

The Energy–Flow Interface: A Unified Thermodynamic Interpretation of Dark Matter, Dark Energy, and the CMB — within the Grid–Higgs Field Framework

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Abstract

The standard Λ CDM model treats dark matter, dark energy, and the cosmic microwave background (CMB) as independent phenomena. Energy–Flow Cosmology (EFC) proposes that they are three thermodynamic phases of a single underlying medium, the Grid–Higgs field. Dark energy corresponds to the divergent, high–entropy phase; dark matter to the convergent, low–entropy phase; and the CMB to the isothermal membrane where their fluxes balance. This framework replaces three disconnected “dark” components with one continuous energy–entropy mechanism and yields testable predictions linking CMB anisotropies, dark–matter distributions, and dark–energy evolution.

1 Introduction

In Λ CDM cosmology, dark matter (DM), dark energy (DE), and the CMB are introduced as unrelated components. Their respective energy densities ($\Omega_{\text{DM}} \approx 0.27$, $\Omega_{\Lambda} \approx 0.69$) reproduce observations but lack a common physical cause. The EFC framework interprets these quantities as manifestations of a single energy–flow field J^μ embedded in the Grid–Higgs background, where entropy S determines local dynamics.

2 Field Framework

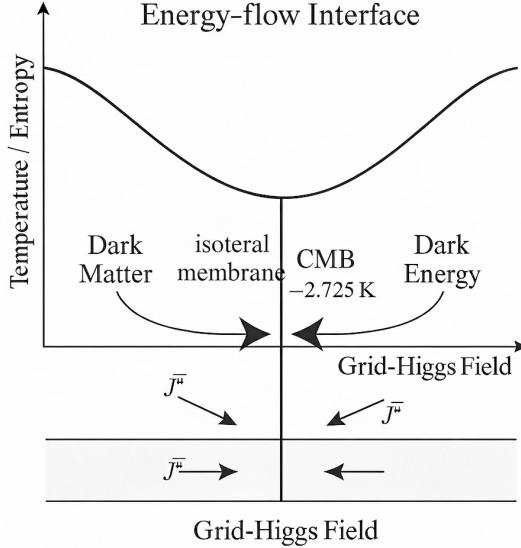
The Grid–Higgs field is described by

$$\mathcal{L} = \frac{1}{2}(\partial_\mu \Phi)^2 - V(\Phi, S), \quad (1)$$

with field variable Φ and local entropy S . Energy transport is represented by the flux vector J^μ satisfying

$$\nabla_\mu J^\mu = \frac{\partial V(\Phi, S)}{\partial S}. \quad (2)$$

Three regimes naturally arise:



- **Convergent flow** ($\nabla_\mu J^\mu < 0$): local condensation \rightarrow dark-matter behavior.
- **Null-flux interface** ($\nabla_\mu J^\mu \approx 0$): thermal equilibrium \rightarrow CMB.
- **Divergent flow** ($\nabla_\mu J^\mu > 0$): global expansion \rightarrow dark-energy behavior.

3 The CMB as an Energy–Flow Interface

In this picture, the CMB is not a fossil radiation field but the present thermodynamic boundary between the two phases of the Grid–Higgs field. Its measured temperature $T_{\text{CMB}} = 2.725 \text{ K}$ represents the equilibrium condition where the net flux vanishes. Small anisotropies ($\Delta T/T \sim 10^{-5}$) are interpreted as oscillations in this interface, coupling local convergent and divergent zones.

Energy–Flow Interface schematic. Convergent (dark–matter) and divergent (dark–energy) regimes of the Grid–Higgs field meet at an isothermal boundary representing the CMB.

4 Thermodynamic Triad and Predictions

The EFI model forms a triad:

$$\begin{aligned} \text{Dark Matter} &\Rightarrow \text{structural energy (local condensation),} \\ \text{Dark Energy} &\Rightarrow \text{latent energy (global pressure),} \\ \text{CMB} &\Rightarrow \text{thermal energy (equilibrium surface).} \end{aligned}$$

Predictions include:

1. Correlation of CMB anisotropies with dark–matter density fields.
2. Weak coupling between T_{CMB} and dark–energy equation–of–state $w(z)$.
3. Phase shift between ISW signal and dark–matter surfaces in large–scale maps.

5 Discussion and Outlook

By interpreting DM, DE, and CMB as phases of a single energy–flow field, EFC resolves the “coincidence problem” and offers a unified thermodynamic description of cosmic structure. Future work will implement the EFC equations in numerical solvers such as CLASS and GADGET–4, enabling Bayesian comparison with Λ CDM.

6 Conclusion

Dark matter and dark energy are the inward and outward phases of the same energy–flow field; the CMB is the thermodynamic membrane where their fluxes balance. This model invites re-examination of the cosmic “dark sector” as an emergent property of the Grid–Higgs energy continuum.

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