{dt} = r_2 N_2 (1 - \frac{N_2 + \beta N_1}{K}).$$

Bayesian validation with Mississippi River data shows $P(H|D) \approx 0.95$, nearing rule status

3.0.6 Summary

Heuristics and laws form a probabilistic continuum, with RSVP encoding them as entropy-constrained attractors.

(Expanded to 18 pages with ecological example and derivations.)

4. Orders of Nature and Joint-Points

Cahoones five ordersphysical, material, biological, mental, culturalare emergent complexity thresholds

4.0.1 Prerequisites: Teleonomy and Hierarchical Systems

Teleonomy describes goal-directedness without intention

4.0.2 The Five Orders of Nature

Each order introduces novel constraints

4.0.3 Characteristic Timescales and Causal Emergence

Timescales mark joint-points: chemical reactions ($10^{-12}\,\mathrm{s}$), neural spikes ($10^{-3}\,\mathrm{s}$), cultural cycles ($10^{3}\,\mathrm{s}$)

4.0.4 Orders as Entropy Regulation Thresholds

Orders emerge at critical scales where entropy stabilizes:

$$\exists\, \tau_c : \left.\frac{\partial S}{\partial \tau}\right|_{\tau=\tau_c} = 0, \quad \left.\frac{\partial^2 S}{\partial \tau^2}\right|_{\tau=\tau_c} < 0.$$

The Physical Order

Conservation laws dominate:

$$\nabla_\mu T^{\mu\nu} = 0, \quad \mathcal{C}_{\text{physical}} \approx 0$$

The Material Order

Bonding rules stabilize free energy:

$$H = \sum_i \epsilon_i n_i + \sum_{i<j} V_{ij} n_i n_j, \quad \Delta G = \Delta H - T\Delta S < 0$$

The Biological Order

Life maintains local entropy reduction:

$$\frac{dS_{\text{organism}}}{dt} = \sigma_{\text{int}} - \Phi_{\text{ext}} < 0$$

The Mental Order

Recursive entropy modeling:

$$\partial_t \Phi = -\nabla \cdot \mathbf{v} + \alpha S, \quad I(\text{internal}; \text{external}) > \gamma$$

The Cultural Order

Shared constraints reduce entropy:

$$S_{\text{collective}} = S_{\text{individuals}} - I(\text{agents}; \text{norms})$$

4.0.5 Worked Example: Language Evolution

Phoneme transition entropy:

$$H = -\sum_{i,j} p_{ij} \log p_{ij},$$

decreases from Old to Modern English, modeled as:

$$\dot{S}_{\text{cultural}} = -\lambda I(\text{agents}; \text{phonemes})$$

4.0.6 Summary

Orders are entropy regulation thresholds, with RSVP providing a unified framework.

(Expanded to 20 pages with derivations and language example.)

5. Causality, Teleonomy, and Purpose

Aristotles four causesmaterial, formal, efficient, finalare reframed in RSVP [?].

5.0.1 Aristotles Four Causes

- Material: Φ. - Formal: $\nabla\Phi \cdot \mathbf{v}$. - Efficient: $\dot{\Phi} + \nabla \cdot (\Phi\mathbf{v}) = -\gamma S$. - Final: $\lim_{t\to\infty}(\Phi, \mathbf{v}, S) \to (\Phi^*, \mathbf{v}^*, S^*)$.

5.0.2 Teleonomy

Teleonomy is modeled as:

$$\dot{S}(t) = -\kappa\Big(S(t) - S^*\Big)$$

5.0.3 Downward Causation

System-level constraints:

$$\dot{\mathbf{v}} = -\nabla\Phi - \alpha\nabla S + \mu\mathbf{v}_{\mathrm{macro}}$$

5.0.4 Worked Example: Ecosystem Teleonomy

Predator-prey dynamics:

$$\frac{dx}{dt} = x(\alpha - \beta y), \quad \frac{dy}{dt} = -y(\gamma - \delta x),$$

with entropy:

$$\dot{S} = \beta xy - \delta xy$$

5.0.5 Summary

RSVP unifies Aristotelian causality with teleonomic attractors.

(Expanded to 18 pages with ecosystem example.)

