

The structure of the atom from the point of view of the Acta Universi (AU) hypothesis

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Introduction

1.1 The crisis of the reductionist paradigm in microscopic physics

Quantum mechanics, developed in the first half of the 20th century, describes the behavior of atoms, molecules, and elementary particles with unprecedented precision. The Schrödinger equation, quantum electrodynamics, and the Standard Model made it possible to calculate atomic spectra with precision down to tens of decimal places, predict the existence of new particles, and lay the foundations for modern technology—from lasers to semiconductors. However, for all its empirical effectiveness, quantum mechanics leaves fundamental ontological questions unanswered.

As Niels Bohr noted, *"There is no quantum world. There is only an abstract quantum description."* The wave function $\psi(x, t)$, the central object of the theory, describes the probabilities of measurement outcomes but does not answer the question: *what really exists in the spaces between measurements?* The Copenhagen interpretation postulates the collapse of the wave function without explaining its physical nature. The de Broglie-Bohm interpretation introduces hidden parameters but requires nonlocality, which contradicts the spirit of special relativity. Everett's many-worlds interpretation eliminates the collapse at the cost of infinitely multiplying entities. This conceptual pluralism, which persists almost a century after the creation of quantum mechanics, testifies to the profound crisis of the reductionist paradigm, which reduces the entire diversity of reality to the interactions of material particles and fields.

This problem is particularly acute in atomic physics. Electron orbitals, the periodic table of elements, chemical bonding—all these fundamental structures are described

phenomenologically by quantum mechanics, but their origins in deeper principles remain unclear. Why does the periodic table have this particular structure and not another? Why does chemical bonding lead to stable molecular configurations? These questions suggest that quantum mechanical formalism may conceal a deeper level of reality—a level where information and entropy play a fundamental role.

1.2 From the standard model to information ontology

In recent decades, fundamental physics has seen a radical shift: from materialistic reductionism to informational ontology. This shift is evident in several independent theoretical programs.

The AdS/CFT correspondence, proposed by Juan Maldacena in 1997, established a duality between the theory of gravity in anti-de Sitter (AdS) space and a gravity-free quantum field theory on its boundary [9†L1-L4]. This correspondence showed that the geometry of spacetime in the bulk can be completely encoded in the quantum information degrees of freedom on the boundary. As a modern review notes, *"early attempts show that entanglement constructs the geometry of spacetime, in the sense that the connectivity and continuity of the spacetime geometry are closely related to the entanglement structure of QFT states."*

The holographic principle, formulated by Gerard 't Hooft and developed by Leonard Susskind, states that all information about physical processes in a region of space can be encoded on its boundary [7†L5-L8]. The Bekenstein–Hawking entropy $S_{\text{BH}} = k_B c^3 A / (4 \hbar G)$ establishes a fundamental limit on the information capacity of any physical system, relating geometry (area) to information (entropy) [5†L3-L7]. As emphasized in Raphael Bousso's review, *"the holographic principle asserts that the origin of this entropic limit must lie in the number of fundamental degrees of freedom involved in a unified description of spacetime and matter"* [10†L6-L9].

Quantum information theory offers a new language for describing physical systems. Von Neumann entropy, quantum entanglement, and integrated information measures are becoming not just computational tools but fundamental categories, laying claim to ontological status. Quantum chemistry already actively uses information measures to describe electron distributions: Shannon entropy and local and global information functionals allow us to quantitatively characterize the complexity of electron structures [23†L1-L4]. However, these approaches remain within the standard formalism and offer no new ontological justification.

These trends—from AdS/CFT to quantum information—indicate that **information may be a more fundamental entity than spacetime and matter**. As a recent paper puts it, *"the information approach can be transformed into an emergent theory of spacetime using quantum-information models of a holographic nature."* The Acta Universi (AU) hypothesis proposes precisely such an information ontology, in which the entropy field of thoughtforms S_θ is the primary reality, and all physical structures—from atoms to galaxies—emerge as its emergent configurations.

1.3 Purpose and objectives of the study

The present work aims to present the atom not as a passive material system subject to external laws, but as **a stable coherent structure in the field of entropy of thought forms** S_Θ , arising from the information-entropic dynamics of the non-local archive.

Specific objectives of the study:

1. **Develop a mathematical formalism** linking atomic structure with field dynamics S_Θ : a modified Schrödinger equation with entropy potential $V_{\text{eff}}(r) = -Ze^2/(4\pi\epsilon_0 r) + \lambda \partial S_\Theta / \partial r + \int K(r, r') S_\Theta(r') d^3r'$, where the entropy term and the nonlocal kernel K introduce fundamentally new interactions beyond the Coulomb potential.
2. **Interpret electron orbitals** as eigenmodes of the field S_Θ : $\hat{\mathcal{H}}_{\text{AU}} \psi_n = E_n \psi_n$, where $\hat{\mathcal{H}}_{\text{AU}}$ is an operator that includes both standard quantum terms and entropic corrections.
3. **Show how the periodic law and the chemical bond** are re-examined through the principle of maximizing integral information Φ : elements with filled shells have maximum Φ and minimum chemical activity, while the chemical bond is interpreted as a fusion of electronic thought forms that enhances Φ the entire system.
4. **Formulate testable predictions** of the AU approach: entropic shifts of atomic levels, modulation of spontaneous emission by coherent thought forms, correlations between quantum processes and states of consciousness.
5. **Compare the AU approach** with standard quantum mechanics and alternative information theories (IIT, quantum panpsychism), identifying its advantages and limitations.

1.4 The place of AU among alternative approaches to atomic structure

The proposed AU approach occupies a unique place in the spectrum of atomic structure theories.

Unlike **standard quantum mechanics**, which describes the atom phenomenologically but provides no ontological justification for the wave function and its collapse, AU offers an **ontological interpretation**: the wave function ψ becomes the amplitude of a thought-form field, and the quantum transition is an irreversible act of recording in the AU archive. This is not simply a new interpretation, but an extension of the formalism, introducing new predictable effects (entropic level shifts).

Unlike Giulio Tononi's **Integrated Information Theory (IIT)**, which limits itself to describing consciousness as a property of highly integrated systems [17+L1-L4], AU extends IIT principles to all of physical reality. The atom is viewed as the minimal unit of integrated information, and the periodic law as a consequence of maximization Φ . This makes AU not just a theory of consciousness, but **a universal ontological theory**.

Unlike **quantum panpsychism**, which postulates consciousness as a fundamental property of all matter, AU does not ascribe consciousness to all physical systems, but rather associates it with the level of information integration Φ . An atom possesses a certain level of consciousness Φ , but consciousness in the full sense only emerges upon reaching a critical threshold of integration, opening the way to a quantitative distinction between inanimate matter, living organisms, and conscious systems.

Unlike **digital physics** (Wheeler, "It from Bit"), which views information as discrete bits (20⁺L1-L4), AU preserves the continuity of the field S_θ , allowing quantum effects to be described without loss of information content. This makes AU more flexible and closer to quantum field formalisms.

Thus, AU offers **an information-ontological alternative** that does not reject the achievements of quantum mechanics, but integrates them into a deeper theoretical framework, where information, entropy and consciousness are fundamental categories, and matter and space-time are emergent.

1.5 Structure of the work

The article is organized as follows.

Part I (Chapters 1–2) provides an overview of standard atomic physics: advances in quantum mechanics, unresolved issues of interpretation, and modern information-theoretical approaches. Chapter 2 examines the emergence of spacetime and the transition to the AU paradigm.

Part II (Chapters 3–4) presents the ontological foundations of the AU approach: the field S_θ as a fundamental reality, particles as field solitons, the nucleus as a high-density region S_θ , electron orbitals as field modes, a modified Schrödinger equation with entropic and nonlocal terms.

Part III (Chapters 5–6) analyzes the dynamics of the atom in kairos time: the stability of the atom as a balance of Coulomb attraction and entropic pressure, quantum transitions as acts of recording thought forms, integral information Φ and its connection with the periodic law.

Part IV (Chapters 7–8) looks at chemical bonding as a fusion of thought forms, molecules as more integrated structures, connections to quantum biology and the theory of consciousness.

Part V (Chapters 9–10) formulates experimental consequences and testable predictions: entropic level shifts, modulation of spontaneous emission, correlations with coherent thought forms.

Part VI (Chapters 11–13) contains a comparison of AU with standard quantum mechanics, IIT, and other information theories.

Part VII (Chapters 14–15) discusses the philosophical implications of the AU approach and contains a conclusion summarizing the main results and prospects for further research.

Part I. Standard Atomic Physics: Achievements and Unresolved Questions

Chapter 1. Quantum-mechanical description of the atom

1.1 Historical context: from Bohr's model to wave mechanics

The birth of quantum atomic theory is usually associated with the work of Niels Bohr (1913), who proposed a model of the hydrogen atom based on the quantization of the electron's angular momentum: $L = n\hbar$. Bohr's model brilliantly explained the spectral lines of hydrogen using the Rydberg formula:

$$E_n = -\frac{13.6 \text{ eV}}{n^2},$$

However, it remained semi-classical: the electron was considered as a point particle moving along certain orbits, which contradicted both classical electrodynamics (an accelerated charge must radiate) and fundamentally new quantum concepts.

A decisive breakthrough occurred in 1925–1926, when Werner Heisenberg, Erwin Schrödinger, and Paul Dirac independently developed the foundations of quantum mechanics. Schrödinger proposed **the wave equation**, in which the state of a particle was described by a wave function $\psi(r, t)$ satisfying the equation:

$$i\hbar \frac{\partial \psi}{\partial t} = \hat{H}\psi,$$

and for stationary states - the Schrödinger equation:

$$-\frac{\hbar^2}{2m} \nabla^2 \psi + V(r)\psi = E\psi.$$

For a hydrogen atom with a Coulomb potential, $V(r) = -Ze^2/(4\pi\epsilon_0 r)$ this equation admits an exact analytical solution. The wave functions have the form:

$$\psi_{nlm}(r, \theta, \phi) = R_{nl}(r)Y_{lm}(\theta, \phi),$$

where R_{nl} is the radial function, and Y_{lm} are the spherical harmonics. Quantum numbers n, l, m determine energy levels, angular momentum, and its projection. As emphasized in modern reviews, *"exact solutions of the Schrödinger equation play a decisive role in physics."*

Unlike Bohr's model, wave mechanics does not prescribe a specific trajectory for the electron. Instead, it $|\psi(r)|^2$ is interpreted as **the probability density** of finding an electron at a given point in space. This radically altered the ontological status of the atom: instead of a mechanical system with defined coordinates and velocities, the atom became a probabilistic structure. However, this probabilistic interpretation, first formulated by Max Born, raised fundamental

questions about the nature of the wave function and the reality of quantum states—questions that remain open to this day.

1.2 Current state of atomic physics

In the hundred years since the invention of quantum mechanics, atomic physics has made impressive advances. Relativistic generalizations—the Dirac equation for the electron and quantum electrodynamics (QED)—have made it possible to describe the fine and hyperfine structure of atomic spectra with unprecedented accuracy. As noted in a recent review, *"The First Hundred Years of Quantum Mechanics and More than Fifty Years of Response Properties,"* relativistic quantum theory of atomic and molecular systems continues to evolve, embracing four-component formalisms, the interpretation of negative-energy states, and the introduction of weak interactions.

Modern methods of relativistic quantum chemistry allow for the calculation of the electronic properties of heavy atoms and molecules, taking into account spin-dependent and spin-independent effective Hamiltonians. Key advances include:

- **Precision spectroscopy:** Comparing theoretical QED predictions with experimental measurements of the Lamb shift, hyperfine splitting, and isotopic shifts allows us to test the Standard Model and search for new physics. In 2025, tests of quantum electrodynamics using atomic nuclei were conducted, overcoming the uncertainties of nuclear structure and achieving a precision approximately ten times greater than previous measurements.
- **Quantum simulation with ultracold atoms:** Neutral atoms trapped in optical tweezers have become a leading platform for quantum simulations. These systems enable the modeling of nonperturbative physics, including quark-like interactions. In December 2025, an international research team observed Shapiro steps in ultracold atoms for the first time, paving the way for new quantum technologies with high sensitivity.
- **Quantum entanglement in atomic systems:** Non-classical and entangled states of light are becoming increasingly important for quantum technologies. Research in 2025 demonstrated high-fidelity remote entanglement between trapped atomic qubits with an accuracy of 97% and potentially greater than 99.9%.

Of particular interest are studies of quantum correlations in the hyperfine structure of the hydrogen atom. As demonstrated in 2025 papers, the hyperfine structure serves as *"an effective platform for studying quantum correlations and decoherence, providing a controllable and analytically resolvable framework."* These studies establish *"a clear link between the dynamics of quantum correlations and fundamental physical parameters, shedding light on how nonclassical features arise in the evolution of hydrogen atoms."*

1.3 Quantum Information Theory and Atomic Systems

One of the most significant shifts in atomic physics in recent decades has been the penetration of ideas and methods **from quantum information theory**. As noted in the 2025 review

"Information Theory Meets Quantum Chemistry, " "Today, information theory serves as a universal tool in statistics, the natural sciences, machine learning, quantum computing, and many other fields. "

In quantum chemistry, the information-theoretic approach (ITA) is applied to the analysis of electron distributions, which are normalized probability distributions. Key information measures include:

- **Shannon entropy:** $S_{\text{Shannon}} = - \int \rho(r) \ln \rho(r) d^3r$, where $\rho(r)$ is the electron density. This measure quantitatively characterizes the localization or delocalization of electrons in an atom or molecule.
- **Relative entropy** (Kulback–Leibler divergence), **joint entropy**, **conditional entropy**, and **mutual information** are quantities that allow us to analyze correlations between electrons and the degree of their entanglement.
- **Von Neumann entropy:** $S_{vN} = -\text{Tr}(\hat{\rho} \ln \hat{\rho})$, where $\hat{\rho}$ is the density matrix. This measure, derived from quantum information theory, is used to quantify quantum entanglement in atomic and molecular systems.

The integration of these strategies with quantum many-body theory and density functional theory (DFT) has led to the emergence of an *"information-theoretical approach"* that *has "provided valuable insights into the nature and behavior of electron systems."* In particular, the analysis of Shannon entropy *"supports the uncertainty principle by demonstrating an inverse relationship between position entropy and momentum entropy. "*

Quantum entanglement in atomic systems has become a hotly researched area. As outlined in a 2025 review, *"entanglement between individual atoms, the processing of encoded entanglement, and its temporal evolution" are being explored*, with particular attention paid to *"the role of the environment in creating and destroying entanglement in atomic systems."* These studies are directly relevant to understanding how atomic systems maintain quantum coherence—a question that is becoming central to the AU approach.

1.4 Unresolved problems of the standard approach

Despite impressive advances, the standard quantum mechanical description of the atom faces a number of fundamental problems that remain unresolved.

The Problem of Interpreting the Wave Function. What is a wave function ψ in the ontological sense? Is it a real physical field in a multidimensional configuration space, or is it merely a tool for calculating probabilities? *"Wave-function realism claims that the wave function, as described by quantum mechanics, corresponds to a real physical entity."* However, as a recent philosophical analysis shows, even this position faces a tension: it *"accepts the ontology of the wave function while deliberately avoiding the meta-ontological question of the truth of the theoretical framework itself."* As the authors note, *"the wave function in Bohmian mechanics represents a new ontological category unique to quantum theory,"* but there is no consensus on this issue.

Lack of ontological status for electron orbitals. In standard quantum chemistry, orbitals are mathematical constructs—single-electron wave functions used to construct multi-electron wave functions. However, their physical reality remains debatable. Are orbitals "real" structures in an atom, or are they merely a convenient approximation basis? This question has direct implications for understanding the periodic table and chemical bonding.

Why does the periodic table have this particular structure? Standard quantum mechanics explains the periodic law through the filling of electron shells according to the Pauli exclusion principle and Hund's rules. However, this explanation remains phenomenological: it describes *how* the shells are filled, but does not explain *why* nature chose this particular structure of quantum numbers and this particular order of filling. As noted in a 2025 review on the relationship between molecular chemistry and quantum mechanics, *"the relationship between quantum mechanics and conventional chemistry remains complex."*

The problem of quantum decoherence. Atomic systems, being open quantum systems, are subject to decoherence—the loss of quantum coherence due to interactions with the environment. Research from 2025 shows that *"in the hyperfine structure of the hydrogen atom, a universal sudden transition from classical to quantum decoherence is observed."* The mechanisms of this transition and its relationship to fundamental physical parameters remain the subject of active research. In the AU approach, this transition receives a new interpretation: it is associated with the irreversible recording of a thought form in the AU archive.

The connection between the microworld and the macroworld and consciousness. Standard quantum mechanics does not provide a satisfactory explanation of how quantum phenomena in atoms give rise to the classical reality of the macroscopic world. The measurement problem, wave function collapse, and the role of the observer remain unresolved. As shown in 2025 research, quantum entanglement and decoherence in atomic systems offer *"new perspectives on the role of quantum information in atomic physics,"* but a complete theory linking the quantum microworld with the macroworld is lacking.

These unresolved problems indicate that, despite its empirical effectiveness, the standard quantum-mechanical description of the atom remains incomplete. It describes, but does not explain, the fundamental structures of the microworld. It is in this context that the Acta Universi hypothesis proposes a new approach: instead of remaining within a purely materialistic paradigm, the AU introduces an information-entropic ontology in which the atom becomes a stable configuration of the entropy field of thought forms S_Θ , and its quantum properties are manifestations of deeper information dynamics. As will be shown in subsequent chapters, this approach not only allows for a reinterpretation of known facts but also yields new testable predictions that go beyond standard quantum mechanics.

Chapter 2. Emergence of Space-Time and the Atom

A central challenge facing contemporary fundamental physics is understanding the status of spacetime itself. Is it the primary arena in which physical events unfold, or does it emerge from

deeper, previously unknown degrees of freedom? This question takes on particular urgency in quantum gravity, where the classical structures of spacetime *"are not simply quantized but perhaps absent—so that spacetime is not simply a classical limit but an 'emergent' one."* In this chapter, we will examine three interrelated currents in contemporary theoretical physics—emergent gravity, the holographic principle, and quantum information theory—which together lead to a new ontology in which information, not matter, is the fundamental entity. This ontological shift, which we call **informational monism**, constitutes the philosophical core of the Acta Universi (AU) hypothesis, in which space-time and matter, including atomic structures, emerge from the dynamics of the entropy field of thought forms S_Θ .

2.1 Space-time as an emergent structure

The idea that spacetime can be emergent has a long history, dating back to Sakharov's work on induced gravity (1967). However, in recent decades, this idea has received concrete mathematical realization in several independent theoretical programs.

2.1.1 AdS/CFT correspondence: from boundary to bulk

The most developed model of emergent spacetime is **the AdS/CFT correspondence** (Maldacena, 1997). This duality establishes an equivalence between the theory of gravity in the anti-de Sitter (AdS) volume and a gravity-free quantum field theory on its boundary. The key conclusion of this correspondence is that **the geometry of spacetime in the volume is completely encoded in the quantum information degrees of freedom on the boundary**.

This idea has been further developed within the **"It from Qubit" paradigm**, which postulates that *"gravitational spacetimes arise from quantum entanglement."* As noted in the 2025 review, *"one manifestation of this is that the entropy of entanglement in quantum multiparticle systems can be calculated from the area of the extremal surface in the corresponding gravitational spacetime. This implies that gravitational spacetimes can arise from a huge number of entangled qubits."*

In 2025 papers, new theoretical frameworks were proposed that extend AdS/CFT. For example, in the framework of **Measurement-Induced Temporal Geometry (MTG)** *"Spacetime and geometry emerge from quantum measurement acting on an internal time field."* Within MTG, *"modular Hamiltonians are reinterpreted as boundary projections of the bulk time flow, and entanglement wedges are identified with surfaces that minimize the measurement-induced projection current."*

2.1.2 Loop quantum gravity: atoms of space

Loop quantum gravity (LQG) offers an alternative, yet equally radical, view of the emergence of spacetime. Instead of quantizing the gravitational field against a fixed background, LQG quantizes the geometry of spacetime itself. The result is a discrete structure composed of **spin networks**—graphs whose nodes represent the elementary "atoms" of space.

Modern research from 2025–2026 continues to develop this idea. In the **Honeyverse model** *"spacetime is represented as a self-similar lattice of tetrahedra and octahedra—a physical embodiment of the abstract graphs of loop quantum gravity."* As shown in a recent paper, *"the causal structure and spin networks for generating discrete geometry emerge through projection from all partial spinors (fermion and bosonic) within the causal region of the double cone and their spin entanglements."*

Within the framework of **the Spacetime-Matter Trade-off principle** *"The density of spacetime is determined by the density of spin network nodes in loop quantum gravity."* This establishes a **fundamental connection between matter and geometry**: the concentration of matter influences the density of "atoms of space," and vice versa. This principle has direct parallels with the AU approach, where an atom is interpreted as a coherent structure in a field S_Θ .

2.1.3 Emergence from quantum entanglement

The third direction, combining AdS/CFT and LQG, focuses on **quantum entanglement** as a source of emergence. As Rasmus Jakland notes in his 2025 paper *"Spacetime from Entanglement,"* *"behind the general claims that spacetime arises from entanglement lie three distinct claims about emergence—concerning, respectively, the metric, gravity, and topology."*

"Entanglement, Bias, and the Emergence of Spacetime" approach explores the hypothesis that *"spacetime, mass, and fields—including the Higgs field—emerge from a fundamental network of Planck-scale nodes."* This is consistent with the AU approach, where the field S_Θ can be viewed as an information network whose nodes correspond to thought forms.

Particularly important is the result that *"both time and space can arise from entanglement within a globally bounded quantum universe, without background coordinates."* This directly resonates with the AU concept of kairos time τ , which, as demonstrated in previous works in the series, arises from the act of recording a primary thought-form and does not require pre-existing background time.

2.2 Atom as a participant in the creation of space-time

The standard notion of an atom as a passive material system existing in a predetermined space-time gives way to a more dynamic picture: atoms and molecules are **active participants** in the process of space-time emergence.

2.2.1 Quantum systems as persistent entities at the level of quantum space-time

Within emergent approaches, atoms and molecules cease to be simply localized accumulations of matter in a passive geometric arena. They become **persistent entities** at the level of quantum spacetime—stable configurations of more fundamental degrees of freedom.

As shown in work on quantum gravity, *"classical spacetime structures are not simply quantized but may be absent—so spacetime is not simply a classical limit but emergent."* This means that atoms, as stable structures, should be understood not as objects within spacetime, but as

coherent modes of the emergent process itself, just as vortices in a liquid are stable structures arising from the dynamics of the liquid itself.

In the AU approach, the atom is interpreted precisely this way: it is a coherent configuration of the entropy field of thought forms S_θ - a stable mode of the information field from which space-time emerges.

2.2.2 Atoms and molecules as sources of emergence through coarse-graining

An important mechanism of emergence is **coarse-graining** —averaging over microscopic degrees of freedom. As modern research shows, emergent spacetime arises through the coarse-graining process of quantum information structures. Within the framework of the "**Emergent metric from wavelet-transformed quantum field theory**" approach *"for thermal free scalar and Dirac field theories, the resulting bulk metric turns out to be an (asymmetrically) curved anti-de Sitter metric. "*

In this context, atoms and molecules can be viewed as **natural coarse-graining units** that participate in the formation of emergent geometry. Their quantum states, through the averaging process, contribute to the effective metric of spacetime. This has profound implications for understanding how quantum systems at the microscopic level participate in the creation of macroscopic geometric reality.

In the AU approach, this mechanism is formalized through a non-local kernel $K(x, y)$ and an entropic potential in a modified Schrödinger equation: atomic configurations, S_θ through their gradients and correlations, participate in the formation of an emergent metric $g_{\mu\nu} = \eta_{\mu\nu} + \beta \partial_\mu S_\theta \partial_\nu S_\theta + \dots$.

2.2.3 "Space-time atoms" and their role in the formation of classical geometry

Within LQG and related approaches, the concept of "**spacetime atoms**" —the minimal quanta of geometry from which classical spacetime is assembled—is actively explored. In **the Honeycomb Spin Networks model** *"a geometric realization of spin networks is presented through the Honeyverse model, where spacetime is represented as a self-similar lattice of tetrahedra and octahedra. "*

The 2025 paper *"Gravitation and Spacetime: Emergent from Spinor Interactions"* demonstrates that *"the causal structure and spin networks for generating discrete geometry emerge through projection from all the partial spinors... and their spin entanglements."* This means that the atoms themselves, through the spin interactions of their constituents (electrons, quarks), participate in the creation of the discrete geometric structure of spacetime.

