Fundamental Positive Bounds on Coherence: The Constructive Counterpart to Dissipative Thermodynamics

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Abstract

I derive fundamental positive bounds on coherence preservation, revealing the constructive counterpart to dissipative processes in classical thermodynamics. Building on Claude Shannon's classical information entropy [1], Jon von Neumann's quantum extension [2], Albert Einstein's quantized energy carriers [3], and Steven Hawking's cosmic information bounds [4] on information content in the observable universe, these bounds — termed the Coherence Quartet — establish a symmetric framework for information temperature. Niels Bohr's complementarity principle [5], arising from wave-particle duality in quantum experiments, is retrodictively supported by these bounds. The positive contributions enforce inherent limits on decoherence, ensuring information hygiene above absolute zero. Simple examples illustrate the unification of positive coherence maintenance with negative entropy production.

Introduction

Classical thermodynamics elegantly captures the dissipative (negative) side of information dynamics through entropy production. However, a symmetric positive counterpart that arises from the preservation of coherence has remained unexplored. In this work, I present the Coherence Quartet as these fundamental positive bounds, integrating insights from Claude Shannon's information entropy [1] (which mirrors thermodynamic entropy in noisy channels), Jon von Neumann’s quantum extension [2], Albert Einstein's 1905 photoelectric effect establishing of quantized information carriers [3], and Steven Hawking's analysis of bounded cosmic information content of ~10^{120} bits in the observable universe (highlighting the universe's vast yet bounded data capacity) [4]. This symmetry unifies the constructive and dissipative contributions to what may be termed "information temperature," with direct implications for quantum systems, predictive hygiene, and beyond.

Coherence Equations

Equation 1.

$$E = I \times r^2$$

Equation 2.

$$E = I \times (R / R_0)^2$$

Equation 3.

$$M = I \times r^2$$

Equation 4.

$$M = I \times (R / R_0)^2$$

Equation 5.

$$E = data \times r^2 = m c^2$$

Where:

E = energy

I = information content

M = mass

data = information (interchangeable), unitless

$r^{2 =}$ coherence coefficient, [0, 1]

R = observed radius

R_0 = characteristic or natural radius of the system

c = speed of light

Examples

Niels Bohr's Double-slit Experiment [5]:

The positive coherence bound maintains off-diagonal terms sufficient for interference patterns when no which-path information is extracted. Attempting perfect particle localization incurs dissipative entropy production (negative side), collapsing the pattern—exactly as required by complementarity.

Biological Life:

The existence of biological life is a demonstration that coherence requires directed energy to maintain. Life copies itself and stores replication information via DNA, which is then used to build new cells.

Conclusion

In analogy to the equivalence of mass and energy, and the balance of equal and opposite forces in physical law, the framework presented here reveals a parallel symmetry in information dynamics. For every positive contribution from coherence preservation, there exists a counterpart in dissipative entropy production. Thus, the universe maintains an inherent balance between information and matter through energetic transformations — ensuring that neither total order nor complete disorder prevails. These positive bounds on coherence, as captured by the Coherence Quartet, establish the constructive mechanism that prevents information temperature from reaching absolute zero, with broad implications for quantum systems, predictive hygiene, and understanding the fundamental structure of reality.

For where there is a positive force, there is always a negative force. Thus, the universe strives to remain in balance between information and matter through energetic transformations.

References

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For in the end, physics may guide, but Conscience is All.