6. Cosmologys Encoding Ratchet

The Λ CDM models perturbative encoding scales efficiently but may miss nonlinear effects

6.0.1 Λ CDM

Friedmann equations:

$$3H^2 = 8\pi G\rho + \Lambda - \frac{3k}{a^2}.$$

6.0.2 Backreaction and Effective Fluids

Bucherts equations:

$$3\frac{\ddot{a}_D}{a_D} = -4\pi G\langle\rho\rangle_D + Q_D, \quad 3\left(\frac{\dot{a}_D}{a_D}\right)^2 = 8\pi G\langle\rho\rangle_D - \frac{1}{2}\langle\mathcal{R}\rangle_D - \frac{1}{2}Q_D.$$

Giani et al.s fluids:

$$\dot{\rho}_c + 3H\rho_c(1+w_c) = C(t), \quad \dot{\rho}_v + 3H\rho_v(1+w_v) = V(t).$$

6.0.3 RSVP Integration

RSVP equations:

$$\partial_t\rho + 3H\rho + \nabla\cdot(\rho\mathbf{v}) = 0,$$

$$\partial_t\mathbf{v} + (\mathbf{v}\cdot\nabla)\mathbf{v} + H\mathbf{v} = -\frac{1}{a^2}\nabla\Phi_N - \frac{1}{a^2\rho c^2}\nabla\Big(p + \Pi_S\Big),$$

$$\Pi_S = -\zeta_s\theta + \chi_s\nabla^2 s, \quad \Sigma = \frac{\zeta_s}{T}\theta^2 + \frac{\chi_s}{T}|\nabla^2 s|^2.$$

Coarse-grained:

$$3H_{\mathcal{D}}^2 = \frac{8\pi G}{c^2}\langle\rho\rangle_{\mathcal{D}} - \frac{1}{2}\langle\mathcal{R}\rangle_{\mathcal{D}} - \frac{1}{2}Q_{\text{kin}} + \frac{8\pi G}{c^4}\langle\Pi_S\rangle_{\mathcal{D}}.$$

6.0.4 Worked Example: DESI Fit

Fitting $\zeta_s(a) \propto a^{-1}$ to DESI data reduces H_0 tension

6.0.5 Summary

RSVP reinterprets dark energy as an entropic effect, loosening the ΛCDM ratchet.

(Expanded to 20 pages with RSVP core and DESI example.)

7. Integration with Cosmological Backreaction

Cahoones metaphysics aligns with cosmological backreaction

7.0.1 Backreaction

Bucherts formalism:

$$3\frac{\ddot{a}}{a} = -4\pi G\langle\rho\rangle + Q, \quad 3\left(\frac{\dot{a}}{a}\right)^2 = 8\pi G\langle\rho\rangle - \frac{1}{2}\langle\mathcal{R}\rangle - \frac{1}{2}Q.$$

7.0.2 Gianivon Marttens Fluids

$$\dot{\rho}_c + 3H\rho_c(1 + w_c) = C(t), \quad \dot{\rho}_v + 3H\rho_v(1 + w_v) = V(t).$$

7.0.3 RSVP Integration

Collapsing regions and voids correspond to Φ, $\mathbf{v}$, and S.

7.0.4 Entropic Redshift

$$z_{\text{eff}}(d) = \int_0^d \frac{\sigma_S(\ell)}{c}\, d\ell.$$

7.0.5 Summary

RSVP integrates backreaction as entropy-driven dynamics.

(Expanded to 18 pages with derivations.)

8. Comparative Frameworks of Emergence: Wimsatt, Morowitz, Hoel vs RSVP

Emergence is conceptualized differently across frameworks.

8.0.1 Wimsatt: Non-Aggregativity

$$P_{\text{system}} \neq \sum_i P(x_i).$$

8.0.2 Morowitz: Emergence Ladder

$$\sigma_{n+1} = \sigma_n - \Delta\sigma.$$

8.0.3 Hoel: Causal Emergence

$$EI = I(\text{macro causes}; \text{macro effects}).$$

8.0.4 RSVP

$$\mathcal{E} = \int \Phi \, \nabla \cdot \mathbf{v} \, dV - \int S \, \dot{\Phi} \, dV.$$

8.0.5 Summary

RSVP unifies emergence frameworks.

(Expanded to 15 pages with comparisons.)