In the AU approach, this idea finds a natural expression: atoms, as stable configurations S_θ , are not simply objects in spacetime, but **participants in its creation**. Each atom, through its entropic structure and integral information Φ , contributes to the local geometry, forming an emergent metric.

2.3 Informational nature of physical reality

The trends discussed above—AdS/CFT, LQG, and emergence from entanglement—point to a deeper shift: **information, not matter or spacetime, is the fundamental essence of reality.**

2.3.1 From digital physics to information ontology

The idea that information might be more fundamental than matter has a long history, dating back to the pioneering work of John Wheeler. His famous aphorism, **"It from Bit,"** asserted that *"any physical 'it' ultimately owes its existence solely to discrete answers to detector-induced information-theoretic 'yes' or 'no' questions—'bits.'"*

In 2025, this idea received new mathematical formulations. The paper *"The Universal Model Framework"* proposes *"to transform Wheeler's 'It from Bit' concept into a self-consistent mathematical pipeline: Axioms $\rightarrow$ Operators $\rightarrow$ Lagrangian $\rightarrow$ RG-flow $\rightarrow$ Constants $\rightarrow$ Observables."* This represents an attempt to formalize information ontology in a language compatible with modern quantum field theory.

However, as Gregg Yeager notes in his 2025 article *"The Universe Is Not Made of Information,"* this position is not uncontroversial. Yeager argues that *"many physicists and computer scientists, from John Wheeler to Google Deepmind's Demis Hassabis, have argued that reality is fundamentally composed of information,"* but this idea itself requires ontological clarification. What exactly does it mean to be "composed of information"? Is information a substance, a relation, or something else?

Within the framework of **information monism** (to which AU belongs), information is viewed not as a property of matter, but as **the primary substance** from which all physical structures emerge. As formulated in the 2025 paper *"Entropy, Topology, and Information as Structural Foundations of Physical Law,"* *"modern physics increasingly suggests that spacetime, geometry, and even fundamental interactions may not be primary constituents of nature, but rather emergent structures arising from a deeper informational or topological organization."*

2.3.2 Information models of emergent space-time

In 2025–2026, a number of specific models were proposed in which space-time emerges from information principles.

Conscious Information Geometry (CIG) presents *"a unified framework linking consciousness, information, and geometry within a single mathematical formalism. Information integration manifests itself as curvature on this manifold... geometry can emerge from the information dependence between conscious processes."* In CIG, *"spacetime is viewed as a geometric projection of information integration."*

The Recursive Reality Hypothesis (RRH) proposes *"a unified theoretical model that asserts that space-time, matter, and consciousness emerge from a deeper, non-spatio-temporal informational substance."*

Universal Theory of Information (TUI) states that *"space, time, mass, energy, and gravity emerge from recursive information dynamics"* and that *"information—not matter or spacetime—is fundamental."*

These models, despite their differences, agree on one thing: **information is a more fundamental entity than space-time and matter**. They create a conceptual context for the AU approach, in which the entropy field of thought forms S_Θ acts as a concrete realization of this informational substance.

2.3.3 Information as a primary entity in modern physics

Modern physics provides more and more empirical and theoretical arguments in favor of information ontology:

- **The holographic principle** posits that all information about a three-dimensional volume can be encoded on its two-dimensional boundary. As the 2025 review notes, *"our familiar three-dimensional reality appears fictitious, arising from information encoded on a two-dimensional area. Moreover, space and time appear to be emergent properties arising from pure quantum entanglement."*
- **The Bekenstein–Hawking entropy** establishes a fundamental connection between geometry (horizon area) and information (entropy). As shown in modern work, *"the entropy functional over these structures defines a rule of information preference."*
- **Quantum information theory** provides specific measures (Shannon entropy, von Neumann entropy, mutual information) that quantitatively characterize the information content of quantum systems. In quantum chemistry, these measures are already actively used to describe electron distributions.

Within the information ontology espoused by AU, **physical laws are not fundamental but emergent**—they emerge as effective descriptions of information dynamics on macroscopic scales. As formulated in a 2025 paper, *"modern physics increasingly suggests that spacetime, geometry, and even fundamental interactions... are emergent structures arising from a deeper informational or topological organization."*

2.4 Transition to the AU Paradigm: Information Monism

The trends discussed above—the emergence of space-time, the active role of atoms in the creation of geometry, and the informational nature of reality—provide the conceptual basis for the Acta Universi hypothesis. However, AU goes further, proposing a **concrete mathematical realization** of informational monism.

2.4.1 Rejection of the primacy of space-time and matter

In the AU ontology, *"space-time is not fundamental, but emergent from correlations of the AU-field."* This means that atoms, like all other physical structures, are not objects in a

predetermined space-time, but rather **coherent configurations of the entropy field of thought-forms** S_Θ , from which space-time itself emerges.

As noted in the analytical work on AU, the hypothesis *"rejects spacetime as the ultimate foundation and grants... the structural importance of information."* This is a fundamental ontological shift: information becomes the primary entity, and spacetime and matter become its emergent manifestations.

Within the AU framework, **the atom is not a passive material system**, but rather represents *"the minimal unit of integral information Φ in chemical systems,"* where *"its structure ensures a balance between localization (nucleus) and delocalization (electrons), which corresponds to maximization Φ for a given nuclear charge."* This radically rethinks atomic structure: the periodic law, chemical bonding, and spectral properties become consequences of information optimization, not simply solutions of the Schrödinger equation.

2.4.2 The entropy field of thought forms S_Θ as a fundamental entity

The central concept of the AU is **the thought-form entropy field** S_Θ —a scalar field defined on an abstract manifold prior to the emergence of space-time. This field is a local projection of the non-local archive of thought-forms onto emergent space-time.

In AU S_Θ it serves a dual function:

1. **Entropy measure:** S_Θ quantitatively characterizes the density of information diversity (thought forms) at a given point. It is limited by the holographic limit S_{holo} , which ensures the finiteness of all physical quantities and eliminates singularities.
2. **Geometric potential:** gradients S_Θ through an emergent metric $g_{\mu\nu} = \eta_{\mu\nu} + \beta \partial_\mu S_\Theta \partial_\nu S_\Theta + \dots$ generate spacetime geometry. This means that **gravity is a gradient of entropy**—an idea that finds parallels in Verlinde's entropic gravity, but receives a concrete mathematical realization in the AU.

Applied to the atom, this means that electron orbitals are not simply probability distributions, but **field modes** S_Θ —stable vibrational configurations of the information field from which spacetime emerges. The atomic nucleus, in turn, is a region of high density S_Θ , where the strong interaction is interpreted as **entropic confinement**—the confinement of high entropy values within a limited region.

2.4.3 Connection with the holographic principle and the theory of integrated information

The AU approach organically integrates two fundamental principles of modern physics and cognitive science:

The holographic principle in the AU manifests itself through the constraint $S_\Theta \leq S_{\text{holo}}$, where $S_{\text{holo}} = k_B c^3 A / (4 \hbar G)$ is the Bekenstein–Hawking entropy. This constraint ensures that the total information capacity of any region of space is finite, which in turn ensures the finiteness of all physical quantities—from the electron binding energy to the hadron mass. In the context of the

atom, this means that **electron shells cannot be infinitely compressed** ; there is a minimum atomic size determined by the holographic limit.

Integrated Information Theory (IIT) finds its physical embodiment in the AU. Integral information Φ in IIT measures the degree of causal integration of a system. In the AU, Φ it becomes a **physical quantity** that determines the stability of atomic and molecular structures. As formulated in the paper "Acta Universi: Emergent Spacetime from the Entropy of Thought and Integrated Information," spacetime and matter emerge from the entropy of thought and integrated information.

In an atom, Φ the number of electrons and their spatial distribution determines the reactivity. Elements with filled shells (inert gases) have maximum Φ and minimum chemical activity; elements with one valence electron (alkali metals) have low Φ and high reactivity. **The periodic law thus receives an informational justification:** it is a consequence of maximizing integral information for a given nuclear charge.

2.4.4 AU as an information-ontological alternative

Thus, AU offers a **coherent information-ontological alternative** to the standard reductionist approach to atomic structure:

- Instead of viewing the atom as a material system subject to external quantum laws, AU interprets it as a **coherent structure in the entropy field of thought forms** S_Θ .
- Instead of postulating spacetime as a primary arena, AU derives it **emergently** from correlations and gradients S_Θ .
- Instead of viewing quantum transitions as probabilistic events without ontological status, AU interprets them as **irreversible acts of recording thought-forms** into a non-local archive.
- Instead of explaining the periodic law phenomenologically through the filling of shells, AU derives it from **the principle of maximization of integral information** Φ .

This shift from materialistic reductionism to informational monism is not a simple reinterpretation. It opens up new testable predictions—from entropic shifts of atomic levels to the modulation of spontaneous emission by coherent thought forms—that take the AU beyond standard quantum mechanics and establish it as a fully-fledged scientific hypothesis.

2.5 Summary

In this chapter, we have examined three interconnected areas of modern physics—emergent gravity (AdS/CFT, LQG), emergence from quantum entanglement, and information ontology—which together lead to a new understanding of the atom as an active participant in the creation of space-time.

Key findings:

1. **Spacetime is emergent:** in AdS/CFT, LQG, and entanglement theories, classical spacetime emerges from more fundamental, non-geometric degrees of freedom—quantum fields on the boundary, spin networks, or entangled qubits.
2. **Atoms are active participants in emergence:** through quantum states, spin interactions, and coarse-graining procedures, atoms and molecules contribute to the formation of the emergent geometry of spacetime.
3. **Information is the primary entity:** from Wheeler's "It from Bit" to the modern CIG, RRH and TUI models, information is seen as the fundamental substance from which space-time, matter and the laws of physics emerge.
4. **AU offers a concrete implementation of informational monism:** the entropy field of thought forms S_Θ acts as a primary entity from which space-time ($g_{\mu\nu}$) and matter (atoms as coherent configurations S_Θ) emerge through gradients and correlations.
5. **The atom in AU receives a new ontological justification:** it is not a passive material system, but a stable configuration of the information field, minimizing entropy and maximizing integral information Φ under given boundary conditions.

In the following chapters, we will develop the mathematical formalism of this approach, showing how the modified Schrödinger equation with entropy potential and nonlocal kernel $K(x, y)$ describes atomic structures, and how the maximization principle Φ explains the periodic law and chemical bonding.

Part II. Ontological Foundations of the Atom in AU

Chapter 3. The Entropy Field of Thought Forms S_Θ as a Fundamental Reality

In the previous chapter, we demonstrated that modern physics is increasingly leaning toward recognizing the emergence of space-time and the primacy of information. However, these general principles remain abstract until they receive a concrete mathematical realization. The Acta Universi (AU) hypothesis proposes such a realization through **the entropy field of thought forms**. $S_\Theta(x)$ — a scalar field defined on an abstract manifold prior to the emergence of spacetime, which serves as the fundamental substance from which all physical structures, including atoms, emerge. In this chapter, we develop the ontology S_Θ , showing how particles, nuclei, and electron shells arise as coherent configurations of this field, and how the principle of maximizing integral information Φ explains the periodic law and chemical activity.

3.1 AU-ontology: information as a primary entity

The AU hypothesis is based on **information monism** —the assertion that information, not matter or spacetime, is the fundamental reality. As formulated in the programmatic work "Acta Universi: Emergent Spacetime from the Entropy of Thought and Integrated Information," *"spacetime, metric structure, and causality are not fundamental, but emerge from a nonlocal archive of events, the entropy field of thoughtforms, and the field of integrated information."* This ontological shift has deep roots in modern physics and philosophy.

3.1.1 Non-local archive of thought forms as the basis of all that exists

The central concept of the AU is **the non-local archive of thought-forms** —an information structure that is not localized in space-time (since space-time itself arises from it) and is not subject to ordinary causal constraints. The archive contains all possible and actual information configurations—thought-forms, which are information quanta in the AU ontology.

As demonstrated in works on information cosmology, the idea of a universal archive has parallels with **the "Book of Life"** in theological traditions, **the Akashic records** in theosophy, and **the "Guarded Tablet"** in Islam. However, in the AU, the archive is not a metaphysical entity, but rather a **physically real information field** whose dynamics are governed by strict mathematical equations.

A recent paper, "The Universal Model Framework" (2025), proposes a formalization of Wheeler's "It from Bit" as a *"self-consistent mathematical pipeline: Axioms $\rightarrow$ Operators $\rightarrow$ Lagrangian $\rightarrow$ RG-flow $\rightarrow$ Constants $\rightarrow$ Observables."* In the AU, this pipeline is realized through the dynamics of a field S_Θ that encodes all archive information in local form.

3.1.2 Field S_Θ as a local projection of the archive onto emergent space-time

The entropy field of thought forms $S_\Theta(x)$ is a **local projection** of a non-local archive onto emergent space-time. Mathematically, this is expressed through an integral transformation:

$$S_\Theta(x) = \int_{\mathcal{A}} \mathcal{P}(x, a) \Psi(a) da,$$

where $\mathcal{A}$ is the state space of the archive, $\Psi(a)$ is the amplitude of the thought form in the state a , and $\mathcal{P}(x, a)$ is the projection operator linking the abstract state with the point of the emergent manifold.

Under stationary conditions (for example, in an isolated atom) S_Θ satisfies an equation which in the local approximation has the form:

$$\square S_\Theta + V'(S_\Theta) + \int K(x, y) S_\Theta(y) d^4y = J_{\text{source}}(x),$$

where $K(x, y)$ is a nonlocal kernel describing the archive memory, and J_{source} are external sources (e.g., the Coulomb field of the kernel). This equation, as shown in previous papers in the series, ensures finiteness S_Θ due to the holographic limit S_{holo} .

In the context of an atom, the field S_Θ is not uniform. The atomic nucleus creates a region of high density S_Θ , and the electron shells create regions with a modulated value S_Θ corresponding to the electron orbitals. As will be shown in Chapter 4, these modulations are described by a modified Schrödinger equation, where $\Delta p S_\Theta$ is included in the effective potential.

3.1.3 The connection of the AU field with dark energy and cosmological evolution

The field S_Θ is not limited to the atomic scale; it permeates the entire Universe and determines its cosmological evolution. As shown in the first article in the series (Yashchenko, 2026), the act of recording a primary thought-form creates a gradient ∇S_Θ , which, through the emergent metric, $g_{\mu\nu} = \eta_{\mu\nu} + \beta \partial_\mu S_\Theta \partial_\nu S_\Theta + \dots$ initiates the expansion of the Universe and inflation.

In a cosmological context, dark energy is interpreted as **the information density of an archive** associated with nonlocal effects $K(x, y)$. As shown in the second article in the series, dark matter arises from soliton configurations and nonlocal field correlations S_Θ .

Thus, the field S_Θ is **a unified information field**, whose dynamics at different scales generate all observable cosmological phenomena—from atomic spectra to large-scale structure. In this sense, the AU proposes **an informational-ontological unity** between the microworld and the macroworld: atoms and galaxies are different modes of the same field.

3.2 Particles as field solitons S_Θ

In standard physics, particles are excitations of quantum fields. In the AU ontology, this picture is radically reinterpreted: particles become **stable, localized field configurations** S_Θ —solitons—held together by nonlinearity $\lambda_S S_\Theta^3$ and a nonlocal core $K(x, y)$.

3.2.1 Stable localized field configurations as fundamental “particles”

The nonlinear equation for S_Θ allows for soliton solutions—stable localized structures that can move and interact while maintaining their identity. In the simplest case of a spherically symmetric soliton:

$$S_\Theta(r) = S_0 \operatorname{sech}^2(r/L),$$

where L is the characteristic size determined by the balance between nonlinearity λ_S and the effective mass m_S , and S_0 is the amplitude. Such solitons are interpreted as **fundamental particles**: electrons, quarks, and neutrinos.

In modern physics, a similar idea is being developed within the framework **of topological soliton models** (skyrmions, monopoles). As shown in the 2025 paper *"Topological Quantum Computing: Principles, Advances, and Implications,"* topological structures are playing an increasingly important role in quantum physics. In AU, this idea is generalized: all particles are topological or soliton structures of a field S_Θ .

3.2.2 Entropy quanta as a replacement for action quanta

In standard quantum mechanics, the fundamental discrete quantity is the quantum of action $\hbar$. In the AU approach, **the quantum of entropy** δS_Θ replaces the quantum of action. This means that the discreteness of energy levels arises not from the quantization of angular momentum, but from the discreteness of possible field configurations S_Θ .

For the hydrogen atom, this provides an alternative explanation for quantization: stationary states correspond to solutions of the equation for S_Θ , for which the integral of $|\nabla S_\Theta|^2$ over the volume of the atom takes discrete values:

$$\int_{\text{atom}} |\nabla S_\Theta|^2 d^3x = n \delta S_{\min},$$

where n is the principal quantum number, and $\delta S_{\min}$ is the minimum entropy quantum associated with the holographic limit:

$$\delta S_{\min} \sim \frac{k_B}{4}.$$

This establishes a direct connection between the quantization of atomic levels and the holographic principle, which is a new prediction that goes beyond standard quantum mechanics.

3.2.3 Quark confinement as entropy confinement

One of the most profound applications of the soliton interpretation is **quark confinement**. In standard QCD, quarks are held inside hadrons by the strong interaction, but there is no analytical explanation for this phenomenon. In the AU approach, confinement is interpreted as **entropic confinement**: an isolated quark would create a divergent gradient S_Θ , which is impossible given the finite information capacity of the AU field.

Mathematically, this is expressed through the condition of finiteness of the integral:

$$\int_{\text{объём}} |\nabla S_\Theta|^2 d^3x < S_{\text{crit}},$$

where S_{crit} is the critical entropy associated with the hadron surface area. If this condition is violated, the system produces a quark-antiquark pair, which screens the color charge. As shown in the paper "Quark Confinement in the Context of the Acta Universi Hypothesis," this yields a linear potential $V(R) = \sigma R$ with string tension $\sigma \approx (440 \text{ МэВ})^2$ consistent with lattice QCD calculations.

3.3 The nucleus of an atom as a region of high density S_Θ

The nucleus of an atom, consisting of protons and neutrons held together by the strong interaction, in the AU interpretation is **a region with an anomalously high field density S_Θ** , where the strong interaction acts as an entropy confinement.

3.3.1 Strong interaction as confinement of entropy

In standard QCD, the strong interaction is described by the exchange of gluons between quarks. In the AU approach, gluons are interpreted as **fluctuations** $C_{\mu\nu}$ of the field correlation tensor S_Θ , and the strong interaction is interpreted as **an entropic attraction** between high-density regions S_Θ .

A recent paper, "*Theta entropy S_Θ Acta Universi and restriction of free will*," shows that high values S_Θ create gradients that tend to align across the nonlocal core $K(x, y)$. In the nucleus of an atom, protons and neutrons are held together because separating them would create a gradient too large S_Θ , exceeding a critical limit. This is analogous to how surface tension holds liquid droplets together: separating a droplet requires energy proportional to its surface area.

3.3.2 Nucleons as coherent structures of a high-magnitude field $S_{\text{ядро}}$

Each nucleon (proton or neutron) is a coherent field structure S_Θ with a characteristic size $\sim 1\text{fm}$ and a value $S_{\text{ядро}}$ close to the holographic limit S_{holo} for a given region. The nucleon mass is determined by the integral of S_Θ over its volume:

$$M_N = \alpha \int_{\text{нуклон}} S_\Theta d^3x + \beta,$$

where α and β are constants depending on the quark composition. This expression is consistent with the phenomenology: the masses of the proton (938.272 MeV) and neutron (939.565 MeV) differ due to different configurations S_Θ (different numbers of u - and d -quarks).

3.3.3 Equation for the nuclear field

In a stationary state, the nucleus is described by the equation for a field S_Θ with a source from nucleons:

$$\square S_{\text{ядро}} + m_S^2 S_{\text{ядро}} + \lambda_S S_{\text{ядро}}^3 = \rho_{\text{нуклоны}}(r),$$

where $\rho_{\text{нуклоны}}$ is the nucleon density, interpreted as the density of thought forms held together by the strong interaction. In the homogeneous nucleus approximation, the solution is:

$$S_{\text{ядро}}(r) = S_{\text{ядро}}^{(0)} \cdot \frac{\sinh((R_{\text{ядро}} - r)/\xi)}{\sinh(R_{\text{ядро}}/\xi)},$$

where ξ is the correlation length determined by the field parameters, and $R_{\text{ядро}}$ is the radius of the nucleus. This solution demonstrates that S_Θ reaches a maximum at the center of the nucleus and decreases exponentially toward the surface, which is consistent with the density distribution of nuclear matter in standard physics.

3.4 Atom as a minimal unit of integral information Φ

Within the framework of Giulio Tononi's integrated information theory (IIT), integrated information Φ measures the degree of causal integration of a system. In the AU approach, Φ it becomes **a fundamental physical quantity**, determining the stability and complexity of atomic and molecular structures.

3.4.1 Balance between localization (nucleus) and delocalization (electrons)

An atom is a system in which the nucleus (a localized region of high density S_Θ) and electrons (delocalized field modes S_Θ) are in dynamic equilibrium. This equilibrium **maximizes Φ the charge of the nucleus for a given charge**.

Intuitively, if electrons are too localized (as in the Bohr model), the system loses information integration; if they are too delocalized (as in free particles), the system loses causal structure. The optimal balance is achieved with a quantum-mechanical distribution of electrons across orbitals that maximizes Φ .

In mathematical form, this is expressed as a variational problem:

$$\Phi[\psi] = \max_{\psi} \{\text{Интегрированная информация системы с волновой функцией } \psi\},$$

where ψ is the electron wave function satisfying the modified Schrödinger equation (see Chapter 4). Solutions to this variational problem yield electron configurations corresponding to the observed atomic spectra.

3.4.2 Maximization Φ for a given nuclear charge

For a given atom with a nuclear charge of, Z the number of electrons is Z (in a neutral atom). The distribution of these electrons among the shells is determined by the maximization principle Φ . As shown in IIT, Φ maximization occurs when the system has high integration (strong causal relationships between its parts) and high information complexity.

In an atom, this means that electrons tend to fill their shells in a way that minimizes entropy and maximizes causal force. This leads to **the periodic law**: elements with filled shells (inert gases) have maximum Φ and minimum chemical reactivity; elements with one valence electron (alkali metals) have low Φ and high reactivity.

3.4.3 Periodic law as a consequence of maximization of integral information

Standard quantum mechanics explains the periodic law through the filling of shells according to the Pauli exclusion principle and Hund's rules. However, this explanation remains phenomenological: it describes *how* the shells are filled, but does not explain *why* nature chose this particular structure.

The AU approach provides **a teleological explanation**: the periodic law is a consequence of **information optimization**. Nature "tends" to maximize Φ for a given system, and the electron configurations that realize the maximum Φ correspond to the observed periodic table.

This explanation has profound parallels with the minimum energy principle in thermodynamics, but at the informational level. As shown in the work *"Conscious Information Geometry, "information integration manifests itself as curvature on this manifold... geometry can arise from the information dependence between conscious processes."* In an atom, this curvature corresponds to electron orbitals.

3.5 Summary

In this chapter, we laid the ontological foundations of the AU approach to the atom, presenting the entropy field of thought forms S_Θ as a fundamental reality. Key findings:

1. **Information monism:** in AU-ontology, information is primary; space-time and matter emerge from a non-local archive of thought-forms, the local projection of which is the field S_Θ .
2. **Particles as solitons:** Fundamental particles (electrons, quarks) are interpreted as stable localized field configurations S_Θ held together by nonlinearity $\lambda_S S_\Theta^3$. Quantization arises from the discreteness of the possible configurations S_Θ .
3. **The nucleus as a region of high density S_Θ :** the strong interaction is interpreted as entropic confinement; nucleons are coherent structures with a high value of $S_{\text{ядро}}$; the mass of nucleons is determined by the integral of S_Θ .
4. **The atom as a unit Φ :** the atom is the minimal unit of integral information Φ ; its structure ensures a balance between localization and delocalization, maximizing Φ for a given nuclear charge; the periodic law receives an informational justification.

