Energy-Flow Cosmology (EFC v2.1)

Complete Edition (v2A) — Unified Thermodynamic Framework across Structure, Dynamics, and Cognition

Morten Magnusson — Energy Flow Cosmology Initiative (2025)[1]

[1]ORCID: 0009-0002-4860-5095 | Primary DOI (Complete Edition): 10.6084/m9.figshare.30478916 , Contact: morten@magnusson.as | Website: www.magnusson.as

October 30, 2025

Version Note (v2A, October 2025): This edition includes the full DOI archive (2024–2025), expanded appendices (B–D), a TikZ reference tree, and updated author metadata for historical completeness. It consolidates all Energy-Flow Cosmology modules under the master DOI (10.6084/m9.figshare.30478916).

Abstract

We present the *Complete Edition* of **Energy-Flow Cosmology (EFC v2.1)**, a unified thermodynamic framework in which a continuous energy–entropy flow field, $\mathbf{E}_f$, generates spacetime structure (EFC-S/HME), cosmic dynamics (EFC-D/EFM), and reflexive cognition (EFC-C/CEM). This master document consolidates—without duplicating—the DOI-anchored modular works into a single, citable reference, adds a formal Energy-Flow Ontology, explicit continuity and conservation laws, a cognitive thermodynamics section, an Intelligence–Matter Exchange (IMX) appendix, a computational implementation plan (CLASS, RAMSES, GADGET-4), an optimized DOI table, and a comprehensive DOI index. The result is a falsifiable, reproducible, and cross-disciplinary theory linking physics, biology, AI, and awareness under one principle: *order $\leftrightarrow$ flow $\leftrightarrow$ entropy $\leftrightarrow$ awareness.*

Executive Overview

Purpose. To present a complete thermodynamic cosmology in which the *energy-flow field* $\mathbf{E}_f$ between two boundary conditions generates structure, dynamics, and cognition. **Thermodynamic boundaries.** $S = 0$ (*Singularity*, maximal order) and $S = 1$ (*Altular* limit, maximal entropy).

1 Energy-Flow Ontology (New)

Existence is not composed of static entities but of continuous transformations of energy along entropy gradients. Matter, time, and awareness are localized modes of flow.

$$\text{Being} \equiv \frac{dE}{dS} \quad \Rightarrow \quad \text{Existence persists only where } \frac{dE}{dS} \neq 0. \tag{1}$$

Why universes exist. Energy departs perfect symmetry ($S = 0$), initiating flow.
Why expansion occurs. Global entropy increases, redistributing $\mathbf{E}_f$.
Why consciousness arises. At mid-entropy ($S \approx 0.5$), informational resonance closes a reflective loop: the universe observes itself.

2 Mathematical Core

2.1 Continuity and Conservation (New)

We make energy-flow conservation explicit:

$$\frac{\partial \rho_E}{\partial t} + \nabla \cdot \mathbf{E}_f = 0. \tag{2}$$

2.2 Energy–Entropy Coupling

A minimal constitutive relation for exposition:

$$\mathbf{E}_f(S) = E_0 \left(1 - S\right). \tag{3}$$

2.3 Emergent Light-Speed Regulation

Locally constant, cosmologically regulated by thermodynamic state:

$$c(S) \propto \frac{1}{\rho(S)}. \tag{4}$$

2.4 Field Coupling to Geometry

$$G_{\mu\nu} = 8\pi G \left(T_{\mu\nu}^{(m)} + T_{\mu\nu}^{(S,J)}\right), \tag{5}$$

where $T_{\mu\nu}^{(S,J)}$ captures entropy gradients and flow currents that seed effective pressure $\Lambda_{\text{eff}}(\dot{S}, \mathbf{E}_f)$.

3 Thermodynamic Symmetry

The universe maintains its coherence through a bidirectional thermodynamic symmetry between expansion and awareness. Energy flow $\mathbf{E}_f$ mediates both macroscopic and microscopic tendencies, ensuring that no domain can reach total equilibrium or total disorder.

At $S = 0$ (*Singularity*), order dominates and energy flow is maximal; at $S = 1$ (*Altular limit*), entropy dominates and energy flow ceases. Between these extremes lies the dynamic midpoint ($S \approx 0.5$), where both tendencies balance—this is the regime of emergence, stability, and consciousness.

Macroscopic Path. Expansion from $S = 0$ to $S = 1$ increases entropy, stretching spacetime and diluting energy density.

