Energy-Flow Cosmology (EFC) Formal Specification

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1 Introduction

Energy-Flow Cosmology (EFC) is a thermodynamic framework in which structure, dynamics, and observable propagation all emerge from the interaction between the entropy field S, the energy–flow field E_f, and the grid-level resistance that shapes how energy and light move through spacetime.

This document defines the mathematical objects, structural relationships, and dynamical laws that form the formal specification of EFC.

2 Foundations of EFC

The two core scalar fields of EFC are:

- the entropy field $S(\mathbf{x})$;

- the energy–flow field $E_f(\mathbf{x})$.

All dynamical and observable quantities are derived from these.

2.1 Entropy Field

The entropy field $S(\mathbf{x})$ encodes the resistance of the grid and defines the focusing and defocusing tendencies of both energy and light.

Two dynamic endpoints bound the entropy domain:

S_0 (s$_0$: low entropy, high structure), $\qquad$ S_1 (s$_1$: high entropy, structural loosening).

The midpoint and entropy span are:

$$S_{\mathrm{mid}} = \frac{1}{2}(S_0 + S_1), \qquad \Delta S = S_1 - S_0.$$

3 Dynamical Sector (EFC-D)

The energy-flow field is defined as:

$$E_f : \mathbb{R}^3 \to \mathbb{R}.$$

It describes the directional flow of energy along entropy gradients.

3.1 Energy-Flow Potential

The effective potential that governs structural and dynamical behavior is:

$$\Phi(E_f, S) = A_\Phi \, E_f \, (1 + S).$$

More general couplings such as

$$\Phi = A_\Phi E_f (1 + S^\beta)$$

may be introduced but are not implemented in the baseline model.

3.2 Circular Velocity Relation

Rotation curves follow:

$$v(r) = \sqrt{r\,\frac{\partial \Phi}{\partial r}}\,.$$

Here the observed behavior depends both on Φ and the entropy-modified light propagation defined in the next section.

4 Light Propagation in EFC

4.1 Effective light speed as a derived quantity

In EFC, the speed of light is not a universal constant. It is an *effective* propagation speed that emerges from the entropy field S, the s_0–s_1 endpoint structure, and the resistance of the energy–flow grid.

Definition. Let S_0 and S_1 denote the endpoint entropies. Define

$$S_{\mathrm{mid}} = \frac{1}{2}(S_0 + S_1), \qquad \Delta S = S_1 - S_0, \qquad x(S) = \frac{S - S_{\mathrm{mid}}}{\Delta S/2}.$$

The effective speed of light is then

$$c(S) = c_0 \left(1 + a_{\mathrm{edge}}\, x(S)^2\right), \tag{1}$$

with c_0 the baseline mid-entropy speed and $a_{\mathrm{edge}} > 0$ a dimensionless parameter controlling enhancement toward the endpoints.

Interpretation.

- $c(S)$ is minimal in the mid-entropy regime.

- $c(S)$ increases smoothly as $S \to S_0$ (focusing).

- $c(S)$ increases smoothly as $S \to S_1$ (defocusing).

Implications. Light propagation depends on the path integral

$$t_{\mathrm{obs}} = \int_{\gamma} \frac{dl}{c(S(l))},$$

meaning that all observable quantities that rely on null propagation (time delays, redshift–distance relations, lensing patterns) must be computed using $c(S)$ rather than a fixed constant c.

This entropy-dependent propagation law is therefore a central element in the formal EFC framework.

4.2 Light Travel Times and Lensing

The observable travel time of a photon following trajectory γ is:

$$t_{\mathrm{obs}} = \int_{\gamma} \frac{dl}{c(S(l))}.$$

Consequences include:

- faster propagation near s_0 and s_1 (enhanced $c(S)$);

- modified magnification and distortion patterns;

- altered time-delay ratios even with identical mass distributions;

- redshift–distance relations dependent on the entropy field.

5   Structural Sector (EFC-S)

Structures in EFC arise from the interplay of S, E_f, $\Phi(E_f, S)$, and the effective light speed $c(S)$. The mid-entropy region where $c(S)$ is minimal forms a natural stability band for halo-like configurations.

6   Conclusion

This formal specification defines the mathematical backbone of Energy-Flow Cosmology: the entropy field, the energy-flow field, the effective potential, and the emergent propagation law $c(S)$ that shapes all null-propagation observables.