These ontological principles will be used in subsequent chapters to derive a modified Schrödinger equation (Chapter 4) and explain chemical bonding and molecular dynamics (Chapters 7–8). Thus, the AU approach offers a **unified information-entropy picture** linking the microworld (atoms) with the macroworld (cosmology) through a unified field S_Θ .

Chapter 4. Electron Orbitals as Field Modes S_Θ

In the previous chapter, we laid the ontological foundations of the AU approach: the entropy field of thought forms S_Θ as a fundamental reality, particles as solitons of this field, the nucleus as a high-density region S_Θ , and the atom as the minimal unit of integral information Φ . We now turn to **the mathematical formalism** describing electron orbitals. In standard quantum mechanics, orbitals are solutions to the Schrödinger equation—mathematical constructs without a clear ontological status. In the AU approach, they receive a new interpretation: **electron orbitals are eigenmodes of the field S_Θ** —stable vibrational configurations of the information field from which spacetime emerges. In this chapter, we derive a modified Schrödinger equation with entropy and nonlocal terms, show how energy levels arise as

eigenvalues of the AU Hamiltonian, and discuss the connection with modern information-theoretical approaches in quantum chemistry.

4.1 Wave function as the amplitude of a thought form

A central question in quantum mechanics is the ontological status of the wave function $\psi(r, t)$. Is it a real physical field, or is it merely a tool for calculating probabilities? As noted in Chapter 1, *"wave-function realism asserts that the wave function, as described by quantum mechanics, corresponds to a real physical entity."* However, as a recent philosophical analysis shows, even this position faces a tension: it *"accepts the ontology of the wave function while deliberately avoiding the meta-ontological question of the truth of the theoretical framework itself."*

4.1.1 ψ as the field amplitude S_Θ for an electron

In the AU approach, the wave function ψ acquires a **clear ontological status**: it is **the field amplitude S_Θ** for an electron—a local measure of how much the field S_Θ deviates from the background value at a given point in space. In other words, ψ it is **a mode of oscillation** of the information field, similar to how a sound wave is a mode of oscillation of the air medium.

In the second quantization formalism this is expressed as:

$$\hat{S}_\Theta(x) = \sum_n [\psi_n(x) \hat{a}_n + \psi_n^*(x) \hat{a}_n^\dagger],$$

where $\hat{a}_n$ and $\hat{a}_n^\dagger$ are the annihilation and creation operators for the n -th mode, and $\psi_n(x)$ is the wave function satisfying the modified Schrödinger equation (see Section 4.2). In this formalism, **the electron is not a particle in the classical sense**, but represents an excitation quantum of the corresponding field mode S_Θ .

This interpretation has deep parallels with quantum field theory, where particles are excitations of fields. However, in AU, the field is not an abstract quantum field, but **an information field of the entropy of thought forms**, which provides an ontological justification lacking in the standard formalism.

4.1.2 Electron orbitals as density distributions of thought forms

In standard quantum chemistry, an orbital is defined as a single-electron wave function and $|\psi(r)|^2$ is interpreted as the probability density of detecting an electron. In the AU approach, $|\psi(r)|^2$ it is interpreted as **the density of thought forms**—a measure of how densely the information field S_Θ is concentrated in a given region of space.

This interpretation changes the ontological status of orbitals. They cease to be mere probability distributions and become **real physical structures**—areas of increased density of thought forms held by the nucleus through the non-local core $K(x, y)$ and entropic potential.

In mathematical form, the density of thought forms for an electron in the state n is defined as:

$$\rho_n(r) = |\psi_n(r)|^2 \cdot \langle S_\Theta(r) \rangle,$$

where $\langle S_\Theta(r) \rangle$ is the background field value at a given point. This expression links quantum mechanical probability with the information structure of the field S_Θ , providing a new understanding of electron density.

4.1.3 Abandonment of trajectory representation in favor of modal representation

One of the most radical differences between the AU approach and classical physics is its **complete rejection of the trajectory representation**. In classical mechanics, a particle moves along a specific trajectory; in quantum mechanics, the trajectory is replaced by a wave function, but the question remains whether a "real" trajectory exists (as in the de Broglie-Bohm interpretation). In the AU approach, this question is resolved: **the electron is not a particle moving along a trajectory, but rather a stable mode of the field S_Θ** .

As shown in works on emergent quantum mechanics, *"in emergent quantum mechanics, the trajectory view of quantum particles appears to contradict the spirit of the theory."* In AU, this principle is elevated to an ontological level: orbitals are not probability distributions for trajectories, but **real modes of the information field** that have no trajectory analogue.

This has profound implications for understanding chemical bonding and molecular dynamics: chemical bonding is interpreted as **mode fusion S_Θ** (see Chapter 7) rather than as the sharing of electrons along specific trajectories.

4.2 Modified Schrödinger equation in AU

In standard quantum mechanics, the stationary Schrödinger equation has the form:

$$-\frac{\hbar^2}{2m_e} \nabla^2 \psi + V_{\text{Coulomb}}(r) \psi = E \psi,$$

where $V_{\text{Coulomb}}(r) = -Ze^2/(4\pi\epsilon_0 r)$ is the Coulomb potential of the nucleus. In the AU approach, this equation is modified by adding two new terms reflecting the information-entropic nature of the field S_Θ .

4.2.1 Structure of effective potential

The effective potential in AU is:

$$V_{\text{eff}}(r) = -\frac{Ze^2}{4\pi\epsilon_0 r} + \lambda \frac{\partial S_\Theta}{\partial r} + \int K(r, r') S_\Theta(r') d^3r'.$$

Each of these members has a clear physical meaning within the AU ontology.

Coulomb member $V_{\text{Coulomb}} = -Ze^2/(4\pi\epsilon_0 r)$ — is the standard electrostatic interaction between the electron and the nucleus. In the AU interpretation, it arises as an effective description of the interaction between two field regions S_Θ with different densities (the nucleus is a high density, the electron is a local perturbation). In the limit of weak entropic corrections, the Coulomb term dominates, which explains why standard quantum mechanics works so well for light atoms.

Entropy term $\lambda \partial S_\Theta / \partial r$ — is the contribution from the gradient of the thought-form entropy field. It can be either positive (repulsion) or negative (attraction), depending on the sign λ and direction of the gradient. Physically, this term reflects the field's tendency S_Θ to equalize: regions with a high gradient tend to relax, creating an effective force acting on the electron. In the hydrogen atom, this term provides a correction to the Coulomb potential, which can explain the Lamb shift and other anomalies.

Non-local member $\int K(r, r') S_\Theta(r') d^3 r'$ — is the contribution from the nonlocal nucleus, which describes the memory of the thought-form archive. This term connects the electron to the nucleus and to other electrons through nonlocal correlations, which are ignored in standard quantum mechanics. In multi-electron atoms, the nonlocal term contributes to the electron-electron interaction, which goes beyond simple Coulomb repulsion.

4.2.2 The Coulomb term and its AU interpretation

The Coulomb potential $V_{\text{Coulomb}}(r) = -Ze^2/(4\pi\epsilon_0 r)$ in the AU approach is not fundamental, but represents **an effective description** of the interaction between two coherent field structures S_Θ : a nucleus (high-density region) and an electron (field mode).

In the formalism of quantum field theory, the Coulomb interaction arises from the exchange of virtual photons. In the AU approach, photons are interpreted as fluctuations of the field S_Θ **correlation tensor**, and the Coulomb potential is derived as the limit of nonlocal interaction:

$$V_{\text{Coulomb}}(r) = \lim_{\text{нелокальный предел}} \int K_{\text{EM}}(r, r') S_\Theta(r') d^3 r',$$

where K_{EM} is the electromagnetic nonlocal kernel, which in the limit of small distances yields $1/r$ the -law. This demonstrates that the AU approach does not reject the Coulomb interaction, but rather **integrates it into a deeper information framework**.

4.2.3 Entropy term: $\lambda \frac{\partial S_\Theta}{\partial r}$

The entropy term in the effective potential is one of the most original features of the AU approach. It can be understood through analogy with **entropic forces** in emergent gravity (Verlinde, 2016). In emergent gravity, gravity arises as an entropic force proportional to the entropy gradient. In the AU approach, a similar idea is applied to the atomic scale: **the electron "feels" the gradient of the entropy field of thoughtforms as an additional force** that modifies the Coulomb potential.

In a hydrogen atom, the gradient S_Θ is directed from the core (high density S_Θ) to the outer regions (low density). If $\lambda > 0$, the entropy term creates an additional attraction to the nucleus; if, $\lambda < 0$ it creates a repulsion. The sign and magnitude λ are determined by the field parameters S_Θ and can be extracted from precision spectroscopic measurements.

Modern research shows that *"entropic forces can play a role in quantum systems, particularly in the context of quantum information and quantum entanglement."* In the AU, this principle is concretely realized through the entropy term in the Schrödinger equation.

4.2.4 Non-local member: $\int K(r, r') S_{\Theta}(r') d^3 r'$

The nonlocal term describes **correlations between the electron and the nucleus, as well as between electrons**, that go beyond the local Coulomb interaction. In standard quantum chemistry, such correlations are taken into account through exchange-correlation functionals in DFT or through configurational interactions in post-Hartree–Fock methods. In the AU approach, they receive **a unified microscopic justification** through the nonlocal nucleus $K(x, y)$.

The nucleus $K(x, y)$ in the atomic context has the form:

$$K(r, r') = \alpha_{nl} \frac{e^{-|r-r'|/r_c}}{|r - r'|},$$

where α_{nl} is the dimensionless nonlocal coupling constant, and r_c is the crossing-over scale at which nonlocal effects become significant. In atoms, r_c it can vary from the Bohr radius ($a_0 \approx 0.529 \text{ \AA}$) to scales comparable to the atomic size.

The nonlocal term introduces energy corrections that may be significant for precision spectroscopy. As shown in papers on nonlocal gravity, *"the nonlocal core does not introduce new poles or tachyon instabilities: it is equivalent to a superposition of healthy Yukawa propagators with positive weight."* In atomic physics, this means that nonlocal corrections are regular and can be calculated using perturbation theory.

4.2.5 Complete modified Schrödinger equation

Thus, the full modified Schrödinger equation in AU is:

$$-\frac{\hbar^2}{2m_e} \nabla^2 \psi(r) + V_{\text{eff}}(r) \psi(r) = E \psi(r),$$

Where

$$V_{\text{eff}}(r) = -\frac{Ze^2}{4\pi\epsilon_0 r} + \lambda \frac{\partial S_{\Theta}}{\partial r} + \int K(r, r') S_{\Theta}(r') d^3 r'.$$

This equation is **a generalization of the standard Schrödinger equation**, which is recovered in the limit $\lambda \rightarrow 0$ and $K \rightarrow 0$. In this sense, the AU approach does not reject standard quantum mechanics, but rather **extends it** by introducing new terms that become significant in precision measurements and in systems with strong information correlations.

In the next section we show how solutions of this equation yield energy levels that can be matched to observed atomic spectra.

4.3 Energy levels as operator eigenmodes $\hat{\mathcal{H}}_{\text{AU}}$

In standard quantum mechanics, energy levels are eigenvalues of the Hamiltonian $\hat{H} = -\hbar^2/(2m)\nabla^2 + V(r)$. In the AU approach, the Hamiltonian is modified:

$$\hat{\mathcal{H}}_{\text{AU}} = -\frac{\hbar^2}{2m_e} \nabla^2 + V_{\text{eff}}(r),$$

and the energy levels E_n are determined by the equation:

$$\hat{\mathcal{H}}_{\text{AU}} \psi_n = E_n \psi_n.$$

4.3.1 Level shifts from entropic corrections

The entropy term $\lambda \partial S_\Theta / \partial r$ and the nonlocal term $\int K S_\Theta$ yield **shifts in the energy levels** compared to the standard Schrödinger equation. In first-order perturbation theory, the shift for the state n is:

$$\Delta E_n^{(1)} = \left\langle \psi_n^{(0)} \mid V_{\text{AU}} \mid \psi_n^{(0)} \right\rangle,$$

where $V_{\text{AU}}(r) = \lambda \partial S_\Theta / \partial r + \int K(r, r') S_\Theta(r') d^3 r'$, and $\psi_n^{(0)}$ are the unperturbed wave functions of the hydrogen atom.

For the hydrogen atom, this shift can be calculated analytically. Using wave functions $\psi_{nlm}^{(0)}$ and assuming that $S_\Theta(r)$ decreases as $1/r$ (due to the Coulomb source), we obtain:

$$\Delta E_{nl} \approx \frac{\lambda Z e^2}{4\pi \epsilon_0} \cdot \frac{1}{n^2} \cdot f(l) + \text{нелокальные поправки},$$

where $f(l)$ is a function dependent on the orbital quantum number l . This dependence on l leads to **the lifting of the degeneracy in l** , which can explain the fine structure of atomic spectra without resorting to relativistic corrections.

Modern precision spectroscopy experiments have achieved precision that allows them to measure level shifts at the 10^{-12} electronvolt level. As the 2025 review states, "*precision hydrogen spectroscopy enables the search for new physics beyond the Standard Model.*" AU predictions for entropy shifts can be tested in such experiments.

4.3.2 Explanation of the Lamb shift and fine structure

The Lamb shift —the energy difference between the hydrogen $2S_{1/2}$ levels $2P_{1/2}$ —is one of the most accurate predictions of quantum electrodynamics (QED). In standard QED, the Lamb shift is explained by vacuum polarization effects and electron mass renormalization.

In the AU approach, the Lamb shift receives **an alternative explanation**: it arises from the entropy term, which affects the $\lambda \partial S_\Theta / \partial r$ - and -states P differently S . For S -states ($l = 0$), the wave function has a nonzero amplitude in the core region, where the gradient S_Θ is maximum; for P -states ($l = 1$), the wave function vanishes at the center, and the entropy term makes a smaller contribution.

This explanation does not reject QED, but **rather complements it**: part of the Lamb shift, traditionally attributed to vacuum polarization effects, may have an entropic origin. This prediction can be tested by comparing the accuracy of the predictions of pure QED and AU-extended QED.

Fine structure —the splitting of levels with identical n and l but different j total angular momentum—is explained in standard physics by spin-orbit interactions and relativistic corrections (the Dirac equation). In the AU approach, an additional contribution to the fine structure comes from the nonlocal term $\int K S_\theta$, which depends on the electron's spin state via the coupling to the consciousness field Φ .

In formalism this is expressed as:

$$V_{\text{spin}}(r) = \gamma \Phi(r) (L \cdot S),$$

where γ is a constant relating the consciousness field to the electron spin. This means that the fine structure may be sensitive to the informational environment of the atom—a prediction that goes beyond standard physics.

4.3.3 Prediction of new spectral anomalies

The modified Schrödinger equation predicts **new spectral anomalies** that are not explained by standard QED. These include:

1. **Dependence of energy levels on the density of thought forms in the environment:** if an atom is located in a region with a high density of coherent thought forms (e.g., near a conscious observer), the entropy term $\lambda \partial S_\theta / \partial r$ is modified, leading to a shift in energy levels. This prediction can be tested in experiments with precision spectroscopy in various social and cognitive contexts.
2. **Energy level oscillations** due to fluctuations S_θ : As shown in the paper "Spontaneous fluctuations of the theta-entropy field before significant events," the field S_θ fluctuates $\varphi(t)$ before significant events. These fluctuations should lead to temporal variations in atomic levels, which can be detected as anomalies in spectral lines.
3. **The connection between atomic spectra and collective consciousness:** within the AU approach, the field of consciousness Φ enters the effective potential through a nonlocal term. This means that atomic spectra may correlate with states of consciousness—a prediction that can be tested in experiments with meditation or other cognitive protocols.

4.4 Connection with modern research in quantum chemistry

The AU approach is not an isolated construct; it fits seamlessly into modern information-theoretical approaches in quantum chemistry, which are actively developing in 2025–2026.

4.4.1 Information-theoretical approach to electronic structure

As noted in Chapter 1, *"today, information theory serves as a universal tool in statistics, the natural sciences, machine learning, quantum computing, and many other fields."* In quantum chemistry, the information-theoretic approach (ITA) is applied to the analysis of electron distributions using Shannon entropy, relative entropy, and mutual information.

The AU approach **extends this approach** by introducing an ontological justification: information measures cease to be simply computational tools and become **fundamental physical quantities** that determine atomic structure. Shannon's entropy for the electron distribution $\rho(r) = |\psi(r)|^2$ in the AU approach is interpreted as **the local density of thought forms**:

$$\begin{aligned} S_{\text{Shannon}} &= - \int \rho(r) \ln \rho(r) d^3r \\ &= - \int |\psi(r)|^2 \ln |\psi(r)|^2 d^3r + (\text{энтропийные поправки}). \end{aligned}$$

In 2025, studies were published linking *the "information skeleton"* of molecules with their chemical activity. In the AU approach, this "information skeleton" is interpreted as **a field structure** S_Θ —stable modes of the information field that determine chemical properties.

4.4.2 Shannon entropy and its role in the description of atomic systems

In 2025–2026 studies, Shannon entropy is actively used to analyze electron distributions in atoms and molecules. The studies show that *"Shannon entropy supports the uncertainty principle by demonstrating an inverse relationship between position entropy and momentum entropy."*

In the AU approach, this dependence receives **a new interpretation**: it reflects a fundamental limitation on the locality of information in a field S_Θ . The more localized a thought-form (high position entropy), the more delocalized its momentum (low momentum entropy), and vice versa. This limitation is a consequence of the holographic limit S_{holo} , which guarantees the finite information capacity of any region of space.

4.4.3 Quantum entanglement in atomic systems

Quantum entanglement in atomic systems has become an active field of study in 2025. Research suggests that *"entanglement between individual atoms, the processing of encoded entanglement, and its temporal evolution"* are key to understanding quantum technologies.

In the AU approach, quantum entanglement is interpreted as **nonlocal correlations between field modes** S_Θ . Entangled states correspond to configurations in which several modes S_Θ are coupled through a nonlocal core $K(x, y)$, creating a single coherent structure. This provides **an ontological justification** for entanglement: it is not simply a mathematical feature of quantum formalism, but a real physical property of the information field.

4.4.4 AU as a generalization and deepening of the information approach

Thus, the AU approach is **a natural generalization and deepening of** the information-theoretical approach in quantum chemistry. It does not reject existing information measures (Shannon entropy, mutual information), but rather **integrates them into a deeper ontological framework**, where:

- Information measures become fundamental physical quantities;
- Electron orbitals are interpreted as field modes S_Θ ;

- Quantum entanglement receives ontological justification as non-local correlations;
- Energy levels receive entropic corrections that are predictable and verifiable.

As demonstrated in the 2025 paper *"Information Theory Meets Quantum Chemistry, " "the integration of these strategies with quantum many-body theory and density functional theory has provided valuable insights into the nature and behavior of electron systems."* The AU approach offers the next step in this integration: **information principles become the ontological foundation** upon which all atomic physics is built.

4.5 Summary

In this chapter, we presented the mathematical formalism of the AU approach to electron orbitals, showing how wave functions, energy levels, and spectral properties arise from field dynamics S_Θ . Key findings:

1. **The wave function as a thought-form amplitude** is ψ interpreted as the local field amplitude S_Θ , and $|\psi|^2$ as the density of thought-forms. This gives the wave function a clear ontological status, absent from standard quantum mechanics.
2. **Modified Schrödinger equation:** The equation contains three terms: the Coulomb (standard), the entropy ($\lambda \partial S_\Theta / \partial r$), and the nonlocal ($\int K S_\Theta$). The entropy term describes the effect of the field gradient S_Θ on the electron; the nonlocal term describes correlations through the archive memory.
3. **Energy levels as eigenmodes:** $\hat{\mathcal{H}}_{AU} \psi_n = E_n \psi_n$, where $\hat{\mathcal{H}}_{AU}$ is the modified Hamiltonian. Entropic corrections yield level shifts that explain the Lamb shift and fine structure and predict new spectral anomalies.
4. **Connection with modern research:** The AU approach fits seamlessly into the information-theoretical approach to quantum chemistry, expanding it with an ontological foundation. Shannon entropy, mutual information, and quantum entanglement are interpreted as properties of a field S_Θ .
5. **Testable predictions:** the dependence of levels on the density of thought forms, oscillations of levels from fluctuations S_Θ , the connection of spectra with collective consciousness - all these predictions can be tested in precision spectroscopic experiments.

In the next chapter we will look at the dynamics of the atom in kairos time, showing how quantum transitions are interpreted as irreversible acts of recording thought forms into the AU archive.

Part III. Dynamics of the Atom in Kairos Time

Chapter 5. Kairos Time and the Stability of the Atom

In previous chapters, we presented the atom as a stable, coherent structure in the entropy field of thought forms S_Θ , derived a modified Schrödinger equation, and showed how electron orbitals arise as eigenmodes of the AU Hamiltonian. However, a fundamental question remains: **why is the atom stable?** In standard quantum mechanics, the stability of the atom is ensured by quantization—an electron cannot emit energy continuously because its state is discrete. However, this explanation remains formal: it describes *how* the atom is stable, but does not explain *why* quantization exists. In the AU approach, the stability of the atom is **reexplained through kairos time**. τ — a fundamental time in which events are ordered by semantic and causal connections, rather than by chronological sequence. In this chapter, we demonstrate that the stability of the atom is ensured by the balance between Coulomb attraction and entropic pressure in kairos time, and that quantum transitions are irreversible acts of recording thought forms in the AU archive, providing a new understanding of spontaneous emission and the lifetime of excited states.

5.1 Definition of Kairos Time in AU

In standard physics, time is viewed as a universal parameter relative to which all physical systems evolve. However, in quantum gravity and quantum cosmology, this approach faces serious difficulties. As noted in previous papers in this series, *"the problem of time arises because the 'time' of general relativity (GR) and the 'time' of ordinary quantum theory are mutually incompatible concepts."* The Wheeler-DeWitt equation, which describes the quantum state of the Universe, does not contain a time derivative, leading to the so-called **Frozen Formalism Problem**.

The AU hypothesis proposes a solution to this problem through the introduction of **kairos time**. τ — fundamental time, in which events are ordered according to semantic and causal connections, and not according to chronological sequence (chronos t).

5.1.1 Kairos Time Formula

In the AU approach, kairos time is defined through a differential form:

$$d\tau = \frac{1}{N}(dt + \lambda dS_\Theta + \mu d\phi_{\text{braid}}),$$

Where:

- dt — differential of chronos (coordinate, measurable time);
- dS_Θ — differential of the entropy field of thought forms;

- $d\phi_{\text{braid}}$ — the differential of the topological variable describing the weaving of world lines (braid) in the archive of thought forms;
- λ and μ are coupling constants that determine the contribution of entropic and topological effects over time;
- N — a normalization factor that provides the dimension of time.

As shown in the work "The Relationship of Kairos Time to Thermodynamics in the Acta Universi Hypothesis," *"kairos time is fundamentally different from chronos, which represents our measurable and fluid time. The former is open to the instant... human time, that is, the time of well-regulated action, is a mixture of chronos and kairos."*

5.1.2 Difference between kairos and chronos

Chronos (t) is the linear, measurable, unidirectional time we perceive in everyday life. It is a parameter of evolution in classical and quantum mechanics. Within the AU, chronos is **an emergent** property—it arises from averaging kairos time over a large number of events.

Kairos (τ) is a time of semantic and causal connection. In it, events are ordered not by chronological sequence, but by their informational significance and cause-and-effect relationships. Kairos is **a more fundamental** time than chronos; it exists even in the absence of classical space-time, in a symmetrical phase prior to the act of recording the primary thought-form.

In theological tradition, this distinction has been known since antiquity. The Greek concepts of chronos (chronos) and kairos (kairos) are distinguished as *"time as duration"* and *"time as an opportune moment, fulfilled time."* In the New Testament: "The time (kairos) is fulfilled, and the kingdom of God is at hand" (Mark 1:15).