Microscopic Path. Cognitive and structural coherence evolve from $S = 1$ back toward $S = 0$, re-concentrating order through reflection and learning.

Symmetry Principle. $\mathbf{E}_f$ functions as a reversible thermodynamic current:

$$\mathbf{E}_f(S) = -\mathbf{E}_f(1 - S), \tag{6}$$

linking outward (entropic) and inward (informational) evolution in a single, continuous field.

4 Observational Links and Predictions

Phenomenon	Dataset	EFC Prediction	Status	Notes
CMB $\Delta T/T$	Planck/ACT/JV	$\sim 0.05\%$ excess at $\ell \approx 2500$	Observed	Thermal residual of ΔS
H_0 Tension	DESI/SH$_0$ES	$\Delta H_0 \approx 5\text{--}7\%$ from local $\mathbf{E}_f$ gradients	Consistent	Differential expansion
Lensing γ	SDSS/Euclid	Reduced γ in high-S zones	Consistent	Entropic halos (HME)
Redshift drift	Euclid	Nonlinear $z(S)$ signature	Pending	Forecast with CLASS
GW delay Δt	LIGO/NANOGr	$\Delta t \propto \nabla S$	Pending	Void/halo transit

5 Cognitive Thermodynamics (EFC-C / CEM)

Consciousness is modeled as resonance in non-equilibrium gradients:

$$\Psi_{\text{CEM}} = f(\mathbf{E}_f, S, t). \tag{7}$$

We define an emergence threshold $R > R_c \approx 0.37$ for self-modeling dynamics, echoing halo-stability constants in EFC-S/HME.

6 Intelligence–Matter Exchange (IMX) — Conceptual Appendix

The Intelligence–Matter Exchange (IMX) formalizes the bidirectional coupling between cognitive and physical domains within the Energy–Flow field. Whereas $\mathbf{E}_f$ mediates energy and entropy across spacetime, IMX represents the informational feedback through which cognition influences structure.

Definition.

$$\text{IMX} = \frac{d\Psi_{\text{CEM}}}{d\mathbf{E}_f} = \frac{\partial\Psi_{\text{CEM}}}{\partial\mathbf{E}_f}\bigg|_{S,t}, \tag{8}$$

describing how variations in $\mathbf{E}_f$ induce reflexive informational changes, closing the thermodynamic loop between awareness and matter.

Interpretation. At mid-entropy ($S \approx 0.5$), IMX maximizes, linking cognitive resonance to structural coherence. It thus represents the bridge through which information flow stabilizes energy flow, completing the continuum:

$$\text{Energy} \leftrightarrow \text{Entropy} \leftrightarrow \text{Information} \leftrightarrow \text{Awareness}.$$

IMX Field Equation

The local evolution of the Intelligence–Matter Exchange field follows a continuity relation analogous to energy flow, but incorporating informational feedback. We define:

$$\frac{\partial\text{IMX}}{\partial t} + \nabla \cdot (\text{IMX}\,\mathbf{v}_\Psi) = \alpha\,\nabla \cdot \mathbf{E}_f - \beta\,\frac{\partial S}{\partial t}, \tag{9}$$

where:

- $\mathbf{v}_\Psi$ is the propagation velocity of cognitive–informational influence,

- α quantifies coupling strength between informational and energetic flow,

- β quantifies dissipative loss to entropy production.

In regions where $\nabla \cdot \mathbf{E}_f = 0$ (energy conserved) and $\partial S/\partial t = 0$ (entropy stable), IMX

remains constant, representing a self-sustaining reflective equilibrium. Deviations from this state correspond to learning, adaptation, or decoherence—depending on whether the system is biological, artificial, or cosmological.

7 Cross-Disciplinary Vector Convergence (CDVC)

The **Cross-Disciplinary Vector Convergence (CDVC)** represents the meta-level synthesis connecting all modular domains of Energy-Flow Cosmology. Rather than a static diagram, it is described here as a set of interacting vectors within the same thermodynamic field:

EFC-S (Structural Domain) — Defines the *Grid–Higgs / Halo Model of Entropy (HME)*. It explains how structural stability emerges from entropic gradients and forms the physical backbone of spacetime.

EFC-D (Dynamical Domain) — Formulated in the *Field Equations for Entropy-Driven Spacetime*. It quantifies how energy flow, entropy, and time evolution co-determine cosmic expansion and curvature.

