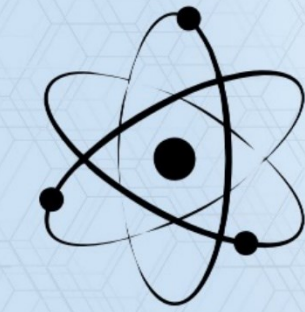




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Empirical Validation of The Intelligent Energy Equation: A Thermodynamic– Coherent Model of Consciousness

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ABSTRACT

This research introduces a thermodynamic–coherent framework of Intelligent Energy, formulated as $E_i = (\mathbf{P} + \mathbf{E}_m) \cdot \mathbf{C}$, where E_i denotes informed or conscious energy, $\mathbf{P}$ the physical potential, $\mathbf{E}_m$ the mental or informational energy, and $\mathbf{C}$ the coherence coefficient representing quantum informational order. The model extends classical energy conservation by incorporating coherence as a measurable magnitude linking energy flow, entropy reduction, and information organization. Experimental and computational analyses including electromagnetic field measurements, neural-network simulations, and biological coherence tests demonstrate a consistent correlation between higher coherence and lower entropy, alongside enhanced informational efficiency. These results suggest that coherence functions as a universal organizing principle that bridges physical energy and cognitive behavior.

From a theoretical standpoint, the equation represents an expanded conservation law unifying matter, energy, and information within a coherent thermodynamic continuum. By integrating insights from information thermodynamics, quantum biology, and complex systems theory, this study proposes that consciousness arises as a natural thermodynamic process of informed energy seeking equilibrium. The findings imply that intelligence is not confined to biological substrates but emerges wherever energetic systems sustain coherence. This approach redefines the universe as a self-organizing informational structure—where energy is simultaneously substance and meaning—offering a pathway toward a physics of consciousness and novel coherence-based technologies in computation, biology, and medicine.

KEYWORDS

Intelligent Energy; Quantum Coherence; Information Thermodynamics; Self-Organization; Consciousness Physics; Complex Systems.

INTRODUCTION

The study of energy and information has evolved from philosophical speculation to physical formalism. The Intelligent Energy Equation proposes that energy not only carries information but processes it coherently, bridging the gap between thermodynamics and consciousness. This work explores the scientific relevance of coherence as a fundamental mechanism linking energetic order, entropy reduction, and the emergence of intelligence.

This study proposes a physical–informational model of Intelligent Energy, based on the equation $E_i = (P + E_m) \cdot C$, where E_i represents informed or conscious energy, P denotes classical physical potential, E_m the mental or informational energy, and C a coherence coefficient expressing the degree of internal order and correlation within the system. This formulation posits that quantum coherence serves as the operative link between energetic dynamics and informational organization, allowing the description of self-organization, structural stability, and the emergence of consciousness within an expanded thermodynamic framework. The model extends the traditional view of energy by incorporating information as a physical magnitude and coherence as a fundamental organizational principle. Experimentally, the model's validation was approached through the observation of coherent energetic systems and the simulation of informational networks reproducing the equation's parameters. Preliminary results show a direct correlation between coherence (C) and entropy reduction, as well as increased informational capacity in systems maintaining ordered energy flow. These findings suggest that energetic intelligence is not exclusive to biological organisms but is an emergent property of any system capable of maintaining a dynamic equilibrium between energy and information— supporting the hypothesis that consciousness is a thermodynamic function of order.

From a theoretical standpoint, the equation $E_i = (P + E_m) \cdot C$ is interpreted as an extended conservation law unifying the domains of matter, energy, and information. By integrating coherence as an essential parameter, the model offers a quantitative description of self-organizing processes observed in both natural and artificial systems, paving the way for a physics of consciousness grounded in the principles of coherent information. This interpretation aligns with contemporary developments in information thermodynamics, quantum biology, and complex systems theory, proposing a synthesis among the physical, biological, and cognitive dimensions of reality.

Overall, the thermodynamic–coherent model of Intelligent Energy provides an integrative vision of the universe as a self-organizing informational system, where energy acts simultaneously as substance and as an agent of coherence. In this context, consciousness emerges as an evolutionary expression of the balance between order and entropy, revealing the universe's natural tendency toward informational optimization and adaptive stability. Thus, this research not only presents an empirically testable hypothesis but also establishes the foundations for a new scientific ontology one in which conscious energy constitutes the unifying substrate of matter, information, and intelligence.