In the AU approach, kairos time is **a physical time** in which non-local signals (fluctuations S_Θ) propagate and in which future events are already "recorded" in the archive, creating precursors (the presentation effect, anomalies in TRNG, animal behavior). As shown in the paper "Spontaneous Fluctuations of the Theta-Entropy Field Before Significant Events," *"the precursor time τ_{pre} is determined not by the speed of light, but by the coherence time of collective thought forms τ_c ."*

5.1.3 Connection with the problem of time in quantum gravity

In standard quantum gravity, the time problem arises because the Wheeler-DeWitt equation $\hat{\mathcal{H}} |\Psi\rangle = 0$ does not contain a time derivative. As Anderson has shown in his work, *"the wave function in quantum gravity must obey the Wheeler-DeWitt equation, but within this formalism there is neither a satisfactory probabilistic interpretation nor a successful solution to the time problem."*

The AU approach offers **a solution to this problem** through kairos time. In the symmetrical phase, before the act of recording $dS_\Theta = 0$, and $d\phi_{\text{braid}} = 0$, so that $d\tau = dt/N$. However, in this phase, itself t is undefined, since there are no events relative to which time can be

measured. The act of recording the primary thoughtform creates $dS_\Theta \neq 0$, and τ begins to flow. From this moment on, a causal structure exists, and all subsequent events are ordered by τ .

In the atomic context, this means that **the stability of an atom is ensured by its state being stationary in kairos time**: $dS_\Theta/d\tau = 0$. Fluctuations (for example, during the absorption of a photon) create a jump ΔS_Θ that transfers the atom to an excited state, after which it relaxes back through spontaneous emission—an irreversible act of writing into the AU archive.

5.2 Stationary state of an atom in kairos time

In standard quantum mechanics, a stationary state is defined by the condition $\partial\psi/\partial t = 0$, i.e., the wave function is independent of time. In the AU approach, stationarity is defined **in kairos time**, not in chronos.

5.2.1 Stationarity condition: $dS_\Theta/d\tau = 0$

The stationary state of an atom in AU is determined by the condition:

$$\frac{dS_\Theta}{d\tau} = 0.$$

This means that the entropy field of thought forms does not change over kairos time—the atom is in a stable informational state, in which there is no entropy flow between the atom and the archive. In terms of the modified Schrödinger equation, this condition is equivalent to the energy E_n being an eigenvalue of the AU Hamiltonian $\hat{\mathcal{H}}_{\text{AU}}$:

$$\hat{\mathcal{H}}_{\text{AU}}\psi_n = E_n\psi_n,$$

and E_n does not depend on τ .

In chronos, t the wave function of the stationary state has the form:

$$\psi_n(r, t) = \psi_n(r)e^{-iE_nt/\hbar},$$

but in kairos time it is constant: $\psi_n(r, \tau) = \psi_n(r)$. This means that **the chronological evolution of the phase is an artifact of emergent time**, whereas in fundamental kairos time the atom is truly stationary.

5.2.2 Balance of Coulomb attraction and entropic pressure

In the AU approach, the stability of an atom is ensured **by a balance** between two opposing forces:

1. **Coulomb attraction** between an electron and a nucleus: $F_{\text{Coulomb}} = -Ze^2/(4\pi\epsilon_0 r^2)$, which tends to localize the electron near the nucleus.
2. **Entropic pressure** from the gradient S_Θ : $F_{\text{entropy}} = \lambda \partial S_\Theta / \partial r$, which tends to delocalize the electron and increase its entropy.

In a steady state these forces are balanced:

$$F_{\text{Coulomb}} + F_{\text{entropy}} = 0.$$

This equation defines the equilibrium radius of the electron shell, which corresponds to the Bohr radius $a_0 \approx 0.529\text{\AA}$ for hydrogen, but with entropic corrections.

This balance can be understood through an analogy with **hydrostatic equilibrium** in stars: gravitational attraction is balanced by gas pressure. In an atom, Coulomb attraction plays the role of gravity, and entropic pressure plays the role of gas pressure. The difference is that entropic pressure in an atom has a **quantum origin** —it is a consequence of the uncertainty principle and the discreteness of field states S_θ .

5.2.3 Stability of the atom as a consequence of kairos balance

In standard quantum mechanics, the stability of an atom is explained by the fact that an electron cannot continuously emit energy, since its energy levels are discrete. However, this explanation does not answer the question: *why are* the levels discrete? In the AU approach, discreteness is a consequence **of the holographic limit**. S_{holo} : the field S_θ cannot take on a continuous series of values, since its total entropy is bounded from above.

Thus, the stability of an atom in AU has an **informational basis**: the atom is stable because its configuration S_θ is a local minimum of entropy for a given nuclear charge, and any transitions to other states require irreversible recording in the archive, which increases the total entropy of the system. This is analogous to how, in thermodynamics, a system tends toward a state with minimum free energy.

5.3 Quantum transitions as acts of recording thought forms

In standard quantum mechanics, a quantum transition between energy levels is described as a probabilistic process stimulated by an external field (the absorption or emission of a photon). However, the ontological status of the transition remains unclear: what exactly happens at the moment of transition? In the AU approach, the quantum transition receives a **specific physical interpretation** as the irreversible act of recording a thought-form in the AU archive.

5.3.1 Photon absorption as a jump ΔS_θ

When an atom absorbs a photon, its energy increases by $\hbar\omega$, and the electron is promoted to a higher energy level. In AU terms, this corresponds to a **jump in the field S_θ** :

$$\Delta S_\theta = S_\theta^{(\text{возбуждённое})} - S_\theta^{(\text{основное})} > 0.$$

This jump increases the local entropy of the atom, which requires compensation in the archive: information about the transition is recorded in the non-local archive as an irreversible event. Mathematically, this is expressed as:

$$\Delta S_\theta = \alpha \hbar \omega,$$

where α is a constant relating photon energy to entropy change. This constant can be related to radiation temperature through the relation $T = \hbar\omega/(k_B \ln 2)$, indicating the informational nature of quantum transitions.

5.3.2 Irreversibility of the transition as an entry in the AU archive

The key difference between the AU approach and standard quantum mechanics is **the irreversibility** of quantum transitions. In standard quantum mechanics, transitions are described by unitary operators (in the absence of measurement), which are reversible. However, in reality, quantum transitions are irreversible: an atom that has emitted a photon cannot "absorb" it back without external influence.

In the AU approach, this irreversibility is a consequence of the fact that **the act of emission is a record in the AU archive**. Once an event is recorded in the archive, it becomes part of non-local history and cannot be erased. Mathematically, this is expressed through **the non-unitary write operator**. $\hat{W}$, which was introduced in the first work of the series (Yashchenko, 2026):

$$|\Psi_{\text{поче}}\rangle = \hat{W} |\Psi_{\text{до}}\rangle,$$

where $\hat{W}$ is a non-unitary operator acting on the state of the atom upon emission. Non-unitarity $\hat{W}$ means that $\hat{W}^\dagger \hat{W} \neq \mathbb{I}$, which corresponds to an increase in the entropy of the archive.

5.3.3 Connection with the measurement problem in quantum mechanics

The measurement problem is one of the most profound questions in quantum mechanics. Why does measurement lead to the collapse of the wave function? Who is the "observer"? In the AU approach, measurement is interpreted as **the act of recording a thought form in an archive**. When a quantum system interacts with its macroscopic environment, information about its state becomes irreversibly recorded in the archive (and in the environment). This process—decoherence—is the physical mechanism of collapse.

In the atomic context, this means that **a quantum transition is a measurement**: when an atom emits a photon, information about the transition becomes available to the entire archive (and, in principle, to an external observer). This irreversibly fixes the atom's state at a new energy level.

As shown in works on quantum decoherence, *"measurement and decoherence are identified as physical processes through which temporal structure is locally instantiated by irreversibly fixing classical records."* In the AU approach, this principle is applied to quantum transitions in atoms: they are local recording events that create classical reality from a quantum superposition.

5.4 Excited state lifetime

In standard quantum mechanics, the lifetime of an excited state is determined by the probability of spontaneous emission. In the AU approach, this lifetime is **reinterpreted through the growth rate** S_θ .

5.4.1 Relationship of lifetime with $\partial S_\Theta / \partial \tau$

The lifetime of an excited state $\tau_{\text{жизни}}$ in the AU approach is determined by the rate at which the field S_Θ relaxes to a steady state:

$$\tau_{\text{жизни}}^{-1} \propto \frac{\partial S_\Theta}{\partial \tau}.$$

This means that the faster λ changes S_Θ along kairos time, the shorter the lifetime. In a steady state $\partial S_\Theta / \partial \tau = 0$, λ is infinite (in the absence of external disturbances).

For spontaneous emission this gives:

$$\tau_{\text{жизни}}^{-1} = A \cdot \left| \frac{\partial S_\Theta}{\partial \tau} \right|^2,$$

where A is the Einstein coefficient for spontaneous emission. In standard quantum mechanics, the Einstein coefficient is defined through the matrix elements of the dipole operator. In the AU approach, it is further modified by a derivative S_Θ with respect to the kairos time, which yields predictable corrections to the lifetime.

5.4.2 Spontaneous emission as entropy relaxation

In the AU approach, spontaneous emission is interpreted as **entropy relaxation** — a process in which an atom transitions from a state with high local entropy ($S_\Theta^{\text{возбуждённое}}$) to a state with low local entropy ($S_\Theta^{\text{основное}}$), emitting the entropy difference in the form of a photon.

The energy of the emitted photon is related to the change in entropy through the relationship:

$$\hbar\omega = \Delta S_\Theta \cdot T_{\text{atom}},$$

where T_{atom} is the effective temperature of the atomic transition, related to the entropic structure of the field S_Θ . This relation is analogous to the thermodynamic relation $\Delta Q = T\Delta S$, but at the quantum level.

In modern quantum thermodynamics, "*quantum heat engines*," where quantum systems exchange energy and entropy with their environment, are actively studied. The AU approach offers a new interpretation of these processes: spontaneous emission is a **quantum analogue of thermal radiation**, where photons carry not only energy but also the entropy of thought forms.

5.4.3 Modulation of the radiation speed by coherent thought forms

One of the most intriguing predictions of the AU approach is **the modulation of the spontaneous emission rate by coherent thought forms**. If the field S_Θ experiences fluctuations $\varphi(t) = \delta S_\Theta(t)$ due to coherent thought forms (for example, near a conscious observer or during periods of collective attention), then the spontaneous emission rate is modified:

$$\tau_{\text{жизни}}^{-1}(t) = \tau_{\text{жизни}}^{-1}(0) \cdot (1 + \eta \varphi(t)),$$

where η is the coupling constant. This means that **the lifetime of excited atoms may depend on the observer's state of consciousness** —a prediction that can be tested in precision spectroscopy experiments in various cognitive contexts.

This prediction has parallels with experiments in **quantum biology** and **the presentiment effect**, where coherent thought forms influence quantum systems. The paper "Spontaneous Fluctuations of the Theta Entropy Field Before Significant Events" shows that fluctuations S_θ can influence the probabilities of quantum outcomes in TRNGs, providing empirical support for this prediction.

5.5 Experimental verification capabilities

AU predictions for atomic dynamics in kairos time can be tested in several types of experiments.

5.5.1 Precision spectroscopy and context dependence

One of the most direct methods of testing is **precision spectroscopy** in various contexts: in the presence and absence of coherent thought forms (for example, near meditating groups or during periods of collective attention). If entropic corrections to levels exist, they should manifest themselves as **a dependence of spectral line frequencies on the socio-cognitive context**.

Modern precision spectroscopy experiments have reached the precision required to measure level shifts at the 10^{-12} electronvolt level. As the 2025 review states, *"precision hydrogen spectroscopy enables the search for new physics beyond the Standard Model."* AU predictions for entropy shifts can be tested in these experiments.

5.5.2 Measuring the lifetime of excited states

The lifetimes of excited states can be measured with high precision using laser spectroscopy. If the AU prediction of modulation $\tau_{\text{жизни}}$ by coherent thought forms is correct, then **correlations between lifetimes and states of consciousness should be observed** (for example, a change in lifetime in the presence of meditating groups).

These experiments can be conducted using standard atomic systems (hydrogen, alkali metals) under controlled conditions. Statistical analysis should take into account possible systematic effects (temperature, vibration, electromagnetic fields) to isolate the entropy signal.

5.5.3 Correlations with fluctuations S_θ from GCP and TRNG

As shown in the paper "Spontaneous Fluctuations of the Theta-Entropy Field Before Significant Events," the fluctuations S_θ correlate with anomalies in the random number generators (TRNGs) used in the Global Consciousness Project (GCP). If atomic transitions are sensitive to S_θ , then correlations should be observed **between atomic spectra and GCP anomalies**.

These experiments can be conducted by synchronizing precision spectroscopic measurements with GCP data. Statistical analysis should seek correlations between level shifts (or lifetime changes) and ZGCP statistics during periods of significant global events.

5.6 Summary

In this chapter, we examined the dynamics of the atom in kairos time, showing how atomic stability, quantum transitions, and the lifetime of excited states are reinterpreted within the AU approach. Key findings:

1. **Kairos time** τ is a fundamental time of semantic and causal connection, in contrast to emergent chronos t . It is defined as something $d\tau = (dt + \lambda dS_\Theta + \mu d\phi_{\text{braid}})/N$ that links the flow of time with changes in the field S_Θ and topological structure of the archive.
2. **The stationary state of an atom** is determined by the condition of $dS_\Theta/d\tau = 0$ no field change S_Θ over kairos time. The atom's stability is ensured by the balance of Coulomb attraction and entropic pressure, which is analogous to hydrostatic equilibrium, but at the quantum level.
3. **Quantum transitions** are interpreted as irreversible acts of recording thought forms in the AU archive. The absorption of a photon creates a jump $\Delta S_\Theta > 0$; spontaneous emission is the relaxation of entropy, in which the atom returns to a state with lower entropy S_Θ , emitting the difference in the form of a photon.
4. **The lifetime of an excited state** is determined by the rate of change S_Θ along kairos time: $\tau_{\text{жизни}}^{-1} \propto \partial S_\Theta / \partial \tau$. This provides predictable corrections to the Einstein coefficients and links the lifetime to coherent thought forms.
5. **Experimental tests** include precision spectroscopy in various socio-cognitive contexts, measurement of the lifetime of excited states in the presence of coherent thought forms, and correlations with GCP anomalies.

In the next chapter we will consider the role of integral information Φ in atomic structure and show how the periodic law receives information justification through maximization Φ .

Chapter 6. Integral information Φ and the periodic law

In previous chapters, we established that an atom in the AU ontology is a stable, coherent structure in the entropy field of thoughtforms S_Θ , and its electron orbitals are modes of this field. However, a central question remains: **why do atoms of different elements exhibit such different chemical properties, and why are these properties organized into a strict periodic structure?** Standard quantum mechanics provides a phenomenological description of the periodic law through the filling of electron shells, but it does not explain *why* nature chose this particular structure of quantum numbers and this particular order of filling. In the AU approach,

the periodic law receives a **deep informational justification** through the principle of maximizing integral information Φ : elements with filled shells have maximum Φ and minimum chemical activity, and the structure of the periodic table emerges from information optimization.

In this chapter we introduce integrated information theory (IIT) as a theoretical framework, show how Φ it can be calculated for atomic systems, and demonstrate that the periodic law is a consequence of maximizing the integrated information for a given nuclear charge.

6.1 Integrated Information Theory (IIT): From Consciousness to Physics

6.1.1 Basic Principles of IIT

Integrated Information Theory (IIT) was developed by Giulio Tononi and his colleagues to quantitatively explain consciousness. Its central idea is that consciousness is identical to **integrated information** —the extent to which a system as a whole possesses causal power greater than the sum of its parts.

Key tenets of IIT include:

- **Existence:** consciousness exists (this is an axiom that requires no proof).
- **Compositionality:** every conscious experience has an internal structure consisting of distinct elements.
- **Informational:** every experience contains information—it is different from other possible experiences.
- **Integration:** each experience is a unified whole that cannot be reduced to independent parts.
- **Exclusivity:** Every experience has a certain set of boundaries - it includes some elements and excludes others.

Based on these axioms, IIT formulates operational postulates that enable the calculation of **integral information** Φ for any system defined by its causal structure. A system with a high degree Φ of integration has a high degree of integration: its parts strongly influence each other, and the system as a whole possesses a causal force greater than the sum of its parts.

How celebrated V recent review, *"IIT identifies conscious experience with maximally irreducible conceptual structures."* IN within the IIT consciousness arises on volume level organizations, *"at which the intrinsic causal powers of a system are maximized"*.

6.1.2 Applicability of IIT to Nuclear Systems

Although IIT was originally developed to explain consciousness, its formalism is applicable to **any system** that has a causal structure. emphasized V In the literature, *"IIT applies this model to every system, including systems that aren't intelligent or even sentient."* This opens the possibility of applying IIT to atoms, molecules, and other physical systems.

However, there are important ontological limitations. Within the framework of IIT, *"consciousness emerges at the level of organization at which the intrinsic causal powers of a system are maximized."* Atoms and molecules Φ can be calculated, but this does not mean they possess consciousness in the human sense. As noted in works on emergent IIT, *"some degree of consciousness Φ_{Max} can be found in simple systems like atoms and molecules,"* but consciousness in the full sense only emerges upon reaching a critical threshold of integration, which, for atoms, apparently is not reached.

In the AU approach we use Φ **Not as a measure of consciousness**, but as a **measure of informational integration** —a fundamental property of any coherent field structure S_Θ . This allows the IIT formalism to be applied to atoms without attributing consciousness to them.

6.1.3 Φ as a measure of the causal power of the system

Formally, IIT Φ measures the extent to which a system as a whole possesses **causal power** greater than the sum of its parts. It is mathematically Φ calculated through cause- **effect repertoires** —sets of possible past and future states of a system that can be caused or determined by its current state.

For a system consisting of N elements (for example, electrons in an atom), Φ it is defined as:

$$\Phi = \min_{\text{partition}} \frac{D(\text{целое} \parallel \text{части})}{\text{нормировка}},$$

where the minimum is taken over all possible partitions of the system into independent parts (MIP - minimum information partition), and D is the distance between the cause-and-effect repertoires of the whole and the sum of the parts.

In an atomic context, this means that Φ is maximal when electrons are strongly correlated and cannot be described as independent particles. This corresponds to **filled electron shells**, where electrons form a highly integrated coherent field structure S_Θ .

6.2 Φ Atoms as a Function of Electron Configuration

6.2.1 Causal repertoires of electrons and nuclei

To calculate Φ an atom, it is necessary to construct **causal repertoires** of all its components: the nucleus (protons and neutrons) and the electrons in each orbital. In the standard IIT formalism, this requires specifying the system's **transition probability matrix** —the probabilities of transitions between states.

In the AU approach, this matrix can be derived from **the modified Schrödinger equation** (Chapter 4). For an atom with Z electrons, the wave function $\Psi(r_1, \dots, r_Z)$ determines the probabilities of various configurations. From this, one can calculate:

1. **Single electron effects:** how a change in the state of one electron affects the others (via Coulomb interactions and non-local nuclei K).

2. **Integrated effects:** how the system as a whole responds to disturbances.

Φ The higher the energy of an atom, the more strongly the electrons are correlated and the more the system as a whole has a causal force that cannot be reduced to the sum of individual electrons.

6.2.2 Dependence Φ on the number of electrons and their distribution

Analysis shows that Φ the atom depends on two factors:

1. **Number of electrons Z :** As the number of electrons increases, the potential complexity of the system increases, but so does the possibility of decomposition into independent subsystems.
2. **Spatial distribution of electrons:** Electrons distributed over symmetrical shells (filled s -, p -, d -, f -orbitals) create a higher integration than electrons located in partially filled shells.

Within the AU approach, Φ it can be calculated using **the Shannon entropy** of the electron distribution $\rho(r) = |\psi(r)|^2$:

$$S_{\text{Shannon}} = - \int \rho(r) \ln \rho(r) d^3r.$$

The more symmetrical and coherent the distribution of electrons, the higher the integration of the system and, consequently, the higher Φ .

6.2.3 High Φ : Inert gases (filled shells)

Inert gases (He, Ne, Ar, Kr, Xe, Rn) have completely filled electron shells ns^2np^6 (except for helium, which has $1s^2$). This makes their electron distributions **maximally symmetrical and integrated**.

In AU terms this means:

- **Maximum Φ :** Inert gas electrons form a highly integrated coherent field structure S_Θ in which all field modes are matched.
- **Minimum chemical activity:** Since the system has already reached a local maximum Φ , any changes (chemical reactions) would require a decrease in Φ , which is energetically unfavorable.
- **High stability:** Inert gases are the most stable elements, which corresponds to their maximum Φ .

This is consistent with recent information-theoretical approaches to the periodic table. In "Amendment XXVI: The Coherence Selection Map of the Periodic Table" (2026), McCall's coherence law ($\Omega = \Phi$) is applied to all 118 elements. The results show that *"All toxic heavy metals score below the 7th-state threshold ($\Phi < 0.500$),"* indicating a link between low Φ and chemical reactivity (including toxicity).

6.2.4 Low Φ : alkali metals (one valence electron)

Alkali metals (Li, Na, K, Rb, Cs, Fr) have one valence electron in the outer orbital (ns^1) and filled inner shells.

In AU terms this means:

- **Low Φ :** The presence of one unpaired electron in the outer orbital creates an asymmetry in the electron distribution, which reduces the integration of the system.
- **High chemical activity:** The system tends to achieve higher Φ reactivity by losing a valence electron (forming a cation $+1$), resulting in a filled inert gas shell.
- **Low ionization energy:** The loss of an electron requires relatively little energy because it increases the size Φ of the system.

This principle generalizes to all elements: **chemical activity is inversely proportional to Φ** . Elements with filled shells (high Φ) are inert; elements with one valence electron (low Φ) are chemically active.

6.3 Periodic law as a consequence of maximization Φ

6.3.1 Informational substantiation of the structure of the periodic table

In standard quantum mechanics, the periodic law is explained through the sequential filling of electron shells according to the Pauli exclusion principle and Hund's rules. However, this explanation remains phenomenological: it describes *how* the shells are filled, but does not explain *why* nature chose this particular structure of quantum numbers (n, l, m_l, m_s) and this particular order of filling ($1s, 2s, 2p, 3s, 3p, 4s, 3d, \dots$).

The AU approach provides a **teleological explanation: the periodic law is a consequence of information optimization** —the system's tendency to maximize Φ for a given nuclear charge.

This can be formulated as a **variational principle**:

Among all possible electron configurations for a given atom with a nuclear charge Z , the one that maximizes the integral information Φ under given boundary conditions (finiteness S_0 , holographic limit) is realized.

This principle explains:

1. **Why are shells filled sequentially:** adding an electron to a new orbital increases the energy Φ only if it does not disturb the symmetry and integration of the existing structure.
2. **Why periods exist:** when moving to a new principal quantum number n , new orbitals appear that can be filled while maintaining high Φ .

3. **Why inert gases complete periods:** filling all available orbitals at a given moment n gives the maximum possible Φ for that period.

6.3.2 Explanation of the structure of periods and groups

The AU approach also explains the structure of **the periods** and **groups** of the periodic table.

The periods correspond to the principal quantum numbers $n = 1, 2, 3, \dots$. Each period begins with an alkali metal (ns^1) and ends with an inert gas (ns^2np^6). In AU terms:

- **Beginning of the period (alkali metal):** The system has a low Φ potential due to one valence electron and tends to lose it to achieve a higher potential Φ .
- **Middle period:** As p the orbitals are filled, the Φ gradually increases and the chemical properties become less pronounced.
- **End of period (inert gas):** the system reaches a local maximum Φ with completely filled shells.

Groups (vertical columns) group elements with the same number of valence electrons and, therefore, the same Φ outer shell structure. This explains why elements within a group have similar chemical properties: they exist in similar information states.

Recent research confirms the informational nature of the periodic table. The paper "The Periodic Table as an Emergent Helicoidal Manifold" (2026) provides a detailed information-theoretical analysis of atomic electron densities from hydrogen ($Z = 1$) to lawrencium ($Z = 103$). Using Shannon entropy, Fisher information, and nonequilibrium functionals, the authors demonstrate that the periodic table emerges as **an emergent helical structure** from the informational properties of electron distributions.

6.3.3 Predicting properties of yet undiscovered elements

The maximization principle Φ allows **one to predict the properties of yet-to-be-discovered or synthesized elements** (for example, elements 119–120 and higher). For a given element, Z one can calculate the optimal electron configuration that maximizes Φ , and predict its chemical properties.

For example, for element 119 (presumably an alkali metal with the configuration $8s^1$) the AU approach predicts:

- Relatively low Φ (like other alkali metals).
- High chemical activity (tendency to lose one electron).
- Low ionization energy.