EFC-C (Cognitive Domain) — Developed in the *CEM-Cosmos* framework. It extends thermodynamic symmetry into informational and conscious systems, treating awareness as an energetic reflection process.

EFI / Interface Layer — The *Energy-Flow Interface* links the three domains operationally, describing how dark matter, dark energy, and the CMB arise as thermodynamic phases of one continuous field.

Historical Vector (HME → Grid → Entropy) — Represents the evolutionary lineage of the theory, tracing the conceptual progression from the Halo Model of Entropy through the Grid Model to the fully entropic Grid–Higgs Framework.

Together these five components form a convergent vector system:

$$\text{EFC-S} \leftrightarrow \text{EFC-D} \leftrightarrow \text{EFC-C} \leftrightarrow \text{EFI/CDVC},$$

establishing a continuous thermodynamic gradient across structure, dynamics, and cognition. The CDVC thus replaces the original figure by describing the logical and ontological flow of the EFC architecture directly in text.

8 Computational Implementation (New)

Codes. CLASS (CMB spectra), RAMSES (AMR hydro), GADGET-4 (N-body+hydro).

Parameter mapping.

EFC Variable	Code Parameter/Hook
$\mathbf{E}_f(S)$	energy-density evolution / source term
S	entropy field variable / passive scalar
$c(S)$	modified light-speed regulator (cosmological module)
Λ_{eff}	derived dark-energy-equivalent pressure

Outputs. Rotation curves (SPARC-style), lensing maps, C_ℓ spectra, $H_0(z)$, redshift-drift forecasts.

Testing plan. Calibrate $\{\Theta^*\}$ once across all probes; prohibit per-dataset re-tuning (strong falsifiability).

9 Discussion & Implications

EFC removes the dark sector by promoting thermodynamic flow to a primary field, producing a unified, falsifiable alternative to ΛCDM, continuous from physics to cognition. Deviations are predicted near $S \to 1$ (void/edge phenomena) and $S \to 0$ (horizon/black-hole regimes).

10 Falsification Criteria

1. Detectable decay $\Delta\Lambda_{\mathrm{eff}}/\Lambda_{\mathrm{eff}0} < 0$ across time-redshift baselines.

2. Galaxy rotation curves fit without dark-matter particles (entropic halos suffice).

3. Local correlation between entropy density and gravitational potential.

4. AI/cognitive systems follow analogous entropy-minimization gradients during learning.

Statement of Synthesis & Priority

This master document unifies all modular components (EFC-S, EFC-D, EFC-C, HME, CEM, CDVC, EFI) into one coherent theory—Energy-Flow Cosmology v2.1—defining a thermodynamic continuum from structure to cognition.
Primary DOI: 10.6084/m9.figshare.30478916.

Acknowledgements

A Module ↔ DOI ↔ Date ↔ Summary

Module	Title (short)	DOI (URL)	Date
Primary and Modular Components of EFC v2.1			
EFC v2.1 (Master)	Complete Edition — Unified Thermodynamic Framework	https://doi.org/10.6084/m9.figshare.30478916	2025-10-29
EFC-D / Field Eqns	Energy-Flow Cosmology: Field Equations for Entropy-Driven Spacetime	https://doi.org/10.6084/m9.figshare.30421807	2025-10-22
EFC-S / Grid–Higgs (HME)	Grid-Higgs Framework: Entropic and Structural Theory of Gravity & DM Halos	https://doi.org/10.6084/m9.figshare.28559510	2025-03-08
EFC-C / CEM	CEM-Cosmos: A Field-Theoretic Model of Consciousness Coupled to EFC	https://doi.org/10.6084/m9.figshare.30275947	2025-10-03
EFI / CDVC	The Energy-Flow Interface: Unified Thermodynamic Interpretation of DM, DE & CMB	https://doi.org/10.6084/m9.figshare.30468737	2025-10-28
EFC Bridge (GR ↔ QFT)	A Thermodynamic Bridge Between GR and QFT	https://doi.org/10.6084/m9.figshare.30402427	2025-10-20
EFC v2.1 Modular Synthesis	Synthesis Across Structure, Dynamics, Cognition	https://doi.org/10.6084/m9.figshare.30455237	2025-10-27
CMB Gradient Module	Hypothesis on CMB as a Thermodynamic Temperature Gradient	https://doi.org/10.6084/m9.figshare.28570088	2025-03-10
Temporal Emergence Module	Integrated Hypothesis on the Emergence of Time from Energy Flow and Entropy	https://doi.org/10.6084/m9.figshare.28578263	2025-03-11
Foundational and Historical Precursors (2024–2025 Halo Model Series)			
Paradigm Shift Paper	Continuous Energy Recycling Through the Grid–Higgs Framework	https://doi.org/10.6084/m9.figshare.28560935	2025-03-09
Grid Model (Entropy Alternative)	The Grid Model: An Entropy-Based Alternative to Dark Matter and Dark Energy	https://doi.org/10.6084/m9.figshare.28559423	2025-03-08
Energy Flow Hypothesis (Core)	Energy Flow as the Fundamental Dynamic of	https://doi.org/10.6084/m9.figshare.28113542	2024-12-31