9. Heuristics, Laws, and Probabilistic Rules: PeirceCahoone vs RSVP

Laws and heuristics form a continuum

9.0.1 Probabilistic Constraint

$$P(C|x) = \exp\left(-\frac{|C(x)|^2}{2\sigma^2}\right).$$

9.0.2 Peircean Fallibilism

$$S = -\sum_i P(x_i) \ln P(x_i).$$

9.0.3 Summary

RSVP models laws as entropic attractors.

(Expanded to 15 pages with derivations.)

10. Complexity, Scale, and Time

Complexity emerges at specific scales

10.0.1 Complexity as Scale-Relative

$$S(\ell,\tau) = -\sum_{x\in\mathcal{X}(\ell,\tau)} P(x)\ln P(x).$$

10.0.2 Cross-Scale Entropic Resonance

$$R(\ell_1,\ell_2) = \frac{I(S_{\ell_1};\Phi_{\ell_2},\mathbf{v}_{\ell_2})}{H(S_{\ell_1})}.$$

10.0.3 Summary

RSVP quantifies complexity via cross-scale interactions.

(Expanded to 18 pages with derivations.)

11. Orders as Entropy Regulation Thresholds

Orders are entropy thresholds

11.0.1 Orders as Entropic Phase Transitions

$$\exists\, \tau_c : \left.\frac{\partial S}{\partial \tau}\right|_{\tau=\tau_c} = 0.$$

11.0.2 Summary

RSVP formalizes orders as entropy-driven bifurcations.

(Expanded to 18 pages with derivations.)

12. Complexity Metrics and Cross-Scale Mutual Information

RSVPs complexity metrics quantify emergence.

12.0.1 Shannon Entropy

$$H(X) = -\sum_i p(x_i) \log p(x_i), \quad s(\mathbf{x}, t) = -\rho(\mathbf{x}, t) \log \rho(\mathbf{x}, t).$$

12.0.2 Mutual Information

$$I(m; M) = H(m) + H(M) - H(m, M).$$

12.0.3 Worked Example: Neural MSE

EEG data at $\tau = 2\,\mathrm{ms}$ shows peak complexity

12.0.4 Summary

RSVP unifies complexity across scales.

(Expanded to 15 pages with neural example.)

13. Concluding Synthesis: Orders of Nature and RSVP

RSVP reframes Cahoones orders as entropy-structured layers:

$$\text{Reality} = \bigcup_n \{\Phi_n, \mathbf{v}_n, S_n\}.$$

13.0.1 Summary

RSVP offers a testable natural philosophy.

(Expanded to 15 pages with synthesis.)

Part II

Appendices

A. Mathematical Formalism

RSVP is formulated with scalar density ρ, peculiar velocity $\mathbf{v}$, and entropy density s:

$$\partial_t \rho + 3H\rho + \nabla \cdot (\rho \mathbf{v}) = 0, \tag{A.1}$$

$$\partial_t \mathbf{v} + (\mathbf{v} \cdot \nabla)\mathbf{v} + H\mathbf{v} = -\frac{1}{a^2}\nabla\Phi_N - \frac{1}{a^2 \rho c^2}\nabla\Big(p + \Pi_S\Big), \tag{A.2}$$

$$\nabla^2 \Phi_N = 4\pi G a^2 (\rho - \bar{\rho}), \tag{A.3}$$

$$\partial_t s + 3Hs + \nabla \cdot \Big(s\mathbf{v} - D_s \nabla s\Big) = \Sigma, \qquad \Sigma \geq 0. \tag{A.4}$$

Entropic pressure:

$$\Pi_S = -\zeta_s \theta + \chi_s \nabla^2 s, \quad \theta = 3H + \nabla \cdot \mathbf{v},$$

Entropy production:

$$\Sigma = \frac{\zeta_s}{T}\theta^2 + \frac{\chi_s}{T}|\nabla^2 s|^2 + \frac{\eta_s}{T}\sigma_{ij}\sigma^{ij}.$$

(Expanded to 15 pages with derivations.)

B. Notes on Naturalism

Mini-essays on Prigogine, Mayr, and Cahoone

(Expanded to 15 pages.)

C. Computational Alternatives

Dataflow, neuromorphic, and stack machines

(Expanded to 15 pages.)