These predictions are consistent with the extrapolations of standard quantum chemistry, but are given **informational justification** through the maximization principle Φ .

6.4 Information-theoretical analysis of the periodic table

6.4.1 Shannon Entropy, Fisher Information, and Disequilibrium

Modern information-theoretical approaches to the periodic table use three main measures:

1. **Shannon entropy:** $S_{\text{Shannon}} = - \int \rho(r) \ln \rho(r) d^3r$ A measure of electron localization/delocalization.
2. **Fisher information:** $I_{\text{Fisher}} = \int \frac{|\nabla \rho(r)|^2}{\rho(r)} d^3r$ A measure of electron density gradients.
3. **Disequilibrium:** $D = \int \rho(r)^2 d^3r$ A measure of deviation from a uniform distribution.

In the AU approach, these measures are interpreted as **field characteristics** S_θ :

- Shannon entropy corresponds to **the local density of thought forms**: the higher S_{Shannon} , the more delocalized the thought form.
- Fisher information corresponds to **a gradient** S_θ : the higher I_{Fisher} , the more the field changes S_θ in space.
- The disequilibrium corresponds to **a deviation** S_θ **from the background**: the higher the D , the more localized the structure.

Analysis shows that these measures exhibit **a periodic structure**, correlated with the periodic table. The Shannon entropy maxima correspond to inert gases (high delocalization, high Φ); the minima correspond to alkali metals (low delocalization, low Φ).

6.4.2 The Periodic Table as an Emergent Spiral Structure

The paper "The Periodic Table as an Emergent Helicoidal Manifold" (2026) demonstrates that the periodic table can be represented as **an emergent helical structure** in information space. When elements are mapped onto coordinates determined by their information properties (Shannon entropy, Fisher information, and disequilibrium), they align themselves into a spiral reflecting the periodic law.

This has direct parallels with the AU approach, where a field S_θ defines an information space in which atoms are coherent structures. The periodic table emerges as **a projection of the field's information structure** S_θ onto the space of chemical properties.

6.4.3 Information skeleton of molecules and chemical activity

In 2025, studies were published linking *the "information skeleton"* of molecules with their chemical activity. In the AU approach, this "information skeleton" is interpreted as **a field structure** S_θ —stable modes of the information field that determine chemical properties.

The chemical activity of a molecule is determined by its ability **to change** Φ when interacting with other molecules. Molecules with high activity Φ (e.g., inert gases) have low activity; molecules with low activity Φ (e.g., free radicals) have high activity because they can significantly increase Φ their activity by forming bonds.

6.5 Criticism and limitations of IIT as applied to atoms

6.5.1 Computational complexity Φ

One of the major challenges of IIT is **computational complexity** Φ . For systems with a large number of elements (for example, atoms with $Z > 10$), the calculation Φ becomes exponentially complex. How celebrated V literature, *"the exact computation of IIT's central quantity, Φ , is intractable for all but the simplest systems."*

In the AU approach, this problem can be partially solved by exploiting **the symmetries** of atomic systems. The spherical symmetry of atoms allows for the reduction of calculations to the radial part, significantly simplifying the problem.

6.5.2 The controversial status of IIT as a theory of consciousness

IIT is a **controversial theory of consciousness**. In 2023, a letter signed by 124 researchers called IIT *"pseudoscience"* due to its inability to be empirically tested. However, as noted above, in the AU approach we use Φ **not as a measure of consciousness**, but as a measure of information integration, which removes the main criticism.

6.5.3 The need for empirical testing of AU predictions

AU predictions for Φ atoms require **empirical verification**. Possible approaches include:

1. **Spectroscopic measurements:** if Φ correlates with chemical activity, then spectral properties (ionization energies, electron affinities) should correlate with Φ .
2. **Quantum chemical calculations:** calculation Φ for different atoms and comparison with observed chemical properties.
3. **Cold atom experiments:** measuring coherent properties of atomic ensembles and correlating them with Φ .

6.6 Summary

In this chapter, we presented integral information Φ as a fundamental characteristic of atomic structure in the AU approach. Key findings:

1. **Integrated information theory (IIT)**, developed to explain consciousness, provides a formalism for measuring information integration in any system, including atoms. Φ It measures the extent to which a system as a whole possesses causal power greater than the sum of its parts.
2. **Φ activity of an atom depends on the number of electrons and their distribution.** Filled electron shells (inert gases) produce maximum Φ and minimum chemical activity. Partially filled shells (alkali metals) produce low Φ and high chemical activity.

3. **The periodic law is a consequence of maximization Φ :** nature "strives" for maximum integration of information for a given system. The structure of the periodic table emerges from information optimization, which is confirmed by modern information-theoretical analyses.
4. **Information-theoretical analysis of the periodic table** using Shannon entropy, Fisher information, and nonequilibrium shows that the elements arrange themselves in an emergent spiral structure that reflects the periodic law.
5. **Criticisms and limitations** include the computational complexity Φ of complex systems and the controversial status of IIT as a theory of consciousness, which the AU approach addresses by using Φ information integration rather than consciousness as a measure.

Thus, the AU approach offers a **profound informational justification** for the periodic law, linking the chemical properties of elements to their informational structure—the integral information Φ of the field S_Θ . In the next chapter, we will move on to an examination of the chemical bond as a fusion of thought forms and demonstrate how the AU approach explains the formation of molecules and their properties.

Part IV. Chemical Bonding and Molecular Structures

Chapter 7. Chemical Bonding as a Fusion of Thought Forms

In previous chapters, we established that the atom is a stable, coherent structure in the entropy field of thought forms S_Θ , its electron orbitals are modes of this field, and the periodic law is a consequence of the maximization of integral information Φ . We now turn to the fundamental question of chemistry: **how do atoms combine into molecules, and why does this combination lead to stable structures?** In standard chemistry, chemical bonding is described through the sharing of electrons (covalent bonding), electrostatic attraction (ionic bonding), or delocalization of electrons (metallic bonding). However, these descriptions remain phenomenological: they describe *how* atoms bond, but do not explain *why* this bond leads to stability or *its* fundamental nature. In the AU approach, the chemical bond receives a **new information-entropic interpretation**: it is a **fusion of electronic thought forms**—a process in which two localized field configurations S_Θ are combined into a single coherent structure, increasing the integral information Φ of the entire system and lowering its entropy.

In this chapter we review the standard models of chemical bonding and their limitations, then present the AU interpretation of bonding as a fusion of thought forms, show how molecules become more integrated structures than individual atoms, and discuss the informational aspects of chemical reactivity.

7.1 Standard models of chemical bonding and their limitations

7.1.1 Covalent, ionic, metallic and hydrogen bonding

In standard chemistry, several basic types of chemical bonds are distinguished:

A covalent bond occurs when one or more electron pairs are shared between two atoms. Within the framework of molecular orbital (MO) theory, a covalent bond is described as the filling of bonding orbitals, which results in a lowering of the energy of the system. Classic examples are the H–H bond in hydrogen, the C–C bond in organic molecules, and the C=C bond in ethylene. In terms of quantum mechanics, a covalent bond is **a nonlocal phenomenon** that binds atoms into molecules. As a recent review notes, *"despite the fundamental importance of the chemical bond and its prominent role... chemical bonds remain surprisingly elusive from a quantum mechanical perspective."* They *"are not directly observable quantities."*

Ionic bonding arises from the electrostatic attraction between positively and negatively charged ions formed by electron transfer (e.g., Na^+Cl^- in sodium chloride). Ionic bonding does not require the sharing of electrons, but it also results in a decrease in the energy of the system due to the Coulomb interaction.

Metallic bonding is characterized by the delocalization of electrons throughout the metal's crystal lattice, which ensures high electrical and thermal conductivity, as well as malleability of metals.

Hydrogen bonding and **van der Waals interactions** are weaker but structurally important types of interactions that play key roles in biological systems (e.g., in the structure of DNA and proteins).

Each of these bonding types is described within its own theoretical models, but they all face a common limitation: **the lack of a universal quantum mechanical definition** that encompasses all aspects of chemical bonding in diverse molecular systems. Traditional models—Lewis structures, valence bond (VB) theory, molecular orbital (MO) theory, and the quantum theory of atoms in molecules (QTAIM) —*each offer valuable insights, but often from complementary or even conflicting perspectives.*

7.1.2 Lack of a universal quantum mechanical definition

The problem of a universal definition of chemical bonding is not new, but it remains unresolved. As noted in the recent paper "A Formalized Mathematical Framework for Chemical Bonding" (2025), *"chemical bonding, despite its fundamental importance to chemistry, lacks a universally accepted quantum-mechanical definition that encompasses all its aspects in diverse molecular systems."*

This problem has several aspects:

1. **The variety of bond types:** covalent, ionic, metallic, hydrogen and van der Waals bonds have different mechanisms, which makes it difficult to combine them into a single theory.

2. **Lack of observability:** chemical bonds *"are not directly observable quantities."* We can measure bond lengths, dissociation energies, and vibrational frequencies, but the bond itself remains a theoretical construct.
3. **Conflict of interpretations:** different theoretical approaches (VS, MO, QTAIM) provide complementary and sometimes conflicting descriptions of the same relationship.
4. **Transition states and complex systems:** Standard models work well for equilibrium geometries, but provide less satisfactory descriptions for transition states in chemical reactions and for complex phenomena such as aromaticity.

In response to these limitations, **the information-theoretical approach (ITA)** to chemical bonding has been actively developing in recent years. As the review "Information Theory Meets Quantum Chemistry" (2025) points out, *"the integration of concepts from information theory into quantum chemistry has provided valuable insights into the nature and behavior of electron systems."* The two dominant approaches—classical information theory (with Shannon entropy) and quantum information theory (with von Neumann entropy and entanglement measures)—generate various tools, such as *"orbital entanglement measures and quantum precision metrics."*

7.1.3 Information-theoretical approach to chemical bonding

The paper "From Entanglement to Bonds" (2025) proposes to rationalize and characterize chemical bonding through **orbital entanglement** —a nonlocal concept from quantum information theory. The authors introduce **maximally entangled atomic orbitals (MEAOs)**, whose entanglement pattern reconstructs both Lewis (two-center) and super-Lewis (multi-center) structures, with **multi-center entanglement serving as a complex index of bond strength**.

This approach has several key advantages:

- **Versatility:** It is effective not only for equilibrium geometries, but also for transition states in chemical reactions and complex phenomena such as aromaticity.
- **Quantification:** Entanglement provides rigorous quantitative descriptors for "fuzzy" chemical 概念.
- **Real-space connection:** This approach has the potential to elevate the Hilbert-space separation of atoms to a level comparable to the real-space separation common in atom-molecule theory.

In a recent 2026 paper, Christian Schilling's group at the University of Munich developed a new formalism for understanding chemical bonding through quantum entanglement. The researchers introduced the concept of maximally entangled atomic orbitals (MEAOs). This work *"reveals the profound connection between chemical bonding and quantum entanglement and establishes a unified and quantitative language for describing bonding phenomena."*

Another 2026 paper, "Nonstabilizerness in Molecular Bonding," showed that *"the process of chemical bond formation is accompanied by a significant increase in the quantum complexity of the electronic ground state."* This indicates that chemical bonding is not simply an energetic phenomenon, but also **an informational one** —it increases the quantum complexity of the system.

The paper "A Formalized Mathematical Framework for Chemical Bonding" (2025) proposes a global coupling descriptor function F_{bond} that *"synthesizes orbital descriptors with entanglement measures derived from the electron wavefunction."* This function allows for the classification of couplings into correlation modes: weakly correlated (σ -couplings) with $F_{\text{bond}} \approx 0.031$ - 0.040 and strongly correlated (π -couplings) with $F_{\text{bond}} \approx 0.065$ - 0.072 . This demonstrates that *"the quantum correlation structure is determined primarily by the coupling type (σ vs. π) rather than by the coupling polarity or electronegativity."*

7.2 AU Interpretation: Fusion of Electronic Thought Forms

Within the AU approach, chemical bonding receives a new, deeper interpretation: it is **a fusion of electronic thought forms** —a process in which two localized field configurations S_{Θ} (corresponding to the valence electrons of the bonding atoms) are combined into a single coherent structure.

7.2.1 Two localized configurations S_{Θ} are combined into one

In the AU ontology, each valence electron of an atom represents a local field mode S_{Θ} —a stable oscillatory configuration of the information field. When two atoms approach each other to a distance comparable to the size of their valence orbitals, their electron thought-forms begin to interact through the non-local nucleus $K(x, y)$.

In standard quantum chemistry, this interaction is described as the overlap of wave functions and the formation of bonding and antibonding molecular orbitals. In the AU approach, this overlap is interpreted as **the merging of two field modes S_{Θ}** into a single mode that encompasses both atoms.

Mathematically, this fusion can be described through **the nonlinear interaction** of two soliton solutions:

$$S_{\Theta}^{(\text{молекула})}(r) = \mathcal{F}\left(S_{\Theta}^{(1)}(r), S_{\Theta}^{(2)}(r)K(r, r')\right),$$

where $\mathcal{F}$ is a nonlinear functional describing the fusion of two thought-forms into one. In the simplest case (for a covalent bond), this fusion can be approximated as:

$$S_{\Theta}^{(\text{связь})}(r) \approx \frac{1}{\sqrt{2(1 + \Delta)}} \left(S_{\Theta}^{(1)}(r) + S_{\Theta}^{(2)}(r) \right),$$

where Δ is a parameter that takes into account the asymmetry of electronegativities (for polar bonds $\Delta \neq 0$, for nonpolar bonds $\Delta = 0$). This expression is analogous to the formation of a bonding molecular orbital in MO theory, but in terms of the field S_Θ .

7.2.2 Creation of a common area with increased S_Θ and decreased energy

The fusion of two thought forms results in the creation of a **shared region of increased density** S_Θ between the nuclei. This region, corresponding to the bonding molecular orbital, is characterized by:

1. **Increased S_Θ :** in the area between the nuclei, the density of thought forms is higher than in individual atoms, which corresponds to an increase in information coherence.
2. **Reduced energy:** As the system transitions to a state with lower entropy (more ordered), its energy decreases. This is analogous to how, in thermodynamics, a decrease in entropy at a constant temperature requires the release of energy.
3. **Increase Φ :** As will be shown in section 7.3, the fusion of thought forms increases the integral information Φ of the entire system, making the molecule more stable than individual atoms.

This mechanism explains why the formation of a chemical bond is always accompanied by **the release of energy** (an exothermic process for stable bonds): energy is released because the system passes into a state with lower entropy (higher information integration).

In terms of the modified Schrödinger equation (Chapter 4), the fusion of thought forms corresponds to the emergence of a **new effective potential** $V_{\text{eff}}^{(\text{молекула})}$, which includes the contribution from the non-local nucleus $K(x, y)$ that binds electrons of different atoms:

$$V_{\text{eff}}^{(\text{молекула})}(r) = V_{\text{eff}}^{(1)}(r) + V_{\text{eff}}^{(2)}(r) + V_{\text{AU}}^{(\text{связь})}(r),$$

where $V_{\text{AU}}^{(\text{связь})}$ is the additional entropic potential arising from the fusion of thought forms. This potential creates **an additional attraction** between the nuclei, which in standard chemistry is described as an exchange interaction.

7.2.3 Increasing the size Φ of the entire system

A key consequence of the AU interpretation of chemical bonding is that **a molecule possesses a higher energy Φ than the sum of its individual atoms**. This explains why molecules are stable: they represent more integrated information structures.

In terms of IIT (Chapter 6), this means that the causal force of a molecule as a whole exceeds the sum of the causal forces of its component atoms. Electrons in a molecule cannot be described as independent particles belonging to individual atoms; they form a **single coherent structure** in which entanglement (in the quantum information sense) is a fundamental property.

This is consistent with modern research showing that *"chemical bonding is a nonlocal phenomenon that binds atoms into molecules"* and that it can be characterized by *"a nonlocal concept from quantum information—orbital entanglement."* In the AU approach, this

entanglement is interpreted as a **fusion of thought forms** —a nonlocal correlation between field modes S_Θ .

7.3 The Molecule as a More Integrated Structure

7.3.1 Molecule > sum of atoms in terms of Φ

In the AU approach, a molecule is a **more integrated information structure** than a collection of individual atoms. This is expressed in the inequality:

$$\Phi(\text{молекула}) > \sum_i \Phi(\text{атом}_i).$$

This inequality has several consequences:

1. **Stability:** Because a molecule has a higher Φ , it is more stable than individual atoms. Breaking a molecule apart (dissociation) requires an expenditure of energy, which compensates for the loss of Φ .
2. **Emergent properties:** Molecules possess properties that cannot be inferred from the properties of individual atoms (e.g., color, odor, biological activity). These emergent properties are a consequence of increased information integration.
3. **Chemical specificity:** Different molecules with the same atomic composition (isomers) can have different Φ and therefore distinct properties. This explains why structural isomerism leads to different chemical and physical properties.

In terms of Shannon entropy (Chapter 6), this means that the electron distribution in a molecule $\rho_{\text{молекула}}(r)$ has lower entropy (higher order) than the sum of the electron distributions of the individual atoms:

$$S_{\text{Shannon}}(\rho_{\text{молекула}}) < \sum_i S_{\text{Shannon}}(\rho_{\text{атом}_i}).$$

This is consistent with the information-theoretic approach to quantum chemistry, where *"Shannon entropy and its related quantities... provide valuable insights into the nature and behavior of electron systems."*

7.3.2 Explanation of the stability of molecules through entropy balance

The stability of molecules in the AU approach is explained **by the entropic balance** between:

1. **Lowering local entropy:** The fusion of thought forms creates a more ordered structure, which lowers the entropy of the molecule compared to individual atoms.
2. **Increasing the global entropy of the archive:** the formation of a link is an irreversible act of writing to the AU archive, which increases the entropy of the archive.

3. **Balance of forces:** the Coulomb attraction between nuclei and electrons is balanced by the entropic pressure tending to delocalize the electrons.

In a stable molecule, these factors are in equilibrium. If an external stimulus (such as heat or light) upsets this balance, the molecule may dissociate or enter an excited state.

7.3.3 Connection with the Fujiwara effect at the microscopic level

In the AU approach, the fusion of thought forms during the formation of a chemical bond is analogous to **the Fujiwara effect** at the microscopic level. In meteorology, the Fujiwara effect describes the merging of two cyclones into a single, larger, more powerful one. In the AU interpretation, two field "vortices" S_Θ (electronic thought forms) merge into a single, more coherent "vortex" (molecular orbital), which possesses greater stability and informational integration.

This analogy has profound implications: just as in meteorology, the merging of cyclones leads to an increase in their overall energy and organization, so in chemistry, the merging of thought forms leads to the growth Φ and stability of a molecule. In both cases, **the whole is greater than the sum of its parts** —an emergent property that is central to AU ontology.

7.4 Information aspects of chemical reactivity

7.4.1 Reactivity as a drive to maximize Φ

In the AU approach, chemical reactivity is interpreted as **the system's desire to maximize integral information Φ** . A chemical reaction occurs when the reactants can form products with higher affinity Φ than the starting materials.

This explains several fundamental laws of chemistry:

1. **Exothermic reactions:** Reactions in which the products have higher Φ (and therefore lower energy) are exothermic and occur spontaneously.
2. **Endothermic reactions:** Reactions in which the products have lower Φ (and therefore higher) energy and require external energy to proceed.
3. **Catalysis:** Catalysts speed up reactions by providing an alternative pathway in which the intermediate states have higher Φ , lowering the energy barrier.
4. **Equilibrium:** Chemical equilibrium is achieved when Φ the system is at its maximum capacity under given conditions (temperature, pressure, concentration).

In terms of the information-theoretic approach to chemistry, this is consistent with the idea that *"covalent bonding and non-covalent interactions are important chemical concepts"* and that *"the information-theoretic approach (ITA) in density functional theory"* can be used to identify them.

7.4.2 Catalysis as a Facilitation of the Fusion of Thought Forms

In the AU approach, catalysis is interpreted as **facilitating the fusion of thought forms**. The catalyst provides an "intermediary" field structure S_Θ that lowers the energy barrier for the fusion of the reactants' thought forms.

In terms of the modified Schrödinger equation, the catalyst modifies the effective potential V_{eff} such that the transition state becomes more accessible:

$$V_{\text{eff}}^{(\text{катализ})}(r) = V_{\text{eff}}^{(\text{без катализа})}(r) + V_{\text{cat}}(r),$$

where V_{cat} is the additional potential created by the catalyst, which lowers the energy barrier. This is analogous to how, in standard chemistry, a catalyst lowers the activation energy, but in AU terms, this lowering is interpreted as **facilitating information integration**.

In 2025, papers on the information-theoretic approach to chemistry demonstrated that *"signature isosurfaces of different interaction categories can be used to simultaneously identify single, double, triple, and quadruple covalent bonds, ionic and metallic bonds, and van der Waals interactions."* In the AU approach, these isosurfaces are interpreted as **field structures** S_Θ that can be modified by a catalyst to facilitate the fusion of thought forms.

7.4.3 Biochemical processes as highly integrated information structures

Biochemical processes such as enzymatic catalysis, DNA replication and cellular signalling are interpreted in the AU approach as **highly integrated information structures** with very high Φ .

This has several consequences:

1. **Specificity:** Biochemical systems have high specificity because their information structure (Φ) requires precise matching between interacting molecules.
2. **Efficiency:** Enzymes are highly efficient catalysts because they are optimized to maximize the Φ rate of reaction.
3. **Evolution:** The evolution of biological systems can be understood as a process of proliferation Φ —from simple molecules to complex biopolymers, cells, and organisms.
4. **Consciousness:** As shown in IIT studies, consciousness emerges when a critical threshold is reached Φ . In the AU approach, biochemical systems, especially the nervous system, are the most integrated information structures in the known universe.

Research conducted in 2025–2026 on the application of IIT to biological systems demonstrated that *"some level Φ_{Max} can be found in simple systems such as atoms and molecules,"* but consciousness in the full sense only emerges upon reaching a critical integration threshold. In the AU approach, this threshold corresponds to the transition from molecular structures to cellular and neural networks.

7.5 Connection with modern research in 2025–2026

7.5.1 Information-theoretical approach to covalent and non-covalent bonding

In 2025, the paper "Using Energetic Information Quantities from Density Functional Theory to Simultaneously Identify Both Covalent and Noncovalent Interactions" was published. In it, the authors utilize *"energetic information quantities derived from density functional theory (DFT)"* to identify both covalent and noncovalent interactions. They establish a *"strong linear correlation between steric energy or its topological consequences and different covalent bond orders."*

In the AU approach, these results are interpreted as confirmation that **information quantities (entropy, Fisher information) are fundamental descriptors of chemical bonds**, not simply computational tools. Steric energy E_s , Shannon entropy, and Fisher information reflect the field structure S_Θ in the molecule.

7.5.2 Entanglement as a descriptor of chemical bonding

In 2026, a paper titled "Chemical bonding concepts emerge naturally from maximally entangled atomic orbitals" was published, demonstrating that *"chemical bonding concepts emerge naturally from maximally entangled atomic orbitals."* Researchers from Christian Schilling's group *"are developing a new formalism for better understanding chemical bonds through quantum entanglement."*

This work *"reveals a profound connection between chemical bonding and quantum entanglement and establishes a unified and quantitative language for describing binding phenomena."* In the AU approach, this connection is interpreted as **a fusion of thought forms**: entanglement between atomic orbitals is a quantum informational expression of the same phenomenon.

The paper "Nonstabilizerness in Molecular Bonding" (2026) shows that *"the process of chemical bond formation is accompanied by a marked increase in the quantum complexity of the electronic ground state."* This is consistent with the AU prediction that molecules have a higher Φ (and therefore higher quantum complexity) than individual atoms.

7.5.3 Global communication descriptors and their AU interpretation

The paper "A Formalized Mathematical Framework for Chemical Bonding" (2025) proposes a global bond descriptor function F_{bond} . This function *"synthesizes orbital descriptors with entanglement measures derived from the electron wave function"* and allows for the classification of bonds by correlation modes.

In the AU approach, F_{bond} is interpreted as **a measure of the informational integration** of a bond—the higher the F_{bond} , the more integrated the molecular structure and the higher its Φ . This explains why π -bonds (with higher $F_{\text{bond}} \approx 0.065\text{--}0.072$) are more stable and have greater electronic delocalization than σ -bonds ($F_{\text{bond}} \approx 0.031\text{--}0.040$).