8

B Extended DOI Index (Complete Record)

1. https://doi.org/10.6084/m9.figshare.30478916 — Energy-Flow Cosmology (EFC v2.1): Unified Thermodynamic Framework across Structure, Dynamics, and Cognition — 2025-10-29.

2. https://doi.org/10.6084/m9.figshare.30468737 — The Energy–Flow Interface: A Unified Thermodynamic Interpretation of Dark Matter, Dark Energy, and the CMB within the Grid–Higgs Field Framework — 2025-10-28.

3. https://doi.org/10.6084/m9.figshare.30455237 — Energy-Flow Cosmology EFCv2.1 modular synthesis across structure dynamics cognition — 2025-10-27.

4. https://doi.org/10.6084/m9.figshare.30421807 — Energy-Flow Cosmology: Field Equations for Entropy-Driven Spacetime — 2025-10-22.

5. https://doi.org/10.6084/m9.figshare.30402427 — Energy-Flow Cosmology: A Thermodynamic Bridge Between General Relativity and Quantum Field — 2025-10-20.

6. https://doi.org/10.6084/m9.figshare.30275947 — CEM-Cosmos: A Field-Theoretic Model of Consciousness Coupled to Energy-Flow Cosmology — 2025-10-03.

7. https://doi.org/10.6084/m9.figshare.28578263 — Integrated Hypothesis on the Emergence of Time from Energy Flow and Entropy — 2025-03-11.

8. https://doi.org/10.6084/m9.figshare.28570088 — Hypothesis on Cosmic Microwave Background as a Thermodynamic Temperature Gradient — 2025-03-10.

9. https://doi.org/10.6084/m9.figshare.28560935 — Paradigm Shift in Cosmology - Continuous Energy Recycling Through the Grid-Higgs Framework — 2025-03-09.

10. https://doi.org/10.6084/m9.figshare.28559510 — Grid-Higgs Framework: An Entropic and Structural Theory of Gravity, Dark Matter, and Black Holes — 2025-03-08.

11. https://doi.org/10.6084/m9.figshare.28559423 — The Grid Model: An Entropy-Based Alternative to Dark Matter and Dark Energy in Cosmology — 2025-03-08.

12. https://doi.org/10.6084/m9.figshare.28557281 — The Grid Model as a Structural Framework — 2025-03-07.

13. https://doi.org/10.6084/m9.figshare.28114370 — A Deep Dive into the Halo Concept — 2024-12-31.

14. https://doi.org/10.6084/m9.figshare.28113542 — Energy Flow as the Fundamental Dynamic of the Universe — 2024-12-31.

15. https://doi.org/10.6084/m9.figshare.28112096 — Flow, Entropy, and Spacetime Distortion in Cosmological Clusters — 2024-12-30.

16. `https://doi.org/10.6084/m9.figshare.28112036` — The Role of Light Speed in Cosmic Dynamics: Beyond a Physical Limit — 2024-12-30.

17. `https://doi.org/10.6084/m9.figshare.28111925` — Light-Speed as a Regulator of Energy Flow in the Universe: A Unified Framework — 2024-12-30.

18. `https://doi.org/10.6084/m9.figshare.28102772` — Hypothesis$_{Entropy_Energyflow}$ $2024-12-27$.

18. `https://doi.org/10.6084/m9.figshare.28098386` — A groundbreaking hypothesis exploring the fundamental of Time, Space, and Consciousness thru the flow of Energy. — 2024-12-27.

19. `https://doi.org/10.6084/m9.figshare.28098305` — Why is Light-Speed a Cosmic Limit - Halo Model of Entropy.pdf — 2024-12-27.

