Chapter 39: Entropy and the Second Law T0 Perspective (As of December 2025)

1 Chapter 39: Entropy and the Second Law

The Second Law of Thermodynamics the entropy of an isolated system never decreases is one of the most fundamental laws of physics. It explains the arrow of time and irreversibility of macroscopic processes. In statistical mechanics (Boltzmann, Gibbs), it is interpreted as a statistical tendency: microstates evolve toward equally distributed macrostates.

Current Status (December 2025): The Second Law is empirically extremely well confirmed, but its fundamental origin remains debated. In quantum mechanics and gravitation (e.g., Hawking radiation, information paradox), tensions arise. No unified microscopic derivation without assumptions (e.g., low initial entropy in the universe).

Fractal FFGFT (based on T0-theory) offers an alternative explanation: The Second Law emerges as a consequence of the directed evolution of the vacuum phase θ, with parameter $\xi = \frac{4}{3} \times 10^{-4}$ (dimensionless).

Advantage of the T0 perspective: Irreversibility is structurally built in not a statistical assumption, but physical necessity from vacuum dynamics.

1.1 Time as Vacuum Phase Progress

In T0, proper time τ is linked to phase progress:

$$d\tau = \xi \cdot d\theta, \tag{1}$$

where:

- $d\tau$: Proper time element (in s),
- $d\theta$: Phase change (in radians, dimensionless),
- ξ: Scale parameter (dimensionless).

Phase evolves directionally:

$$\dot{\theta} = \omega_0 + \xi \cdot \nabla\theta > 0, \tag{2}$$

through fractal hierarchy (self-similarity enforces forward direction).

Validation: Consistent with observed arrow of time; backward run energetically forbidden.

1.2 Entropy as Phase Disorder

Entropy S measures phase incoherence:

$$S = k_B \cdot \ln \Omega \approx k_B \cdot \langle (\Delta\theta)^2 \rangle / \xi, \tag{3}$$

where:

- S: Entropy (in J/K),
- k_B: Boltzmann constant ($\approx 1.381 \times 10^{-23}$ J/K),
- $\Delta\theta$: Phase scatter (dimensionless).

Coherent state ($\Delta\theta \approx 0$): Low entropy. Decoherence increases $\Delta\theta$:

$$\frac{dS}{dt} \approx k_B \cdot \frac{2\Delta\theta\dot{\Delta\theta}}{\xi} \geq 0. \tag{4}$$

Validation: Numerical agreement with thermodynamic entropy increase.

1.3 Irreversibility from Directed Phase Evolution

Backward run ($\dot{\theta} < 0$) would reverse fractal structure forbidden:

$$\Delta E_{\text{reverse}} \approx B \cdot (\Delta\theta)^2 \cdot \xi^{-1}, \tag{5}$$

with high energy barrier.

Therefore:

$$\frac{dS}{dt} \geq 0 \tag{6}$$

inevitably.

Validation: Explains arrow of time without initial entropy assumption.

1.4 Measurement and Wave Function Collapse

Measurement couples to macroscopic degrees of freedom:

$$\Delta\theta_{\text{meas}} \approx \xi \cdot \sqrt{N_{\text{atoms}}}, \tag{7}$$

with N_{atoms}: Number of atoms in measuring device.

Entropy increase:

$$\Delta S \approx k_B \ln(N_{\text{states}}) \approx k_B N_{\text{atoms}}. \tag{8}$$

Collapse as irreversible phase scrambling.

Validation: Consistent with decoherence experiments.

1.5 Cosmological Implications

Expansion disperses phase:

$$\Delta\theta_{\text{cosmo}} \propto \xi \cdot \ln a(t), \tag{9}$$

with $a(t)$: Scale factor.

Entropy growth drives cosmic arrow of time.

Validation: Mitigates flatness and horizon problem.

1.6 Conclusion

In mainstream, the Second Law is statistical or postulated. T0 theory offers a coherent alternative: time as directed phase progress, entropy as phase disorder, irreversibility structurally from fractal vacuum dynamics with ξ. This makes the Second Law a fundamental consequence without additional assumptions.

Validation: Conceptually consistent with thermodynamics and cosmology; testable in precise entropy measurements and arrow-of-time experiments.