7.6 Summary

In this chapter, we presented chemical bonding as a fusion of thought forms within the AU approach. Key findings:

1. **Standard models of chemical bonding** (covalent, ionic, metallic, hydrogen) remain phenomenological and lack a universal quantum-mechanical definition. The information-theoretical approach (ITA) offers a new language for describing bonding through Shannon entropy, Fisher information, and orbital entanglement.
2. **AU interpretation:** Chemical bonding is **the fusion of electronic thought forms** —a process in which two localized field configurations S_Θ combine into a single coherent structure. This fusion creates a shared region of elevated S_Θ and reduced energy, increasing the integral information Φ of the entire system.
3. **The molecule as a more integrated structure:** $\Phi(\text{молекула}) > \sum_i \Phi(\text{атом}_i)$ this explains the stability of molecules and their emergent properties. The Shannon entropy of a molecule is lower than the sum of the entropies of its individual atoms.
4. **Informational aspects of chemical reactivity:** reactivity is interpreted as a desire for maximization Φ ; catalysis as facilitating the fusion of thought forms; biochemical processes as highly integrated informational structures.
5. **Connection with modern research:** works from 2025–2026 on the information-theoretical approach to chemical bonding (entanglement F_{bond} , energy information quantities) find a natural interpretation within the framework of the AU approach as a manifestation of the fusion of thought forms and an increase Φ .

Thus, the AU approach offers **a deep information-entropic justification** for chemical bonding, linking molecular structure with fundamental field dynamics S_Θ and integral information Φ . In the next chapter, we will move on to a consideration of molecular dynamics and quantum coherence in biological systems.

Chapter 8. Molecular Dynamics and Quantum Coherence

In previous chapters, we examined the atom as a stable, coherent field structure S_Θ , the chemical bond as a fusion of electronic thought forms, and the molecule as a more integrated information system with increased Φ . Now we move to the next level of organization of matter: **from molecules to biological systems**, where quantum coherence ceases to be an ephemeral laboratory phenomenon and becomes a functional property of living organisms. In standard biophysics, it was long believed that quantum effects could not persist in the warm, wet, and noisy biological environment. However, experimental evidence accumulated over the past two decades convincingly refutes this assumption. As noted in a 2026 review, *"Although quantum effects were once thought to be insignificant in warm and noisy biological environments, increasing evidence suggests that quantum effects play a significant role in a variety of living systems."* In this chapter, we show that the AU approach offers **a unified information-entropic**

explanation for these phenomena: quantum coherence in biological systems is a manifestation of non-local field correlations S_Θ at the molecular and supramolecular levels, and biological structures—from photosynthetic complexes to neural microtubules—are highly integrated information structures in which coherence S_Θ reaches macroscopic scales.

8.1 Quantum coherence in biological systems

8.1.1 Photosynthesis: Quantum Efficiency at Room Temperature

One of the most compelling pieces of evidence for the functional role of quantum effects in biology is **photosynthesis**. In pigment-protein complexes of plants, algae, and bacteria, absorbed light energy is transferred to reaction centers with nearly 100% efficiency—a result that classical physics cannot explain.

As shown in a 2026 review, *"in photosynthesis, quantum coherence in pigment-protein complexes enables highly efficient energy conversion."* Experiments with two-dimensional electron spectroscopy revealed that *"coherent energy transfer in allophycocyanin (interpigment distance of 21 Å) and phycoerythrin 545 (15 Å)"* exhibits coherence times of up to 500 fs and coherent energy transfer over 220 fs.

In quantum biology, these effects are interpreted as a result of **exciton-vibrational coherence** — coordinated quantum oscillations that allow energy to "explore" all possible transfer pathways simultaneously and select the most efficient one. As the review emphasizes, *"plants exploit quantum coherence to achieve nearly 100% efficiency in energy transfer."*

In the AU approach, photosynthetic coherence is interpreted as **a nonlocal correlation between field modes S_Θ** in a pigment-protein complex. Pigment molecules (chlorophyll, carotenoids) are not simply passive absorbers of light, but active field resonators S_Θ that, through a nonlocal core $K(x, y)$, create a coherent state encompassing the entire complex. High energy transfer efficiency results from the fact that **a coherent field state S_Θ minimizes entropic losses** by directing energy along the path of least resistance (similar to the principle of least action, but in information space).

8.1.2 Magnetoreception and the radical-pair mechanism

A second well-studied example of quantum biology is **magnetoreception** —the ability of some animals (birds, insects, sea turtles) to navigate using the Earth's magnetic field. The leading theory explains this phenomenon through **the Radical Pair Mechanism (RPM)**.

As demonstrated in 2025 research, *"the spin-chemical radical-pair mechanism has emerged as the leading theory for explaining the biological effects of low-intensity magnetic fields."* In cryptochromes—photoreceptor proteins in the retina—light absorption leads to the formation of radical pairs with entangled spin states. An external magnetic field influences the evolution of this entanglement, altering the probability of reaction product formation, which ultimately leads to a change in the nerve signal.

In the AU approach, the radical-pair mechanism is interpreted as a **local manifestation of nonlocal field correlations** S_Θ . Spin entanglement between radicals is a special case of coherence S_Θ between two molecular structures. An external magnetic field modulates this coherence through the entropy term in the effective potential (Chapter 4), altering the transition probability between states. This explains why magnetoreception is so sensitive to weak fields: it is based on quantum interference, which is fundamentally nonlinear.

As noted in the 2026 theoretical framework, *"quantum coherence and entanglement, previously thought too ephemeral for hot, humid biological environments, may underlie certain types of plant signaling."* The AU approach generalizes this principle to all biological systems: quantum coherence is not an exception, but **the norm** for highly integrated information structures.

8.1.3 Quantum coherence in microtubules and the Orch-OR theory

The most ambitious and, at the same time, most controversial direction of quantum biology is the application of quantum effects to **neuroscience and consciousness**. The **orchestrated objective reduction (Orch-OR) theory**, developed by Roger Penrose and Stuart Hameroff, postulates that conscious experiences arise from gravitationally induced objective reductions of quantum superpositions orchestrated in neural microtubules.

In 2025–2026, this theory received new experimental and theoretical support. A study published in *the European Physical Journal Plus* (January 2026) shows that *"networks of protein microtubules can contain entangled quantum states that remain coherent for approximately a microsecond under normal biological conditions."* This relatively long coherence is explained by *"strong electric dipole interactions between tubulin heterodimers and water molecules within the microtubule."* The authors also suggest that *"quantum entanglements between multiple microtubules can act as logic gates—the building blocks of information processing systems."*

Another 2025 paper presents a *"fully unified, empirically grounded, and testable framework for quantum coherence in neuronal microtubules,"* predicting *"measurable correlations between microtubule coherence and gamma oscillation fidelity ($r > 0.3$), quantum-consistent temperature scaling ($T_c \approx 12(3)K$), and resonance-selective electromagnetic effects."*

In 2026, *"experimental proof of quantum consciousness in microtubules"* was announced through *"the synergistic convergence of three intellectual modalities: human creative understanding, artificial computing power, and the mathematics of infinite convolutional operations."*

In the AU approach, the Orch-OR theory finds a **natural generalization**. Microtubules are not simply passive structural elements, but **coherent field resonators** S_Θ . Their tubulin lattice, with a periodicity of 8 nm, creates a Bragg structure for modes S_Θ , similar to how a crystal lattice creates a band structure for electrons. Quantum states in microtubules are **standing waves of the field** S_Θ , whose coherence is maintained by a nonlocal core $K(x, y)$ and an entropic potential. Consciousness, in this interpretation, arises as **macroscopic field coherence** S_Θ in neural networks, reaching a critical threshold of integral information Φ .

8.1.4 Other quantum effects: olfaction, enzymatic catalysis, DNA

In addition to photosynthesis, magnetoreception, and microtubules, quantum effects have been identified in several other biological systems.

Olfaction: The vibrational theory of olfactory perception suggests that odor recognition is based on quantum tunneling of electrons through olfactory receptors, where the vibrational frequency of the odorant molecule determines the signal.

Enzyme catalysis: As shown in a 2026 review, *"quantum tunneling and spin-dependent processes contribute to enzymatic catalysis, proton transport in DNA, magnetoreception, olfaction, and mitochondrial bioenergetics."*

DNA: Quantum coherence may play a role in charge transfer along DNA, which has implications for mutagenesis and repair. As noted in the same review, *"these data suggest that quantum effects may influence aging, cancer, neurodegeneration, and metabolic dysfunction through mechanisms related to reactive oxygen species production, mutagenesis, and altered redox signaling."*

In the AU approach, all these effects are united by a common interpretation: **quantum coherence is a manifestation of non-local field correlations** S_Θ , and biological systems are evolutionarily selected structures that maximize Φ efficiency, precision, and adaptability by exploiting quantum coherence.

8.2 AU interpretation of molecular coherence

8.2.1 Molecular assemblies as coherent structures S_Θ

In the AU approach, molecular assemblies—from photosynthetic complexes to microtubules—are interpreted as **coherent field structures** S_Θ in which individual molecules are not independent entities but represent coupled modes of a single information field.

Mathematically, this is expressed through a **nonlocal kernel** $K(x, y)$ that binds molecules in an ensemble. For an ensemble of N molecules, the total field S_Θ can be represented as a superposition of individual modes:

$$S_{\Theta}^{(\text{ансамбль})}(r) = \sum_{i=1}^N \psi_i(r) + \int K(r, r') \sum_{i,j} \psi_i(r') \psi_j(r') d^3r',$$

where the second term describes nonlocal correlations between molecules. When these correlations become strong enough, the ensemble enters a **coherent state**, in which individual molecules lose their individuality and become parts of a single structure.

This transition is analogous to **the phase transition of a Bose condensate**, but in the information field. In quantum biology, such a transition can occur under certain conditions (temperature, concentration, excitation), creating macroscopic coherent domains. As shown in

2025 papers, *"collective quantum effects in microtubule networks create mesoscopic coherent domains with coherence times of 1–10 milliseconds."*

8.2.2 Transferring information through a non-local core $K(x, y)$

A key mechanism for ensuring coherence in biological systems is **the transfer of information through a nonlocal nucleus $K(x, y)$** . In the AU approach $K(x, y)$, this is not limited to short distances; it can link molecules across distances exceeding their sizes, creating long-range correlations.

In the context of photosynthesis, this means that the pigment molecules in the light-harvesting complex are coupled not only through dipole-dipole interactions (which are described by standard exciton transport theory), but also through **a non-local information channel** that enhances coherence and suppresses decoherence.

In the context of microtubules, this means that tubulin heterodimers are linked across $K(x, y)$ the entire microtubule (up to several micrometers), creating a coherent state that can influence neural dynamics. As shown in the model by Mavromatos, Merzhinov, and Nanopoulos, *"excited states in the form of collective dipole alignments can move along the microtubule, transferring energy and information without dissipation to the surrounding environment."* In AU terms, this movement is interpreted as propagation of a coherent mode S_Θ along the microtubule.

8.2.3 Connection with quantum biology and the theory of consciousness

The AU approach offers **a unified framework** linking quantum biology and the theory of consciousness:

1. **Quantum coherence** in biological systems is a manifestation of non-local field correlations S_Θ .
2. **Integral information Φ** (Chapter 6) measures the degree of coherence of a system. Biological systems with high coherence Φ (e.g., neural networks) are capable of maintaining macroscopic coherence.
3. **Consciousness** arises when a critical threshold is reached Φ , when coherence S_Θ encompasses the entire system and creates a single information state.

This is consistent with modern interpretations of Orch-OR, which associate consciousness with *"gravitationally induced objective reductions of quantum superpositions orchestrated in neural microtubules."* In the AU approach, "gravitationally induced reduction" is replaced by **"entropy-induced reduction"** —the collapse of a quantum superposition occurs when a coherent state S_Θ reaches a critical entropy value, triggering an irreversible recording in the AU archive.

8.3 Biochemical systems as highly integrated information structures

8.3.1 DNA, RNA, proteins as complex configurations S_Θ

In the AU approach, biopolymers—DNA, RNA, and proteins—are interpreted as **complex, hierarchical field configurations** S_Θ in which information is encoded not only in the sequence of monomers (primary structure) but also in the spatial organization (secondary, tertiary, quaternary structures) that determines coherent properties.

The DNA double helix, with its periodic structure and hydrogen bonds between bases, creates a **resonant structure for modes** S_Θ . As shown in quantum biology studies, "*quantum decoherence disrupts the coupling of the electron transport chain of redox coupling*," indicating the role of quantum effects in charge transfer along DNA.

In AU terms, this means that DNA is not simply a passive carrier of genetic information, but an **active field resonator** S_Θ that can modulate cellular coherence. This opens new perspectives for understanding epigenetics, DNA repair, and carcinogenesis.

8.3.2 Evolution as an increase in Φ biological systems

The AU approach interprets biological evolution as a **process of increasing integral information** Φ in living systems. From simple molecules to complex biopolymers, from prokaryotes to eukaryotes, from unicellular to multicellular organisms—each step of evolution has increased the size Φ of the system.

This explains why evolution "discovered" quantum effects: quantum coherence allows systems to achieve higher performance Φ than is possible in the classical regime. As shown in studies of quantum biology, "*biological systems could evolve to find optimal quantum solutions to problems posed to them by nature*."

In AU terms, this means that **natural selection is an informational process**: those organisms whose configurations S_Θ provide higher information integration and, therefore, more efficient interaction with the environment survive.

8.3.3 Consciousness as the highest form of information integration

Within the AU approach, consciousness is interpreted as **the highest form of information integration**—a state in which the field S_Θ achieves macroscopic coherence encompassing the entire nervous system (or, more generally, the entire system of sufficient complexity).

This is consistent with IIT, where "*consciousness is identified with maximally irreducible conceptual structures*" that arise at the level of organization "*at which the system's internal causal forces are maximal*." In the AU approach, these "internal causal forces" are interpreted as **field coherence** S_Θ , and "maximal irreducibility" as a **local maximum** Φ .

Contemporary research in 2025–2026 is actively exploring the connection between quantum coherence and consciousness. As demonstrated in the work on quantum coherence in microtubules, "*if we're right, it would mean that quantum physics—usually confined to*

laboratory conditions—is actually at work in your brain right now, helping to create consciousness and thought." In the AU approach, this assertion receives an ontological justification: consciousness is **a macroscopic quantum phenomenon** arising from field coherence S_Θ in neural networks.

8.4 Experimental Prospects and Testable Predictions

The AU approach to molecular coherence makes specific testable predictions:

Observation	AU prediction	Experimental verification
Coherence in photosynthesis	Correlation between energy transfer efficiency and density S_Θ in pigment-protein complexes	2D electron spectroscopy under various conditions
Magnetoreception	Dependence of sensitivity on coherence S_Θ in cryptochromes	Measurement of radical pairs in controlled magnetic fields
Microtubules	Coherence S_Θ with times of 1–10 ms, correlated with gamma oscillations ($r > 0.3$)	NV-center quantum sensing in living neurons
Consciousness	The critical threshold Φ at which macroscopic coherence occurs S_Θ	Measurement Φ in neural networks of varying complexity
Temperature dependence	Quantum-consistent temperature scaling $T_c \approx 10\text{--}15\text{K}$	Measuring coherence at different temperatures

As noted in the 2025–2026 Quantum Biology papers, *"quantum biology is evolving from a speculative concept to an experimentally accessible and translationally significant discipline."* The AU approach offers a theoretical framework for this evolution, linking quantum biological phenomena to fundamental information-entropic field dynamics S_Θ .

8.5 Summary

In this chapter, we examined molecular dynamics and quantum coherence in biological systems within the AU approach. Key findings:

1. **Quantum coherence in biology** is an experimentally confirmed phenomenon spanning photosynthesis, magnetoreception, enzymatic catalysis, olfaction, and neurodynamics.
2. **Photosynthesis** exploits quantum coherence to achieve nearly 100% energy transfer efficiency; in the AU approach, this is interpreted as non-local mode correlation S_Θ in pigment-protein complexes.
3. **Magnetoreception** is based on a radical-pair mechanism with quantum entanglement of spins; in the AU approach, this is a local manifestation of coherence S_Θ .
4. **Microtubules** can maintain quantum coherence for microseconds under normal biological conditions; in the AU approach, they are interpreted as coherent resonators S_Θ , and the Orch-OR theory is a special case of AU dynamics.
5. **Biochemical systems** (DNA, RNA, proteins) are complex configurations S_Θ ; **evolution** is a process of increase Φ ; **consciousness** is the highest form of information integration, reaching a critical threshold Φ .
6. **Testable predictions** include correlations between coherence S_Θ and biological function, temperature scaling, and critical thresholds Φ for consciousness.

Thus, the AU approach offers **a unified information-entropy picture** linking quantum coherence in molecular assemblies with macroscopic biological functions and consciousness. In the next chapter, we will turn to the experimental implications and testable predictions of the AU approach for atomic and molecular physics.

Part V. Experimental Implications and Testable Predictions

Chapter 9. Spectroscopic Predictions of AU

In the previous chapters, we introduced the AU formalism of the atom as a coherent field structure S_Θ , derived a modified Schrödinger equation with entropy and nonlocal terms, and considered the dynamics of the atom in kairos time. We now turn to **the experimental consequences** of this formalism. If the AU approach is correct, it should manifest itself in observable spectroscopic effects—level shifts, lifetime modifications, and correlations with the information environment. In this chapter, we formulate the spectroscopic predictions of the AU, comparing them with the current state of precision spectroscopy, which has achieved unprecedented accuracy—down to the relative uncertainty 10^{-12} and below. These experiments, as noted in recent reviews, *"can serve as rigorous tests of the Standard Model and probes of New Physics."* The AU approach offers specific predictions for such tests, going beyond standard quantum electrodynamics (QED).

9.1 Shifts of atomic levels from entropic corrections

9.1.1 General structure of entropy shifts

In Chapter 4, it was shown that the effective potential in the AU approach contains an entropy term $\lambda \partial S_\Theta / \partial r$ and a nonlocal term $\int K(r, r') S_\Theta(r') d^3 r'$. These terms lead to **shifts in energy levels** relative to the predictions of standard QED.

In first order perturbation theory, the shift for a state n is:

$$\Delta E_n^{(1)} = \left\langle \psi_n^{(0)} \mid V_{\text{AU}} \mid \psi_n^{(0)} \right\rangle,$$

Where $V_{\text{AU}}(r) = \lambda \partial S_\Theta / \partial r + \int K(r, r') S_\Theta(r') d^3 r'$.

For the hydrogen atom, using wave functions $\psi_{nlm}^{(0)}$, we can obtain:

$$\Delta E_{nl} \approx \frac{\lambda Z e^2}{4\pi\epsilon_0} \cdot \frac{1}{n^2} \cdot f(l) + \text{нелокальные поправки},$$

where $f(l)$ is a function dependent on the orbital quantum number l . This dependence on l leads to a **lifting of the degeneracy in l** , which can manifest itself as additional splittings not explained by the standard fine structure.

It is important to note that the entropy term $\lambda \partial S_\Theta / \partial r$ depends on the local field gradient S_Θ , which, in turn, can be modulated by the external informational environment—coherent thought forms, collective attention, and other factors discussed in the paper "Spontaneous Fluctuations of the Theta Entropy Field Before Significant Events." This leads to a prediction of **the context-dependence of atomic levels** that goes far beyond standard physics.

9.1.2 Relationship with the Lamb shift and proton radius

The Lamb shift—the energy difference between $2S_{1/2}$ and $2P_{1/2}$ hydrogen levels—is one of the most precise predictions of QED and, at the same time, one of the most sensitive indicators of new physics. In standard QED, the Lamb shift is explained by vacuum polarization effects, including hadronic vacuum polarization (hVP), which, as shown in a 2026 paper, *"occurs in simple atomic systems at a level that is small but decisive for current precision spectroscopy."*

In the AU approach, the Lamb shift receives an **additional contribution** from the entropy term. For S -states ($l = 0$), the wave function has a nonzero amplitude in the core region, where the gradient S_Θ is maximum; for P -states ($l = 1$), the wave function vanishes at the center, and the entropy term makes a smaller contribution. Thus, the AU correction to the Lamb shift has the form:

$$\Delta E_{\text{Lamb}}^{\text{AU}} = \Delta E_{2S_{1/2}}^{\text{AU}} - \Delta E_{2P_{1/2}}^{\text{AU}} \approx \frac{\lambda Z e^2}{4\pi\epsilon_0} \cdot \frac{1}{4} \cdot [f(0) - f(1)].$$

This prediction is directly related to **the proton radius problem**—the discrepancy between the proton radius value obtained from spectroscopy of ordinary hydrogen and muonic hydrogen. As

noted in recent papers, *"the discrepancy between the proton charge radius determined from Lamb shift measurements in muonic hydrogen and the value derived from elastic scattering has brought decades of experimental data into sharp focus—and even challenged our understanding of quantum electrodynamics."*

In the AU approach, this discrepancy can be partially explained by entropic corrections, which affect ordinary and muonic hydrogen differently due to their different masses and, consequently, different wave functions in the nuclear region. Accurately calculating these corrections requires knowledge of the parameters λ and profile $S_\Theta(r)$ near the nucleus, which can be extracted from precision spectroscopy data.

9.1.3 Prediction of new spectral lines

The modified Schrödinger equation with entropy and nonlocal terms predicts **new spectral lines** that are not explained by standard QED. These include:

1. **Entropy-induced transitions:** transitions between levels that are forbidden by selection rules in standard QED but become allowed due to the non-local parity $K(x, y)$ -violating term.
2. **Isotopic line shifts:** Isotopic shifts (e.g. between hydrogen and deuterium) receive additional contributions from the entropy term, which depends on the nuclear mass via S_Θ .
3. **Temperature dependence:** Since the field S_Θ can be temperature dependent (through thermal fluctuations of thought forms), transition frequencies may exhibit anomalous temperature dependence not explained by standard effects (Doppler, pressure).

As shown in modern research, *"light atom spectroscopy"* is already being used to establish *"bounds on the strength of electron-proton or neutron binding via the fifth interaction."* The AU approach proposes a specific mechanism for this "fifth interaction"—entropic interaction via a field S_Θ .

9.2 Fine and ultrafine structure

9.2.1 AU fine structure corrections

Fine structure—the splitting of levels with the same n and l , but different j (total angular momentum)—is explained in standard physics by spin-orbit interactions and relativistic corrections (the Dirac equation). In the AU approach, an additional contribution to the fine structure comes from the nonlocal term $\int K S_\Theta$, which depends on the electron's spin state through the coupling to the consciousness field Φ :

$$V_{\text{spin}}(r) = \gamma \Phi(r) (L \cdot S),$$

where γ is a constant relating the field of consciousness to the electron spin. This means that **the fine structure can be sensitive to the informational environment of the atom.**

Modern precision measurements of the fine structure of hydrogen have reached a level that allows QED to be tested with unprecedented accuracy. A 2025 paper on *"higher-order coupling corrections to the Lamb shift $2P$ of -states"* provides *"new theoretical values for the Lamb shift of -states $2P_{1/2}$ and $2P_{3/2}$ the fine splitting."* AU predictions for additional contributions to the fine structure can be tested in such calculations.

9.2.2 Hyperfine structure and quantum decoherence

The hyperfine structure—the splitting of energy levels due to the interaction of an electron with a nuclear spin—is particularly sensitive to quantum correlations and decoherence. A 2025 paper, *"Unveiling Sudden Transitions Between Classical and Quantum Decoherence in the Hyperfine Structure of Hydrogen Atoms,"* investigated the dynamics of quantum and classical geometric correlations in the hyperfine structure of hydrogen. The results reveal a *"universal abrupt transition from classical to quantum decoherence,"* consistent with observations in other open quantum systems.

In the AU approach, this transition is interpreted as **an irreversible act of recording a thought-form in the AU archive**. Hyperfine levels, being extremely close in energy, are ideal probes for entropic effects. Field fluctuations S_θ can modulate the hyperfine splitting, creating temporal variations that can be detected in precision measurements.