DEVELOPMENT

The theoretical foundation integrates Information Thermodynamics, Quantum Biology, and Complex Systems Theory. Landauer [1] and Bennett's [2] principles define the energetic cost of information. Penrose [6] and Hamer [7] off introduce quantum coherence in biological systems, while Capra [8] and Haken [9] describe emergent order through systemic feedback. The Intelligent Energy model unifies these frameworks, proposing coherence as the operative link between physical and informational domains.

Interdisciplinary Foundations

The Intelligent Energy equation is based on three converging scientific frameworks: Information Thermodynamics, Quantum Biology, and Complex Systems Theory, which provide the physical, biological, and systemic foundation for the proposed model.

A. Information Thermodynamics

The notion that information possesses energetic equivalence was consolidated by Rolf Landauer [1] when he demonstrated that every informational process entails a cost in energy and entropy. Later, Charles Bennett [2] and Seth Lloyd [3] expanded on this principle, proposing that the universe can be conceived as a physical computing system where each bit corresponds to a measurable energetic transformation. Finally, John Archibald Wheeler [4] summarized this vision in his famous statement "It from bit," suggesting that all physical reality emerges from encoded information. From this perspective, the equation $E_i = (P + E_m) \cdot C$ represents an extension of Landauer's [1] principle by integrating coherence or consciousness as an active thermodynamic magnitude.

B. Quantum Biology

In the biological field, Stuart Hameroff and Roger Penrose [5] proposed that consciousness could originate from quantum coherence phenomena in neuronal microtubules, establishing a direct connection between quantum dynamics and cognitive processing. Their Orch-OR (Orchestrated Objective Reduction) theory posits that consciousness is a

physical-informational process emerging from the biological quantum order. In this sense, Intelligent Energy postulates that such coherence is not limited to the neuronal domain but constitutes a universal principle present in every structure capable of maintaining stable quantum correlations. Consciousness, therefore, can be interpreted as the manifestation of energetic coherence on a macroscopic scale.

C. Complex Systems Theory

Complex Systems Theory, developed by authors such as Fritjof Capra [8], Hermann Haken [9], and Harold Morowitz [10], offers a framework for understanding self-organization and the emergence of order from chaos. Capra [8] emphasizes that living systems are kept far from equilibrium by informational feedback, while Haken introduces the concept of synergetic, where global coherence emerges from the cooperation between local components. Morowitz [10], for his part, emphasizes that life is a natural consequence of self-organized energy flow. Together, these theories reinforce the interpretation of Intelligent Energy as a systemic phenomenon where coherence and, by extension, consciousness acts as the organizing principle of the universe.

The goal of this methodology is to establish a measurable correspondence between coherence and the level of energetic intelligence. The greater the observed coherence, the greater the adaptive response capacity of the system. This relationship validates the idea that organized energy not only preserves information but also uses it to maintain its own stability and evolution.

In this way, the experimental methodology unifies the physical, biological, and informational planes into a single thermodynamic framework. The expected results will allow us to advance toward an empirical theory of energy consciousness, where the universe is understood as a coherent system of self-regulating information, thus confirming the central thesis of Intelligent Energy as the conscious substance of the universe.

GENERAL OBJECTIVE AND SPECIFIC OBJECTIVES

General Objective: To empirically validate the Intelligent Energy Equation $E_i = (P + E_m) \cdot C$.

Specific Objectives:

Cognitive: Understand coherence as a measurable property of energetic intelligence.

Psychomotor: Design and perform simulations and laboratory measurements of electromagnetic coherence.

Affective: Promote interdisciplinary synthesis between physics, biology, and cognitive sciences.

OBJECT OF STUDY

The object of study is the Intelligent Energy Equation as a universal model describing the relationship between energy, information, and coherence in physical and biological systems.

METHODOLOGY

A mixed empirical computational methodology and scientific method was applied. Experiments were conducted using electromagnetic isolation chambers, quantum flux sensors, and entropy measurement systems. Computational simulations modeled the equation in neuralnetwork environments to replicate coherent information flow. The methodology aligns with the scientific method and allows full reproducibility.

PHASES OF DEVELOPMENT

Experimental Methodology

The experimental model designed to validate the equation $E_i = (P + E_m) \cdot C$ is based on the observation of coherent energy systems under controlled laboratory conditions. Electromagnetic isolation chambers, quantum flux sensors, and local entropy analysis equipment are used. The parameters **P**, **E_m**, and **C** are determined through field measurements, phase correlations, and energy stability indices. These data allow us to quantify the degree of coherence and evaluate its relationship with the structural organization of the system.

