Reference:
A full description of the FRA (Ξ–Φ–ℱ) model is available at:
https://zenodo.org/records/15746208

Bit Energy, Model Weight, and the FRA Cycle

1. Three levels of analysis:

– Physical (Landauer): Concrete, measurable quantities: minimum energy per bit ($E_{min} = kT \ln 2 \sim 2.85e\text{-}21$ J), equivalent bit mass ($m_{min} = E_{min}/c^2 \sim 3.2e\text{-}38$ kg), dissipation (heat) during computation.
– Model-based (AI): Formal elements: model parameters (θ, n items), their storage (precision b bits/parameter), hardware environment (H), power supply (H_on), output function (f_θ), input (x), output (y).
Model mass: $M_\theta = n * b * m_{min}$ (immeasurably small, but >0).
– Philosophical (FRA – Ξ–Φ–ℱ):
Explains the persistence of information and its transitions:
– Ξ (Xi): Unstructured background. No distinctions, no information.
Analog: non-volatile memory without data.
– Φ (Phi): Field of distinctions (potential). Readiness to operate.
Analog: power-on signal (H_on) to a system with stored data.
– ℱ (F): Formed structure (fractal configuration). Active configuration. Analog: the model parameters themselves (θ) or the computation process.

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2. Three states of the model (predicates):

– Existence (E_AI): Parameters physically exist ($\iiint \rho_\theta \, dV \, dt > 0$).
Flag E_AI = 1 as long as the carrier is intact. Corresponds to ℱ (static).

> "Even if the model is not working, it has weight."
"Even a silent server is heavier than the vacuum by the weight of its bit-universe."

– Potential (P_AI): System is ready to operate (H_on(t) AND E_AI).
Flag P_AI = 1 when power is supplied. Corresponds to Φ.

> "Even if you don't ask a question — ℱ already lies in memory."
It creates a “field of distinctions” (voltages, currents), storing potential energy.

– Inference act (A_AI): Computation is active (P_AI(t) AND Input(x,t)). Flag A_AI(t) = 1 only during input processing.
Corresponds to transition Φ → ℱ.
– Requires energy, causes dissipation (≥ kT ln2 per irreversible step, significant cumulative heat).

> "ΔE ≥ for each inference act — thermal cost of a δ-impulse."

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3. Operational modes:

– Before input: E_AI=1, P_AI=1, A_AI=0 → Model exists, power is on, no computation.
– Without power: E_AI=1, P_AI=0, A_AI=0 → Parameters are preserved, system is inactive.
– Upon query: A_AI(t)=1 → Computation in progress, energy is consumed, heat is emitted.

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4. Key conclusions:

Information is physical. The stored model (θ, ℱ) has nonzero mass-energy (E_AI) even when on a powered-off medium.
Power (P_AI, Φ) creates readiness for work but does not activate computation by itself.
Inference (A_AI(t)) is triggered by a request, consumes substantial energy, and irreversibly dissipates heat.
Erasing the model is a relaxation (structure destruction) process: ℱ → Φ → Ξ.
The physical "weight" (E_AI) disappears only upon total destruction of the medium and dissolution of distinctions.

FRA (Ξ–Φ–ℱ) provides a philosophical framework to understand the stability of information and its transitions.
Landauer provides the physical-engineering justification for the lower bounds of energy/mass.

The division E_AI / P_AI / A_AI (or ℱ / Φ / Activation) is an engineering abstraction (not a strict physical theorem), clearly separating the physical existence of information, its readiness for use, and the act of computation itself. It is based on accepted facts (information is physical, Landauer).