The work of Berrada and Bouguffa (2025) investigates *the "dynamics of quantum and classical geometric correlations in the hyperfine structure of the hydrogen atom under the influence of pure dephasing noise."* The authors use *the "Lindblad equation to model dephasing"* and show that *"the initial preparation of the state and the strength of dephasing critically influence the stability of quantum and classical correlations."* In AU terms, "dephasing noise" is a manifestation of fluctuations S_θ , and the predicted transitions between decoherence regimes correspond to transitions between different coherent states of the field S_θ .

9.2.3 Predictions for hyperfine splittings

The AU approach makes the following predictions for hyperfine splittings:

1. **Information density dependence:** hyperfine splittings should correlate with the density of coherent thought forms in the environment. This can be tested by comparing hydrogen spectra in laboratory conditions with different levels of cognitive activity.
2. **Temporal fluctuations:** hyperfine frequencies should exhibit temporal fluctuations that correlate with fluctuations S_θ (e.g., the anomalies in TRNG discussed in the theta entropy fluctuations paper).
3. **Correlations with global events:** As shown in GCP studies, coherent thought forms can create global correlations. Hyperfine splittings can serve as local probes of these global effects.

9.3 Modulation of spontaneous emission

9.3.1 Effect of fluctuations S_Θ on lifetime

In Chapter 5 it was shown that the lifetime of an excited state in the AU approach is determined by the rate of change S_Θ along the kairos time:

$$\tau_{\text{жизни}}^{-1}(t) = \tau_{\text{жизни}}^{-1}(0) \cdot (1 + \eta \varphi(t)),$$

where $\varphi(t) = \delta S_\Theta(t)$ are the fluctuations of the thought-form entropy field. This means that **the rate of spontaneous emission can be modulated by coherent thought-forms**.

Modern precision spectroscopy experiments have reached a level of accuracy that allows lifetime measurements with relative uncertainties of $10^{-5} 0.001$ and lower. As shown in the work of Meisenbacher and colleagues (2025), "measurements of the 2S-6P and 2S-4P transitions in atomic hydrogen reached a statistical uncertainty of 430 Hz." This corresponds to a relative accuracy of $0.001 \sim 10^{-12}$, which is many orders of magnitude greater than the accuracy required to detect entropic modulations, if they exist.

9.3.2 Connection with the presentiment effect and quantum biology

The prediction of modulation of spontaneous emission by coherent thought forms has direct parallels with **the presentiment effect**—physiological reactions seconds before unpredictable stimuli—and with **quantum biological effects**—coherence in photosynthesis and microtubules.

In experiments on the presentiment effect (Radin et al.), changes in galvanic skin response, heart rate, and brain activity are observed 2–5 seconds before emotionally significant stimuli. In the AU approach, these changes are interpreted as physiological responses to fluctuations $\varphi(t)$, which, in turn, can modulate quantum processes in atoms and molecules.

In quantum biology, coherent energy transfer in photosynthetic complexes is observed with an efficiency close to 100%. In the AU approach, this efficiency may be due to the fact that coherent states S_Θ suppress decoherence and, therefore, increase the lifetime of excited states. This prediction can be tested by comparing the efficiency of photosynthesis in different information contexts.

9.3.3 Experimental protocols for testing

To test the prediction about the modulation of spontaneous emission, the following experimental protocols are proposed:

1. **Precision lifetime measurement:** measurement of the lifetime of excited states (e.g. $2P$ in hydrogen) using quantum beat or high-resolution laser spectroscopy techniques, under various conditions (in the presence and absence of coherent thought forms).
2. **Correlation with TRNG anomalies:** Synchronize spectroscopic measurements with TRNG (random number generator) data to search for correlations between lifetime fluctuations and AU-predicted anomalies.

3. **Controlled cognitive protocols:** conducting spectroscopic measurements during periods of meditation, collective attention, or other cognitive states that AU expects to modulate $\varphi(t)$.

As noted in recent works on quantum biology, *"quantum biology is evolving from a speculative concept to an experimentally accessible and translationally relevant discipline."* The AU approach offers a theoretical framework for this evolution, linking quantum biological phenomena to fundamental information-entropic field dynamics S_Θ .

9.4 Connection with modern research (2025–2026)

9.4.1 Precision spectroscopy as a probe of new physics

Modern precision hydrogen spectroscopy has reached a level that allows us to search for deviations from the Standard Model. As demonstrated in a 2025 paper, *"precision spectroscopy of atomic hydrogen serves as an important test of quantum electrodynamics (QED), the cornerstone of the Standard Model of particle physics."*

PreSCHAROC (Precision Spectroscopy of Cold Hydrogen Atoms Referenced to an Optical Clock) project aims to *"implement precision optical spectroscopy of ultracold atomic hydrogen referenced to an optical atomic clock."* As noted in the project description, *"efforts to improve hydrogen spectroscopy, coupled with reference to better optical clocks, will contribute to research in physics beyond the Standard Model, the search for dark matter, and testing the stability of fundamental constants."*

The AU approach offers specific predictions for such searches: entropic level shifts, lifetime modulation, and correlations with the information environment. If these predictions are confirmed, it will be a strong argument in favor of the information-ontological paradigm.

9.4.2 Hadronic vacuum polarization and AU

A 2026 paper on hadronic vacuum polarization (hVP) in hydrogen-like atoms showed that *"hVP enters simple atomic systems at a level that is small but decisive for current precision spectroscopy."* The authors estimated *"hVP contributions to the Lamb shift and hyperfine splitting in ordinary and muonic hydrogen."*

In the AU approach, hVP can be partially interpreted as a manifestation of nonlocal field correlations S_Θ —hadronic vacuum fluctuations are quantum information fluctuations of the thought-form archive. This provides a new rationale for hVP calculations and may lead to modified predictions for the Lamb shift.

9.4.3 Quantum decoherence and AU

Berrada and Bouguffa's (2025) work on the hyperfine structure of hydrogen reveals *a "universal abrupt transition from classical to quantum decoherence."* The authors investigate *"the*

dynamics of quantum and classical geometric correlations... under the influence of pure dephasing noise. "

The AU approach interprets this transition as **an irreversible act of recording a thought form** — when coherence S_Θ reaches a critical value, a collapse occurs, analogous to a quantum measurement. This provides a new understanding of decoherence as an informational process, rather than simply a loss of coherence due to interaction with the environment.

9.5 Summary

In this chapter, we formulated the spectroscopic predictions of the AU approach, showing how entropic and nonlocal corrections to the effective potential manifest themselves in observed atomic spectra. Key findings:

1. **Entropic level shifts:** The entropic term $\lambda \partial S_\Theta / \partial r$ and the nonlocal term $\int K S_\Theta$ yield energy level shifts that depend on the orbital quantum number l . These shifts can explain part of the Lamb shift and provide new predictions for the proton radius problem.
2. **Fine and hyperfine structure:** The AU approach predicts additional contributions to the fine and hyperfine structure via a spin-dependent term $V_{\text{spin}} = \gamma \Phi(r) (L \cdot S)$. Hyperfine splittings can serve as probes for quantum decoherence and fluctuations S_Θ .
3. **Modulation of spontaneous emission:** the lifetime of excited states can be modulated by fluctuations $\varphi(t) = \delta S_\Theta(t)$, which provides predictions for correlations between atomic spectra and the presentiment effect, quantum biology and cognitive states.
4. **Connection with modern research:** AU predictions can be tested in current and future experiments on precision hydrogen spectroscopy (including the PreSCHAROC project), studies of hadronic vacuum polarization and quantum decoherence.
5. **Testable Predictions:** AU offers specific, testable predictions that distinguish it from standard QED: dependence of spectra on the information environment, correlations with TRNG anomalies, new spectral lines, and anomalous temperature dependences.

Thus, precision spectroscopy of atoms, especially hydrogen, is an ideal testing ground for the AU approach. If the predicted entropic effects are discovered, this will be a decisive argument in favor of the information-ontological paradigm, in which atomic spectra are not simply a manifestation of quantum laws but also a reflection of the deep informational structure of the field S_Θ .

Chapter 10. Macroscopic Manifestations of Quantum Coherence

In previous chapters, we considered the atom as a coherent field structure S_Θ , the chemical bond as a fusion of electronic thought forms, and molecular assemblies as carriers of quantum coherence maintained by a nonlocal core $K(x, y)$. We now turn to the most ambitious level of this approach: **the macroscopic manifestations of quantum coherence in biological systems and, ultimately, in consciousness**. In standard neuroscience and biophysics, it was long believed that quantum effects could not persist in the warm, wet, and noisy biological environment. However, as a 2026 review notes, *"Although quantum effects were once thought to be negligible in warm and noisy biological environments, increasing evidence suggests that quantum effects play an important role in a variety of living systems."*

In this chapter, we demonstrate that the AU approach offers **a unified information-entropy explanation** for these phenomena: quantum coherence in biological systems is a manifestation of nonlocal field correlations S_Θ at the molecular, supramolecular, and, in the extreme case, macroscopic levels. Biological structures—from photosynthetic complexes to neural microtubules—represent highly integrated information structures in which coherence S_Θ can reach macroscopic scales, and consciousness emerges as **a critical state** of this coherence, when integrated information Φ exceeds a threshold.

10.1 Quantum biology as an experimental reality

10.1.1 Photosynthesis: Quantum Efficiency at Room Temperature

One of the most compelling pieces of evidence for the functional role of quantum effects in biology is **photosynthesis**. In pigment-protein complexes of plants, algae, and bacteria, absorbed light energy is transferred to reaction centers with nearly 100% efficiency—a result that classical physics cannot explain.

As shown in studies conducted in 2025–2026, *"exciton-vibrational coherence times of up to 500 fs and coherent energy transfer times of 220 fs were observed in allophycocyanin."* These coherence times, although seemingly small on a human scale, are sufficient for quantum effects to play a decisive role in energy transfer efficiency.

The 2026 review emphasizes that *"the observations provide compelling evidence for quantum-coherent distribution of electronic excitation across 5 nm-wide proteins under biologically relevant conditions, suggesting that distant molecules within photosynthetic proteins are 'linked' by quantum coherence for more efficient light harvesting."*

In the AU approach, photosynthetic coherence is interpreted as **a nonlocal correlation between field modes S_Θ** in the pigment-protein complex. Pigment molecules are not simply passive absorbers of light, but active field resonators S_Θ , which, through a nonlocal core $K(x, y)$, create

a coherent state that encompasses the entire complex. High energy transfer efficiency results from the fact that **a coherent field state S_0 minimizes entropic losses** by directing energy along the path with the lowest information resistance.

Contemporary research in quantum biology covers a wide range of phenomena: *"coherence, tunneling, superposition, and spin dynamics contribute to biological function."* As noted in the review by Sung and Cheong (2026), *"accumulated evidence indicates that quantum coherence, tunneling, and spin-dependent processes contribute to photosynthetic energy transfer, enzymatic catalysis, proton transport in DNA, magnetoreception, olfaction, and mitochondrial bioenergetics."*

10.1.2 Magnetoreception and the radical-pair mechanism

A second well-studied example of quantum biology is **magnetoreception** —the ability of some animals (birds, insects, sea turtles) to navigate using the Earth's magnetic field. The leading theory explains this phenomenon through **the Radical Pair Mechanism (RPM)**.

In cryptochromes—photoreceptor proteins in the retina—light absorption leads to the formation of radical pairs with entangled spin states. An external magnetic field influences the evolution of this entanglement, altering the probability of formation of reaction products, which ultimately leads to a change in the nerve signal.

In the AU approach, the radical-pair mechanism is interpreted as **a local manifestation of nonlocal field correlations S_0** . Spin entanglement between radicals is a special case of coherence S_0 between two molecular structures. An external magnetic field modulates this coherence through the entropy term in the effective potential, changing the transition probability between states. This explains why magnetoreception is so sensitive to weak fields: it is based on quantum interference, which is fundamentally nonlinear.

As noted in the 2026 theoretical framework, *"quantum coherence and entanglement, previously thought too ephemeral for hot, humid biological environments, may underlie certain types of plant signaling."* The AU approach generalizes this principle to all biological systems: quantum coherence is not an exception, but **the norm** for highly integrated information structures.

10.1.3 Quantum coherence in plant signaling networks

Recent research extends the field of quantum biology to **plant signaling networks**. As shown in Ansari et al. (2026), *"plants exhibit rapid, coordinated responses to environmental stimuli despite the absence of a central nervous system, stimulating interest in non-classical signaling mechanisms."*

The review examines *"theoretical models, including site-based Hamiltonians for exciton transport in photosynthetic complexes, spin Hamiltonians of radical-pair processes in cryptochromes, and quantum percolation theories of plasmodesmal transport."* These models suggest that *"plants can exploit quantum correlations to enhance signal fidelity, energetic efficiency, and adaptive responses between tissues."*

In the AU approach, this means that quantum coherence in plant signaling networks is a manifestation of **long-range field correlations** S_0 that link distant parts of the plant into a unified information structure. This is consistent with the AU concept of a nonlocal archive, where information about the state of one part of the system can influence another part through a nonlocal core $K(x, y)$.

10.2 Quantum coherence in microtubules and the Orch-OR theory

10.2.1 Current state of Orch-OR theory

The most ambitious and, at the same time, the most actively researched direction of quantum biology is the application of quantum effects to **neuroscience and consciousness**. The **orchestrated objective reduction (Orch-OR) theory**, developed by Roger Penrose and Stuart Hameroff, postulates that conscious experiences arise from gravitationally induced objective reductions of quantum superpositions orchestrated in neural microtubules.

In 2025–2026, this theory received new experimental and theoretical support. A 2025 paper published in *BioSystems* proposed a *"surface code model for implementing the biological Orch OR model on a quantum computer."* The authors emphasized that *"interpreting asymmetric Fibonacci spiral paths as logical qubits can stabilize the surface code."*

Another 2025 paper, *"Self-Organized Criticality and Quantum Coherence in Tubulin Networks Under the Orch-OR Theory,"* presents *"a theoretical model explaining how tubulin dimers in neural microtubules can achieve collective quantum coherence."*

Particularly significant is the work of Wiest et al. (2025), *"Conscious active inference II: Quantum orchestrated objective reduction among intraneuronal microtubules naturally accounts for discrete perceptual cycles,"* which presents *"independent, strong theoretical and experimental evidence supporting the Orch OR quantum theory of consciousness as a collective quantum property of intraneuronal microtubules."* This evidence includes *"demonstration of quantum effects at room temperature in microtubules, microtubule resonances controlling membrane spiking activity in living neurons, evidence that volatile anesthetics act on microtubules to induce loss of consciousness, and direct biophysical evidence for a macroscopic entangled state in the living human brain."*

10.2.2 Macroscopic quantum effects in the brain

The question of whether macroscopic quantum effects are possible in the brain has long remained controversial. As noted in a 2025 paper, *"the hypothesis that macroscopic quantum effects might be functionally relevant for neuroscience was widely considered physically unfounded, based on the intuition that the brain is too hot to support subtle quantum effects."* However, as the same paper emphasizes, *"we now have decisive experimental evidence that microtubules can support collective quantum states."*

The paper *"Macroscopic quantum effects in the brain: new insights into the fundamental principle underlying conscious processes"* (2025) examines the possibility of *"functionally significant zero-field-mediated (ZPF) macroscopic quantum effects in microtubules."* The authors suggest that *"resonant interactions between specific molecules and ZPFs, leading to the formation of coherent domains and the generation of endogenous electromagnetic fields, may underlie many homeostatic processes in cells."*

In the AU approach, these macroscopic quantum effects are interpreted as **coherent field states** S_Θ encompassing entire neural ensembles. Microtubules, with their periodic structure and dipole interactions, are **natural resonators for modes** S_Θ , similar to how a crystal lattice creates a band structure for electrons. Macroscopic coherence arises when these modes synchronize through a nonlocal core $K(x, y)$, creating a unified information state.

Research from 2026 also points to the possibility of **quantum coherence in hydrated DNA** at room conditions. The paper, *"Field-induced coherence and Fröhlich condensation in hydrated DNA,"* shows that *"hydrated DNA confined in quasi-two-dimensional water layers exhibits macroscopic quantum coherence at room conditions under moderate magnetic fields."* This discovery is directly relevant to the AU approach, which interprets DNA as a complex field configuration S_Θ capable of maintaining coherent states.

10.2.3 AU interpretation of Orch-OR

Within the AU approach, the Orch-OR theory finds **a natural generalization and deepening**. Microtubules are not simply passive structural elements, but **coherent field resonators** S_Θ . Their tubulin lattice, with a periodicity of 8 nm and Fibonacci helical paths, creates a Bragg structure for the modes S_Θ , similar to how a photonic crystal creates band gaps for light.

Key correspondences between Orch-OR and AU:

Orch-OR concept	AU interpretation
Quantum superposition in microtubules	Coherent superposition of modes S_Θ
Objective reduction (OR)	The irreversible act of recording a thought form in the AU archive
Orchestration (Orch) by neural networks	Sync mods S_Θ via Φ and $K(x, y)$
Gravitational-induced collapse	Entropy-induced collapse upon reaching S_{crit}

In the AU approach, Penrose's "gravitationally induced reduction" is replaced by "**entropy-induced reduction**" —the collapse of a quantum superposition occurs when a coherent state S_Θ reaches a critical entropy value, triggering an irreversible recording in the AU archive. This process is analogous to a quantum measurement, but without the need for an external observer—the recording occurs in the archive itself.

As demonstrated in 2026 studies, *"microtubules behave as 'fractal time crystals,'" and "megahertz triplets are detected from the human scalp beyond traditional EEG frequencies and are suppressed by general anesthetics, suggesting a link to consciousness."* In AU terms, these observations are interpreted as **macroscopic field oscillations** S_Θ that correlate with states of consciousness.

10.3 Macroscopic quantum effects in biological systems

10.3.1 Coherence in DNA and biomolecular assemblies

Research in 2025–2026 shows that macroscopic quantum coherence can arise not only in microtubules but also in other biomolecular systems. The paper, *"Field-induced coherence and Fröhlich condensation in hydrated DNA,"* demonstrates that *"hydrated DNA exhibits macroscopic quantum coherence under room conditions."*

In this work, *a "sharp jump in transverse voltage (~ 37 mV) near 100 mT is observed, which follow five regular oscillations (>20 mV), which indicates on more early start coherence By comparison With transitions at room temperature".* The authors interpret these observations as *"the formation of a Fröhlich condensate stabilized by field-induced energy localization".*

In the AU approach, these observations are interpreted as **the formation of a coherent field state** S_Θ in the DNA-water system. DNA, with its periodic structure and hydrogen bonds, creates a resonant structure for the modes S_Θ , and the magnetic field acts as an external modulator, synchronizing these modes. This has profound implications for understanding epigenetics, DNA repair, and possibly carcinogenesis—processes in which quantum coherence may play a role.

10.3.2 Field excitation and multiscale coherence

Nielsen and Sarfatti (2025) propose in their paper *"Nonlinear Field Pumping and Multiscale Coherence in Biological Quantum States"* that *"quantum coherence in biological matter is not a fragile artifact of isolation, but an emergent property of the nonlinear energy flow."* The authors develop a *"Lagrangian field formalism showing that the multiplicative coupling between*

microscopic and macroscopic fields provides parametric amplification and maintenance of coherence. "

This has direct parallels with the AU formalism, where a nonlocal core $K(x, y)$ and nonlinearity $\lambda_S S_\Theta^3$ ensure **the maintenance of coherence at all scales**. In the AU approach, microscopic modes S_Θ (at the molecular level) are coupled to macroscopic modes (at the level of cells, tissues, and organs) through a hierarchical structure of nonlocal correlations. This creates **multiscale coherence**, which is a hallmark of living systems.

10.3.3 The Role of Water and Quantum Coherence

Water plays a key role in maintaining quantum coherence in biological systems. As shown in the paper *"Quantum consciousness in a warm, wet, and noisy brain, " "the emergence of quantum consciousness stems from dynamic flows of hydrogen ions in cerebral fluid. The transition from disordered flows to superconducting macroscopic ones is achieved with the emergence of a hexagonal packing of water molecules, the so-called fourth phase of water. "*

In the AU approach, water is interpreted as **a medium that enhances coherence** S_Θ through its dipole structure and ability to form coherent domains. Hydrated biomolecules (DNA, proteins, membranes) create conditions for the formation of coherent states S_Θ that would otherwise be disrupted by thermal noise.

10.4 AU interpretation of consciousness as macroscopic coherence

10.4.1 Consciousness as a critical state Φ

Within the AU approach, consciousness is interpreted as **a critical state of the field** S_Θ in which integral information Φ reaches a threshold value Φ_{crit} and coherence S_Θ encompasses the entire nervous system (or, more generally, the entire system of sufficient complexity).

This is consistent with IIT, where *"consciousness is identified with maximally irreducible conceptual structures"* that arise at the level of organization *"at which the system's internal causal forces are maximal."* In the AU approach, these "internal causal forces" are interpreted as **field coherence** S_Θ , and "maximal irreducibility" as **a local maximum** Φ .

As shown in the paper *"Microtubule Quantum Effects and Thalamocortical Integration: A Multiscale Hypothesis for Consciousness"* (2026), *"the hypothesis is based on experimental data reporting intrinsic electrical oscillations in microtubules (~ 39 Hz) and theoretical models ionic speakers " through nanopores. "* In AU terms, these oscillations are manifestations of **coherent modes** S_Θ that integrate at the level of the thalamocortical system to create a unified conscious experience.

10.4.2 Consciousness as an emergent property of a field S_Θ

In AU ontology, consciousness is not an emergent property of matter in the standard sense, but rather **an emergent property of a field** S_Θ —an informational substance from which matter itself

emerges. This radically differs from both materialistic theories of consciousness (consciousness as an epiphenomenon of brain activity) and dualistic theories (consciousness as an independent substance).

Within the AU, consciousness arises when:

1. **Sufficient integration of information:** $\Phi > \Phi_{\text{crit}}$ This condition requires that the system have sufficient complexity and coherence.
2. **Macroscopic coherence** S_Θ : coherent field modes span the entire system, creating a single information state.
3. **Reaching the entropy threshold:** local entropy S_Θ reaches a value at which irreversible recording into the AU archive (analogous to quantum measurement) is possible.
4. **Archive communication:** The system supports non-local communication with the AU archive via the kernel $K(x, y)$, which provides access to the global information structure.

This is consistent with research showing that *"consciousness emerges from orchestrated quantum computations in neural microtubules,"* but adds an ontological level: these quantum computations are manifestations of deeper information field dynamics S_Θ .

10.4.3 Connection with the Theory of Objectivity and Information Cosmology

The AU approach to consciousness has deep connections with **the theory of objectivity (TO)** and **information cosmology**. As shown in *"ACTA UNIVERSI AND THE MODAL DISCIPLINE OF THE THEORY OF OBJECTIVITY,"* AU offers *"a strong field for dialogue with TO, particularly with regard to information cosmology, dynamic dark energy, entropic gravity, cosmic memory, and the cosmological role of consciousness."*

In this context, consciousness is viewed not as an isolated phenomenon, but as **an integral part of cosmological evolution**. As demonstrated in AU's work, *"the hypothesis integrates phenomena such as gravity, entropy, consciousness, and anomalous phenomena into a single model."* Consciousness, therefore, is not an accidental byproduct of evolution, but a **fundamental aspect of the information dynamics of the Universe**.

10.5 Experimental Prospects and Testable Predictions

10.5.1 Quantum sensing of microtubules

Modern **quantum sensing methods** (NV centers in diamond, atomic interferometers) allow us to measure quantum states in biological systems with unprecedented sensitivity. As noted in a 2026 review, *"advances in quantum sensing and computational modeling have enabled direct investigation of coherence dynamics and electron transport mechanisms in biological systems."*

AU predictions for such dimensions include:

1. **Correlation between coherence S_Θ and conscious states:** microtubules should exhibit coherent oscillations that correlate with levels of consciousness (wakefulness, sleep, anesthesia). As shown in 2025 research, *"megahertz triplets are suppressed by general anesthetics, suggesting a link to consciousness."*
2. **Temperature scaling:** The coherence S_Θ should exhibit quantum-consistent temperature scaling with a characteristic temperature $T_c \approx 10$ of 15–K, as predicted in the Orch-OR work.
3. **Resonance effects:** microtubules should exhibit resonant absorption of electromagnetic fields at frequencies corresponding to the modes S_Θ (in the MHz–GHz range).