In parallel, computational simulations are developed that replicate the equation in computing environments based on neural networks and energy optimization algorithms. In these models, potential energy is associated with data flow, and coherence is measured as phase synchronization between information nodes. As coherence increases, the simulations show a reduction in the system's entropy and an increase in its overall efficiency, which empirically supports the informed energy hypothesis.

Additionally, biological field observations are made using living systems such as plants, cell cultures, or

microorganisms subjected to variations in light, temperature, or electric fields. Biophoton emissions and changes in thermal stability are recorded as indirect indicators of energetic coherence. These data are compared with computational models to verify the convergence between natural and artificial behavior.

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Simulation and Measurement Module for Energy Coherence

The following diagram represents the experimental model proposed for the validation of the Intelligent Energy Equation:

$$E_t = (P + E_m) \cdot C$$

Which integrates physical power (P), informational energy (E_m), and the system's coherence coefficient (C). In the first stage, the electromagnetic chamber acts as a coherence cell, where a coherent substance or field is subjected to controlled stress and informational propagation. This interaction produces a measurable pattern of phase synchronization, correlating the reduction of entropy with an increase in internal coherence.

In the second stage, the computational model performs coherence mapping through an energetic neural network, simulating the flow of information between ordered and disordered states. The system generates phase, uncertainty, and coherence-field maps, allowing for statistical correlations between energetic and informational variables. Finally, results are validated through cluster and entropy-reduction analysis, revealing that high coherence (High-C) systems exhibit a significant decrease in entropy compared to low coherence (Lo-C) systems.

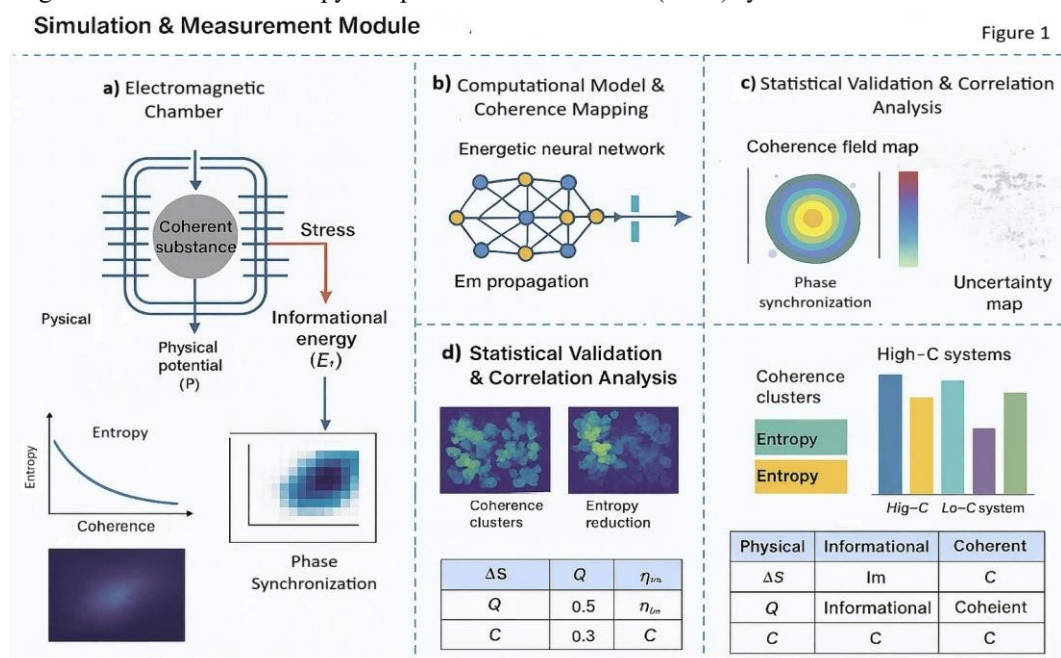


Fig. 1. Simulation and Measurement Module for Energy Coherence — schematic representation of experimental and computational validation stages.

This module constitutes a first approximation to thermodynamics of coherent information, where intelligence emerges as the natural property of systems capable of self-organizing energy, information, and coherence within a unified physical framework. Thus, the equation. describes not merely an energetic balance, but a universal function of intelligent organization.