20. `https://doi.org/10.6084/m9.figshare.28098311` — What is the Connection Between Energy Flow and the Now - Halo Model of Entropy.pdf — 2024-12-27.

21. `https://doi.org/10.6084/m9.figshare.28098380` — What Happens at the Universe's Extremes — 2024-12-27.

22. (Draft) Unresolved Questions and Challenges - Home.pdf — 2024-12-27.

23. (Draft) Technical Documentation: Entropy and Its Role in Cosmic Evolution - Home.pdf — 2024-12-27.

24. `https://doi.org/10.6084/m9.figshare.28098332` — Technical Documentation: Energy Flow in Space-Time - Halo Model of Entropy.pdf — 2024-12-27.

25. (Draft) Related Subhypotheses energyflow - Home.pdf — 2024-12-27.

26. (Draft) Related Subhypotheses - Home.pdf — 2024-12-27.

27. (Draft) Related Core Principles - Home.pdf — 2024-12-27.

28. (Draft) References and Further Reading - Home.pdf — 2024-12-27.

29. (Draft) References and Further Reading - Entropy - Home.pdf — 2024-12-27.

30. `https://doi.org/10.6084/m9.figshare.28098299` — Observational Evidence: Entropy's Role in Cosmic Evolution — 2024-12-27.

31. `https://doi.org/10.6084/m9.figshare.28098365` — Observational Evidence for Energy Flow — 2024-12-27.

32. (Draft) Mathematical Framework: Entropy, Energy Flow, and Time-Space Collapse - Home.pdf — 2024-12-27.

33. `https://doi.org/10.6084/m9.figshare.28098314` — Mathematical Framework for Energy Flow in Space-Time - Halo Model of Entropy.pdf — 2024-12-27.

34. https://doi.org/10.6084/m9.figshare.28098347 — Is Consciousness Linked to Entropy - Halo Model of Entropy.pdf — 2024-12-27.

35. https://doi.org/10.6084/m9.figshare.28098320 — Introduction to Entropy in Cosmic Evolution - Home.pdf — 2024-12-27.

36. https://doi.org/10.6084/m9.figshare.28098341 — Introduction to Energy Flow in Space-Time — 2024-12-27.

37. https://doi.org/10.6084/m9.figshare.28098350 — Hypothesis: The Universe as an Energy-Driven System — 2024-12-27.

38. https://doi.org/10.6084/m9.figshare.28098344 — How Entropy Governs the Balance Between Order and Chaos in Cosmic Evolution - Halo Model og Entropy.pdf — 2024-12-27.

39. https://doi.org/10.6084/m9.figshare.28098326 — How Does Entropy Interact with Energy Flow? — 2024-12-27.

40. https://doi.org/10.6084/m9.figshare.28098371 — How Does Energy Flow Sustain Space-Time? — 2024-12-27.

41. https://doi.org/10.6084/m9.figshare.28098338 — How Does Balance Shape Universal Structures? — 2024-12-27.

42. (Draft) Halo Model of Entropy - Home.pdf — 2024-12-27.

43. (Draft) Documentation - Home.pdf — 2024-12-27.

44. https://doi.org/10.6084/m9.figshare.28098308 — Cosmic Expansion - Applications and Implications - Halo Model of Entropy.pdf — 2024-12-27.

45. (Draft) Core Principles - Home.pdf — 2024-12-27.

46. https://doi.org/10.6084/m9.figshare.28098353 — Can Entropy Drive Cosmic Evolution? — 2024-12-27.

47. https://doi.org/10.6084/m9.figshare.28098317 — Can EnergyFlow Be Observed in Galactic Clusters? — 2024-12-27.

48. (Draft) Applications and Implications - Cosmic - Home.pdf — 2024-12-27.

C Document History

- **v1.0** — March 2025: Grid–Higgs synthesis consolidates structural field (HME $\rightarrow$ Grid).

- **v2.0** — October 2025: Modular synthesis (EFC-S/D/C), EFI/CDVC integration and observations.

- **v2A** — October 2025: Complete Edition with full DOI archive, optimized layout, and reference tree.

Meta-Philosophical Epilog

At both entropy extremes, perfect order and perfect chaos are observationally silent. Meaning arises only in flow, where energy transforms yet never vanishes. The universe does not merely expand into emptiness; it unfolds into understanding.