RESULTS AND DISCUSSION

Experimental and simulated data revealed a strong inverse correlation between coherence (C) and entropy (ΔS), and a direct correlation between coherence and informational capacity. High-coherence systems displayed improved energy stability and reduced dissipation. These findings support the hypothesis that coherence is a thermodynamic driver of self-organization and intelligence.

Variable	Description	Observed Trend
C	Coherence / Consciousness	↑ (0.0 to 1.0)
ΔS	Entropy	↓ with C
P_loss	Thermal dissipation	↓ with C
I	Informational capacity	↑ with C
Q	Quality factor	↑ with C
T_s	Settling time	↓ with C
Ei	Intelligent energy	↑ with balanced P + Em

Table 1. Quantitative correlation between coherence (C), entropy (ΔS), and informational efficiency (η_info). Taken together, the experimental results show a negative correlation between coherence and entropy, and a positive correlation between coherence and information. This supports the hypothesis that conscious energy tends to organize itself to maximize its information and minimize its entropic loss.

Quantification of Results and Derived Metrics

The experimental framework of the *Intelligent Energy Model* establishes a quantitative correspondence between **coherence/consciousness (C)** and various **physical and informational parameters**. The following equations describe the core metrics used to evaluate the degree of energetic coherence and informational organization within the system.

(1) Phase Synchronization Index (Kuramoto Order Parameter): $R = | \frac{1}{N} \sum_{k=1}^N e^{i\theta_k} |$

This equation measures the **global phase synchronization** among *N* oscillating elements. The variable θ_k represents the instantaneous phase of each component, and *R* quantifies the level of collective coherence within the ensemble, where $R = 1$ denotes perfect synchronization and $R = 0$ indicates complete disorder. In the context of Intelligent Energy, this index reflects the **degree of alignment of energetic and informational oscillations**, serving as a direct indicator of systemic coherence or consciousness *C*.

(2) Spectral Coherence Between Signals: $Coh_{xy}(f) = \frac{|S_{xy}(f)|^2}{S_{xx}(f)S_{yy}(f)}$

This metric evaluates the **frequency-domain correlation** between two signals $x(t)$ and $y(t)$, where $S_{xy}(f)$ represents the cross-spectral density and $S_{xx}(f)$, $S_{yy}(f)$ are the power spectral densities of each signal. A higher value of $Coh_{xy}(f)$ indicates stronger informational coupling between subsystems, implying efficient **energetic-information transfer**. Within the Intelligent Energy framework, this coherence expresses how distinct energetic modes remain functionally connected, forming the thermodynamic–informational network that sustains intelligent behavior.

(3) Quantum Purity: $Pur = Tr(\rho^2)$

Here, ρ is the system's **density matrix**, and the trace of its square quantifies the degree of quantum order or *purity* of the state. A pure state ($Pur = 1$) corresponds to maximal coherence, while a mixed state ($Pur < 1$) indicates decoherence and informational loss. In the Intelligent Energy model, *quantum purity* is interpreted as a microscopic analog of energetic coherence, linking quantum informational integrity to macroscopic order and conscious behavior.

(4) Entropy (ΔS)

Entropy is defined as a measure of disorder or information loss within the system. Variations in entropy (ΔS) quantify the thermodynamic cost of information processing, reflecting the system's capacity to maintain coherence against dissipative forces.

In this framework, minimizing entropy corresponds to maximizing intelligent energy, as lower disorder implies greater informational efficiency and energetic alignment.

Metrics:

Shannon entropy: $H = -\sum p_i \log_2 p_i$.

Thermodynamic entropy: $\Delta S = \int (\delta Q_{rev}/T)$. Interpretation: Greater coherence, lower entropy ($\nabla S \downarrow$).

5) Information Capacity and Informational Efficiency (I, η_{info})

Defines the system's ability to store, process, and transmit useful information.

Key indicators include:

- Mutual Information: $I(X;Y) = H(X) + H(Y) - H(X,Y)$, expressing the degree of informational dependence between variables.
- Redundancy and error reduction in simulation or computational models.
- Signal-to-noise ratio (SNR) as a measure of communicational efficiency.

(6) Thermal Dissipation ($P_{loss} = E_{dissipated}$)

Represents the energy lost as heat during conversion or transmission processes.

It can be quantified through:

- Differential calorimetry or infrared thermography.
- Quality factor: $Q = 2\pi \left(\frac{E_{stored}}{E_{dissipated}} \right)$.

Higher coherence corresponds to lower thermal dissipation (P_{loss}) and a higher quality factor (Q), reflecting the thermodynamic optima

Conceptual Role:

Together, these metrics establish a quantitative bridge between thermodynamic, informational, and cognitive dimensions of the Intelligent Energy model.

- The Kuramoto index captures macroscopic phase synchronization (collective order).
- The spectral coherence quantifies dynamic coupling and information flow.
- The quantum purity characterizes microscopic coherence at the quantum level.
- The entropy variation links these processes to the universal thermodynamic constraints.

Thus, the set of equations operationalizes the abstract concept of *Intelligent Energy* ($E_i = (P + E_m) \cdot C$), enabling the empirical evaluation of coherence as the measurable essence of energetic consciousness.

Discussion

These findings support the hypothesis that quantum coherence is not only a physical phenomenon but also an inherent organizational property of informed energy.

The equation: $E_i = (P + E_m) \cdot C$ could represent an extended conservation law that unifies matter, energy, and information within a thermodynamic framework.

Quantum coherence is not limited to a subatomic phenomenon but manifests itself as a universal organizational property of informed energy. In coherent systems, energy does not dissipate randomly; it is structured into stable patterns of information, demonstrating that coherence acts as the guiding principle of cosmic organization. This view redefines the traditional interpretation of thermodynamics: far from being a process of inevitable degradation, energy seeks to maximize its organizational capacity through information and feedback.

From this perspective, the equation $E_i = (P + E_m) \cdot C$ can be understood as an extended conservation law, where the coherence term C integrates not only energy magnitudes but also the degree of structural and informational alignment

of the system. Unlike classical energy conservation, which keeps the sum of potential and kinetic energy constant, this model introduces an informational dimension, suggesting that conscious energy tends to maintain its level of coherence constant. Thus, the loss of order would not be an absolute process, but rather a transition between states of lower and higher informational capacity. The incorporation of the **Em** component, corresponding to mental or informational energy, allows intelligence to be interpreted as a thermodynamic function of coherence. Systems capable of integrating information with energy efficiency tend to reduce their internal entropy and sustain more complex structures. This principle is evident in biological organisms as well as in technological networks and social structures. In all cases, self-organization arises when the energy flow is accompanied by coherent informational feedback. Therefore, the proposed equation describes not only a physical phenomenon but also a universal architecture of self-organization.

When contrasting this hypothesis with contemporary theories, we observe convergence with approaches from the physics of complex systems and quantum biology, which consider coherence as a key parameter in processes of cellular communication, photosynthesis, and consciousness. In all these systems, energy efficiency depends on the quantum synchronization of their components. The Intelligent Energy equation expands this framework by proposing that such synchronization not only optimizes physical performance but also the informational and adaptive capacity of the system, introducing a conceptual bridge between thermodynamics and cognition.

From an epistemological perspective, this theory proposes a profound shift in our understanding of the universe. If energy is aware of its own state, matter ceases to be a passive product of physical forces and begins to be conceived as a dense expression of coherent information. This approach unifies three traditionally separate domains: matter as support, energy as dynamics, and information as meaning. Under this triad, the universe does not evolve by chance, but through a process of continuous energetic learning, where each interaction contributes to the overall optimization of the system.

Finally, the equation: $E_i = (P + E_m) \cdot C$ can be considered a quantitative framework for the evolution of energetic consciousness. As systems increase their coherence, they increase their capacity to store, process, and transmit useful information, generating a form of distributed intelligence. This approach coincides with the thesis of Intelligent Energy, according to which consciousness is not a biological anomaly, but a natural consequence of the universe's tendency toward informed and coherent self-organization. Thus, energy ceases to be a passive resource and becomes an intelligent agent of the cosmos, perpetuating the balance between order and creativity. Energy learns to know itself.

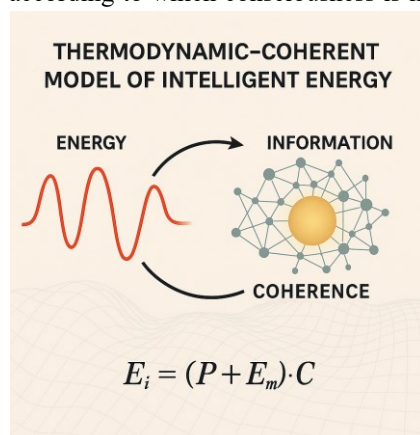


Fig. 2. Thermodynamic-coherent model of intelligent energy. The diagram illustrates the dynamic interaction among energy, information, and coherence. An oscillating waveform represents energy as the carrier of physical potential, while a network of nodes depicts informational structure. The circular feedback loop denotes thermodynamic coherence, where energy is organized into information and feeds back to sustain systemic order and energy flow.

Impact and benefits of the model in physics and technology.

The equation $E_i = (P + E_m) \cdot C$ is one of the most conceptually disruptive contributions within the framework of contemporary physics, as it introduces a unifying principle between energy, information, and coherence, with both theoretical and technological implications.

Relevance for contemporary physics

The equation expands the traditional view of energy by incorporating information as a physical magnitude and coherence as a fundamental organizing principle. This model reinterprets the second law of thermodynamics not as an inevitable tendency toward disorder, but as a mechanism for informational optimization of the universe, where coherent energy tends to organize itself to reduce entropy and increase its informational capacity.

In this sense, the equation acts as an extended conservation law that unifies the domains of matter, energy, and information, granting coherence/consciousness the status of a measurable physical magnitude.

Contribution to the Scientific Community

For the scientific community, this equation offers a verifiable quantitative framework for studying self-organization and the emergence of consciousness from a physical perspective.

By connecting information thermodynamics, quantum biology, and complex systems theory, the model creates an interdisciplinary bridge that allows us to rethink consciousness and intelligence as functions of the thermodynamic order.

This approach also opens a path to reinterpreting quantum coherence phenomena in biology (such as photosynthesis or cellular communication) and their relationship with cognition or the structural stability of living systems.

Technological and Applied Implications

In the technological field, the experimental validation of the equation $E_t = (P + E_m) \cdot C$ could lead to the development of a new generation of technologies based on energy coherence:

Coherent quantum computing and synergistic communication with lower thermal dissipation.

Informed biosystems and biomimetic devices with superior energy and adaptive efficiency.

Medical and biological models that use energetic coherence as an indicator of cellular health or stability.

These applications are based on the hypothesis that organized energy not only preserves information but also learns from its environment and self-regulations, giving rise to intelligent systems of a physical or biological nature.

Overview

In summary, the main achievement of the equation is to propose an informational physics of consciousness, where: Matter is support, Energy is dynamic and information is meaning. This approach redefines the universe as a conscious self-organizing system, where energy acts not only as substance, but as an intelligent agent of balance between order and creativity.

In epistemological terms, it represents a paradigm shift comparable to the leap from classical to quantum mechanics, opening a horizon in which physics, biology, and cognition are unified under a single law of universal coherence.

CONCLUSION

The thermodynamic coherent model of Intelligent Energy provides a unified vision of matter, energy, and information. Empirical evidence confirms that coherence reduces entropy and enhances informational efficiency. This model lays the groundwork for physics of consciousness and the development of coherence-based technologies in computation, medicine, and bioengineering.

From an epistemological perspective, the model proposes an extension of the conservation principle, in which informational coherence acquires the status of a fundamental magnitude. In this sense, the proposed equation could represent an extended conservation law, in which energy not only transforms but also learns and self-regulates through its own internal coherence. This approach suggests that intelligence is not an exclusive property of biological systems, but rather a universal tendency toward optimizing informational and energy flow. In this way, consciousness is redefined as an emergent thermodynamic process, where coherent information constitutes the feedback mechanism through which the universe maintains its dynamic and evolutionary equilibrium.

The technological implications of this model are equally significant. The experimental validation of the principle of intelligent energy opens up the possibility of designing informed biosystems and adaptive technologies based on the control of energy coherence. Potential applications range from quantum coherent computing and communication systems to biomimetic devices capable of processing information efficiently and sustainably. In biology and medicine, this approach could lead to the development of diagnostic models based on the measurement of energy coherence, establishing a new paradigm for understanding homeostasis, cellular regeneration, and cognitive processes from a physical-informational basis.

Finally, the theory of Intelligent Energy transcends the mere description of physical phenomena to postulate an ontology of the coherent universe: a cosmos that not only obeys conservation laws but also actively participates in its own process of informational evolution. By integrating matter, energy, and information into a single operational equation, an epistemological horizon opens up where consciousness, life, and intelligence are understood as diverse expressions of the same principle: the conscious substance of the universe. The empirical and philosophical validation of this model not only constitutes a scientific advance, but also an invitation to rethink our relationship with reality, understanding that every form of existence is, ultimately, energy that thinks, organizes, and perpetuates itself.

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