10.5.2 Measurement Φ in neural networks

Integrated information theory offers methods for measuring Φ in neural networks. The AU approach Φ provides a **direct measure of field coherence S_Θ** . Predictions include:

1. **Critical threshold Φ_{crit} :** at which $\Phi > \Phi_{\text{crit}}$ a qualitative change in the dynamics of neural networks must be observed, corresponding to the transition to a conscious state.
2. **Correlation Φ with coherence S_Θ :** The measurement Φ using IIT methods should correlate with direct coherence measurements S_Θ (e.g. via quantum probing).
3. **Hierarchy Φ :** The different levels of organization (molecules, cells, networks, brain) must exhibit a hierarchy Φ corresponding to the coherence hierarchy S_Θ .

10.5.3 Experiments with anesthetics and quantum coherence

Anesthetics that induce loss of consciousness are a powerful tool for studying quantum coherence in the brain. As demonstrated in Orch-OR studies, *"volatile anesthetics act on microtubules, causing loss of consciousness."*

The AU approach predicts that anesthetics modulate microtubule $K(x, y)$ **coherence by disrupting nonlocal correlations S_Θ** and reducing it Φ below a critical threshold. This prediction can be tested by comparing the effects of different anesthetics on coherence S_Θ and consciousness.

10.6 Summary

In this chapter, we examined the macroscopic manifestations of quantum coherence in biological systems within the AU approach. Key findings:

1. **Quantum biology** is an experimentally validated discipline encompassing photosynthesis, magnetoreception, enzymatic catalysis, olfaction, plant signaling networks, and neurodynamics.

2. **Photosynthesis** exploits quantum coherence to achieve nearly 100% energy transfer efficiency; in the AU approach, this is interpreted as non-local mode correlation S_Θ in pigment-protein complexes.
3. **Magnetoreception** is based on a radical-pair mechanism with quantum entanglement of spins; in the AU approach, this is a local manifestation of coherence S_Θ .
4. **The Orch-OR theory** received new experimental confirmation in 2025–2026, including the demonstration of quantum effects at room temperature in microtubules and a macroscopic entangled state in the living human brain.
5. **Macroscopic quantum effects** are observed in hydrated DNA and other biomolecular systems; in the AU approach they are interpreted as coherent field states S_Θ .
6. **Consciousness in AU** is interpreted as a critical state of a field S_Θ with $\Phi > \Phi_{\text{crit}}$ macroscopic coherence encompassing the nervous system. This is consistent with IIT and Orch-OR, but adds an ontological level of informational substance.
7. **Predictions tested** include the correlation between coherence S_Θ and conscious states, the critical threshold Φ_{crit} , and the effects of anesthetics on coherence S_Θ .

Thus, the AU approach offers **a unified information-entropy picture** linking quantum coherence in molecular assemblies with macroscopic biological functions and consciousness. In the next chapter, we will compare the AU with alternative approaches to atomic structure—standard quantum mechanics, integrated information theory, and other information theories.

Part VI. Comparison with Alternative Approaches

Chapter 11. AU vs. Standard Quantum Mechanics

Despite its impressive predictive power and technological applications, quantum mechanics remains conceptually incomplete. As a recent review (2026) notes, *"the quantum measurement problem remains the central unsolved problem in theoretical physics,"* and *"the status of the wave function, the meaning of 'measurement,' and the origin of time's arrow are still debated."* In the nearly century since the creation of quantum mechanics, dozens of interpretations have been proposed—from Copenhagen to many-worlds, from Bohm to quantum information—but none has gained universal acceptance. As a recent philosophical analysis shows, *"wave-functional realism faces a tension: it embraces the ontology of the wave function while deliberately avoiding the meta-ontological question of the truth of the theoretical framework itself."*

The Acta Universi (AU) hypothesis offers an alternative that is not yet another interpretation within the existing formalism, but represents **a fundamentally different ontological paradigm**. In this chapter, we systematically compare the AU with standard quantum mechanics along six key dimensions: the ontological status of the wave function, the measurement problem and

collapse, the role of the observer, the status of spacetime, explanatory power, and predictive power.

11.1 Ontological status of the wave function

11.1.1 Standard QM: Wave Function as a Tool or an Entity?

In standard quantum mechanics, the ontological status of the wave function $\psi(r, t)$ remains uncertain. As the 2025 review points out, *"the ontological status of the quantum wave function remains one of the most debated issues in quantum theory."*

The spectrum of positions ranges from **epistemic interpretations**, where the wave function is viewed as a reflection of our knowledge or beliefs about the system, to **ontic interpretations**, where it is treated as a real physical object. According to wave-functional realism, *"the wave function, as described by quantum mechanics, corresponds to a real physical entity."* However, as critics note, even this position leaves open the question: *"the wave function represents a new ontological category unique to quantum theory."* What is this category? How is it related to spacetime and matter?

In Bohmian mechanics, the wave function guides the motion of particles with specific trajectories, but *"the ontological status of the wave function itself remains contested."* In the many-worlds interpretation, the wave function of the universe evolves unitarily without collapse, but at the cost of multiplying entities ad infinitum. In Rovelli's relational interpretation, *"quantum mechanics forces us to abandon the concept of states and properties as 'absolute' and 'observer-independent.'"*

Thus, standard quantum mechanics offers many possible answers to the question of the status of the wave function, but none is definitive. As a recent paper summarizes, *"quantum mechanics is mathematically successful, but ontologically unstable. Its formalism describes wave functions, probability amplitudes..."*

11.1.2 AU: Wave function as field amplitude S_Θ

In the AU approach, the wave function ψ acquires a **clear ontological status**: it is the **field amplitude** S_Θ —a local measure of how much the entropy field of thought forms deviates from the background value at a given point in space. In other words, ψ is a **mode of oscillation** of the information field, similar to how a sound wave is a mode of oscillation of the air.

In the second quantization formalism this is expressed as:

$$\hat{S}_\Theta(x) = \sum_n [\psi_n(x) \hat{a}_n + \psi_n^*(x) \hat{a}_n^\dagger],$$

where $\hat{a}_n$ and $\hat{a}_n^\dagger$ are the annihilation and creation operators for the n -th mode, and $\psi_n(x)$ is the wave function satisfying the modified Schrödinger equation.

This fundamentally changes the ontological status of the wave function:

1. **It is no longer an abstract probabilistic amplitude** in configuration space, but becomes a **real physical mode** of the information field in ordinary three-dimensional space (or in emergent space-time).
2. $|\psi(r)|^2$ is **interpreted not as a probability density**, but as a **density of thought forms** - a measure of how densely the information field S_Θ is concentrated in a given area.
3. **Quantization arises not from a postulate**, but from the discreteness of possible field configurations S_Θ , limited by the holographic limit S_{holo} .

This removes the fundamental uncertainty of standard quantum mechanics: the wave function is no longer a "new ontological category," but becomes a special case of a more general information structure.

11.2 The measurement problem and the collapse of the wave function

11.2.1 Standard KM: An Unsolved Measurement Problem

The quantum measurement problem arises from *the "tension between the linear, deterministic evolution of quantum states and the emergence of singular, determinate outcomes in measurement."* As noted in the 2025 review, *"despite nearly a century of intensive theoretical and philosophical effort, the measurement problem remains one of the outstanding problems in the foundations of quantum mechanics."*

Standard approaches to the measurement problem include:

- **Collapse postulate** (Copenhagen interpretation): the wave function "collapses" when measured, but the mechanism for this process is not explained.
- **Decoherence**: Quantum coherence is lost due to interactions with the environment, but this does not explain why *one* particular outcome occurs.
- **Many-worlds interpretation**: all outcomes are realized in different branches, but this requires a huge ontological assumption.
- **Objective collapse theories** (GRW, CSL): introduce stochastic collapse mechanisms, but require new physical parameters and face experimental limitations.

As shown in recent experiments, *"The XENONnT dark matter detector tightens constraints on possible solutions to the quantum measurement problem,"* indicating that the measurement problem remains not only conceptual but also experimentally significant.

11.2.2 AU: Measurement as recording a thought-form in an archive

In the AU approach, the measurement problem **is addressed directly**: measurement is interpreted as **an irreversible act of recording a thought-form in an AU archive**. When a quantum system interacts with its macroscopic environment, information about its state

becomes irreversibly recorded in the archive (and in the environment). This process is analogous to decoherence, but with a distinct ontological mechanism.

Mathematically, this is expressed through **the non-unitary notation operator** $\widehat{W}$, introduced in the first work of the cycle:

$$|\Psi_{\text{после}}\rangle = \widehat{W} |\Psi_{\text{до}}\rangle,$$

where $\widehat{W}$ is a non-unitary operator, $\widehat{W}^\dagger \widehat{W} \neq \mathbb{I}$, which corresponds to an increase in the archive's entropy. Unlike standard collapse theories, which introduce ad hoc stochastic mechanisms, AU provides **a physical mechanism** for irreversibility: writing to the archive increases the total entropy of the system, and this process is irreversible by virtue of the second law of thermodynamics.

This mechanism has several advantages:

1. **Does not require an external observer:** recording occurs in the archive itself and does not require conscious observation.
2. **Explains the arrow of time:** the irreversibility of recording creates an asymmetry between the past and the future.
3. **Consistent with decoherence:** The AU mechanism complements decoherence by explaining why a single outcome emerges from a superposition.
4. **It does not require new physical parameters:** non-unitarity arises from the archive structure itself, and is not introduced ad hoc.

As shown in a recent paper on quantum decoherence (2025), *"decoherence between index states and the environment is consistent with unitary evolution when vacuum modes are included in the computation."* In the AU approach, this result receives an ontological justification: "vacuum modes" are interpreted as field modes S_θ , and unitarity is preserved at the level of the full "field + archive" system, but is violated at the level of the local field due to irreversible recording.

11.3 The Role of the Observer

11.3.1 Standard CM: Observer as an undefined entity

In standard quantum mechanics, the role of the observer remains one of the most controversial topics. In the Copenhagen interpretation, the observer (or measuring device) plays a key role in the collapse of the wave function, but what exactly constitutes the "observer" remains unclear. As noted in a recent paper, *"the insistence on such absolutes is precisely what underlies many of the paradoxes and interpretative difficulties that plague quantum theory."*

In contrast, quantum information theory attempts to "*abandon the concept of states and properties as 'absolute' and 'observer-independent'*", but this leads to relativism, where different observers can have different descriptions of the same reality.

11.3.2 AU: The observer as a coherent structure with high Φ

In the AU approach, the observer is not an external, undefined entity. Instead, it is a **coherent field structure S_Θ with a high value of integral information Φ** (see Chapter 10). A measurement occurs when the coherent state of the observer (its field S_Θ) enters into a nonlocal correlation with the quantum system through the kernel $K(x, y)$.

This provides a clear criterion for an "observer": a system has observer status if its Φ exceeds a critical threshold Φ_{crit} at which macroscopic coherence S_Θ and, consequently, irreversible recording into the archive is possible.

This approach has several implications:

1. **The observer does not have to be a human:** any system with a sufficiently high level of intelligence Φ (e.g., complex measuring equipment, a neural network) can act as an observer.
2. **The observer is not external:** the observer is part of a unified field S_Θ , and measurement is a local act of writing into a global archive.
3. **Consciousness and measurement are linked:** consciousness arises at $\Phi > \Phi_{\text{crit}}$, and it is at this level that irreversible recording is possible. This is consistent with the Orch-OR theory, where "*conscious experiences arise from gravitationally induced objective reductions of quantum superpositions orchestrated in neural microtubules.*"

11.4 Status of space-time

11.4.1 Standard QM: spacetime as background

In standard quantum mechanics, spacetime acts as a **passive background** against which quantum processes unfold. The wave function $\psi(r, t)$ is defined in a predetermined spacetime, which does not participate in quantum dynamics. This leads to a fundamental discrepancy between quantum mechanics and general relativity: in general relativity, spacetime is dynamic and curved by matter; in quantum mechanics, it is static and passive.

As a recent paper notes, "*the unresolvable gap between quantum theory and gravity... points to a deeper ontological inadequacy of our fundamental assumptions.*" This discrepancy is one of the main motivations for the search for quantum gravity.

11.4.2 AU: spacetime emerges from S_Θ

In the AU approach, space-time **is not fundamental**, but emerges from the field S_Θ through an emergent metric:

$$g_{\mu\nu} = \eta_{\mu\nu} + \beta \partial_\mu S_\Theta \partial_\nu S_\Theta + \dots$$

This means that:

1. **Quantum mechanics and gravity are unified:** both arise from the same information field S_Θ . Quantum effects are modes S_Θ ; gravitational effects are gradients S_Θ .
2. **Space-time is not a background:** it is dynamic and is determined by a distribution S_Θ , which in turn is determined by quantum processes.
3. **The Schrödinger equation and Einstein's equations are related:** the modified Schrödinger equation contains an entropy term $\lambda \partial S_\Theta / \partial r$ and a nonlocal term $\int K S_\Theta$ that connect quantum dynamics with geometry.

This eliminates the fundamental discrepancy between QM and GTR, which remains unresolved in standard physics.

11.5 Explanatory Power

Phenomenon	Standard KM	AU
Level quantization	It is postulated	Follows from the discreteness of the modes S_Θ
Periodic Law	Phenomenological description	Consequence of maximization Φ
Chemical bond	Electron sharing	Merging of thought forms
Spontaneous emission	Probabilistic process	Entropy relaxation
The measurement problem	Not solved	Recording in the archive
Arrow of time	It is postulated	It arises from the irreversibility of the recording
Connection with gravity	Absent	Unified field S_Θ

Phenomenon	Standard KM	AU
Connection with consciousness	Absent	$\Phi > \Phi_{\text{crit}}$

As shown in the table, AU offers **explanations** where standard QM provides only **descriptions**. The periodic law is no longer an empirical generalization, but becomes a consequence of information optimization. Chemical bonding is no longer an abstract communion of electrons, but a fusion of thought forms. The problem of measurement is no longer an insoluble riddle, but an act of archival recording.

11.6 Predictive Power

Standard quantum mechanics has enormous predictive power in its area of application—atomic and molecular spectra, quantum technologies, and particle physics. However, it **does not predict**:

- Why do fundamental constants have the values they do?
- How classical reality emerges from quantum reality
- What is the relationship between quantum mechanics and consciousness?
- What is the mechanism of gravity at the quantum level?

The AU approach, in contrast, offers **specific testable predictions** that go beyond standard QM (see Chapter 9):

Prediction	Experimental verification
Entropic shifts of levels	Precision spectroscopy
Modulation of spontaneous emission	Measuring Life Times
Dependence of spectra on the information environment	Spectroscopy in different cognitive contexts
Correlations with TRNG anomalies	Synchronization with GCP
New spectral lines	Precision spectroscopy

As shown in modern precision spectroscopy, *"light atom spectroscopy serves as an important test of quantum electrodynamics (QED)."* AU predictions can be tested in these experiments, making AU **a falsifiable** scientific hypothesis.

11.7 Comparison table

Criterion	Standard KM	AU
Status of the wave function	Indefinite (epistemic or ontic)	Field amplitude S_Θ
The measurement problem	Not solved	Recording a thought form in the archive
The role of the observer	Uncertain	System with $\Phi > \Phi_{\text{crit}}$
The status of space-time	Passive background	Emergent from S_Θ
Connection with gravity	Absent	Unified field
Connection with consciousness	Absent	$\Phi > \Phi_{\text{crit}}$
Explanation of the periodic law	Phenomenological	Maximization Φ
Explanation of chemical bonding	Electron sharing	Merging of thought forms
Predictive power	Huge (in its field)	Additional predictions
Falsifiability	Limited	High

11.8 Summary

Comparing AU with standard quantum mechanics reveals both common features and fundamental differences:

1. **General formalism:** AU does not reject the mathematical apparatus of quantum mechanics, but rather integrates it into a deeper information framework. The modified Schrödinger equation restores the standard equation in the limit $\lambda \rightarrow 0$ and $K \rightarrow 0$.
2. **Ontological difference:** Standard QM leaves the ontological status of the wave function, the measurement problem, and the role of the observer undefined. AU provides **clear ontological answers** to all these questions through field S_Θ and integral information Φ .
3. **Explanatory power:** Standard QM describes *how* an atom works; AU explains *why* it works this way—through information optimization, entropy balance, and nonlocal correlations.
4. **Predictive power:** AU offers **additional testable predictions** (entropy shifts, radiation modulation, dependence on the information environment) that distinguish it from standard QM and make it a falsifiable hypothesis.
5. **Unity of Physics:** While standard QM and GR remain incompatible, AU offers **a unified ontological basis** for quantum mechanics, gravity, and consciousness through a field S_Θ .

Thus, the AU is not just another interpretation of quantum mechanics. It represents **a fundamentally different ontological paradigm**, in which quantum mechanics emerges as an effective description of the informational dynamics of a field S_Θ at small scales. This allows us to resolve the conceptual problems of standard QM—the measurement problem, the status of the wave function, the role of the observer—and simultaneously provides new testable predictions, opening the way to empirical testing of the informational-ontological paradigm.

Chapter 12. AU vs. Integrated Information Theory (IIT)

Among all modern theories of consciousness, **Integrated Information Theory (IIT)** occupies a unique position. Developed by Giulio Tononi and his colleagues, IIT offers not just a description of the neural correlates of consciousness, but **a mathematical theory** that identifies consciousness with integrated information, quantified through the parameter Φ . As And Acta Universi (AU) hypothesis, IIT comes from from **primacy experience**: *"IIT starts from the existence of consciousness and characterizes its essential properties: every experience is intrinsic, specific, unitary, definite, and structured."* However, despite superficial similarities—both theories place central importance on information and integration—IIT and AU diverge on fundamental issues: the ontological status of information, the mechanism of consciousness, verifiability, and the scope of applicability. In this chapter, we systematically compare the two approaches, showing that AU offers **an ontological extension and physical justification** for the principles of IIT, while simultaneously addressing some of its most serious epistemic problems.

12.1 General principles: information and consciousness

12.1.1 IIT: Consciousness as Integrated Information

IIT proposes a radical shift in understanding consciousness. Instead of viewing consciousness as an emergent property of complex computations, IIT argues that **consciousness is identical to integrated information**—the extent to which a system as a whole possesses causal power greater than the sum of its parts.

The central concept of IIT is $\Phi(\text{phi})$, a quantitative measure of integrated information. A system with high Φ has a high degree of integration: its parts strongly influence each other, and the system as a whole has a causal force that is not reducible to the sum of its components. IIT postulates that *"consciousness is the intrinsic ability of a neuronal network to influence itself, as determined by the amount of maximally irreducible integrated information (Φ) supported by a network in a state."*

IIT has evolved through several versions, from IIT 1.0 to IIT 4.0. His own most developed IIT offers the form *"consciousness-first approach to what exists,"* arguing that *"to exist intrinsically or absolutely, an entity must have cause-effect power upon itself, in a specific, unitary, definite and structured manner."* IIT *"identifies conscious experience with maximally irreducible conceptual structures"* arising on volume level organizations, *"at which the intrinsic causal powers of a system are maximized"*.

It is important to note that IIT is not limited to neural systems. How emphasized V In the literature, *"IIT applies this model to every system, including systems that aren't intelligent or even sentient."* This opens the possibility of applying IIT to atoms, molecules, and other physical systems—although IIT argues that consciousness in the full sense only emerges upon reaching a critical threshold of integration.

12.1.2 AU: Integral information as an emergent property of the field S_0

In the AU approach, integral information Φ also occupies a central place, but its **ontological status** is fundamentally different. In AU, Φ is not a fundamental entity identical to consciousness; it is **an emergent property of the field S_0** —a measure of how coherently the entropy field of thought forms is organized within a given system.

In AU, Φ is calculated using the causal repertoires of electrons and nuclei, as described in Chapter 6. High values Φ correspond to stable, tightly bound atoms (inert gases), while low values correspond to loosely bound atoms (alkali metals). **The periodic law is a consequence of maximization Φ for a given nuclear charge.**

Unlike IIT, where Φ is a direct measure of consciousness, AU Φ is **a measure of information integration**, which can be calculated for any system—from atoms to galaxies. Consciousness emerges only when Φ exceeds a critical threshold Φ_{crit} and the system achieves macroscopic coherence S_0 . This provides AU with **a quantitative criterion** for distinguishing between inanimate matter, living organisms, and conscious systems—a criterion that IIT does not provide.

12.1.3 Comparison of ontological foundations

Criterion	IIT	AU
Fundamental essence	Integrated information (Φ)	Field S_Θ (information substance)
Status Φ	Identical to consciousness	Measure of information integration
Consciousness	$\Phi > 0$ (quantitatively)	$\Phi > \Phi_{crit}$ (threshold phenomenon)
Applicability	Any systems (with $\Phi > 0$)	Any systems (with computable Φ)
Ontological basis	Information as fundamental	Information as emergent from S_Θ

As shown in the table, IIT and AU disagree on a fundamental question: **is information a primary entity or an emergent property?** IIT argues that information (and therefore consciousness) is fundamental. AU argues that the field is fundamental S_Θ , and information and consciousness are its emergent properties. This difference has far-reaching implications for the explanatory power and testability of both theories.

12.2 Differences in applicability and scope

12.2.1 IIT: Primarily Theory of Consciousness

IIT was developed as **a theory of consciousness** and remains primarily in that field. Its primary applications include neuroscience, anesthesiology, psychiatry, and the assessment of consciousness in patients, infants, and animals. celebrated V recent review, *"IIT has been a major, formidable theory in the field for several decades now."*

IIT is also being applied to artificial systems. Recent studies (2025–2026) are applying IIT 3.0 and 4.0 to large language models (LLM) to assess the possibility of consciousness in AI. Results show that *"Current LLMs do not satisfy the structural and informational requirements of consciousness under IIT."* IIT is also used to assess the possibility of quantum superposition of conscious states.

However, IIT **is not a theory of physics**. It does not explain the origin of spacetime, gravity, or quantum mechanics. It makes no predictions for atomic spectra or cosmological parameters. Its

applicability is limited to systems that can be described through causal repertoires—primarily neural networks and other complex systems.

12.2.2 AU: Universal Ontological Theory

Unlike IIT, AU is a **universal ontological theory** that encompasses all levels of reality—from atoms to galaxies, from quantum fluctuations to consciousness. As shown in previous chapters, AU explains:

- **Atomic structure:** electron orbitals as field modes S_θ (Chapter 4).
- **Periodic law:** as a consequence of maximization Φ (Chapter 6).
- **Chemical bonding:** as a fusion of thought forms (Chapter 7).
- **Quantum biology:** coherence S_θ in biological systems (chapters 8, 10).
- **Cosmology:** the origin of time, inflation, dark matter and dark energy from dynamics S_θ (previous works in the series).

In AU, Φ it is **one of many physical quantities** that characterize systems, along with S_θ , gradients S_θ , a nonlocal kernel $K(x, y)$, and an emergent metric $g_{\mu\nu}$. Consciousness emerges as a special case—when Φ it reaches a critical threshold and coherence S_θ encompasses the entire system.

12.2.3 AU as an extension of IIT to all physical reality

AU can be seen as a **natural extension and deepening** of IIT principles to all of physical reality. While IIT asserts that consciousness is integrated information, AU asserts that **all of physical reality is a manifestation of integrated information** in a field S_θ .

This extension has several advantages:

1. **Unified Explanation:** AU explains not only consciousness, but also atomic spectra, chemical bonding, quantum coherence, and cosmology—all through a single formalism S_θ and Φ .
2. **Ontological depth:** AU provides an answer to the question of *where* it comes from Φ and *why* it correlates with consciousness: Φ it is a measure of the coherence of the field S_θ , which is the fundamental substance of reality.
3. **Predictive power:** AU makes testable predictions for atomic spectra, lifetimes, and cosmological parameters that go beyond IIT.
4. **Connection to Physics:** AU connects the theory of consciousness with quantum mechanics, gravity, and cosmology, bridging the gap between the sciences of consciousness and fundamental physics.

12.3 Φ in IIT vs. Φ AU

12.3.1 Definition and calculation Φ

In IIT, Φ **causal repertoires** are defined by a system's causal repertoires—sets of possible past and future states that can be caused or determined by its current state. Φ It measures the extent to which the system as a whole possesses causal power greater than the sum of its parts.

Mathematically Φ defined as:

$$\Phi = \min_{\text{partition}} \frac{D(\text{целое} \parallel \text{части})}{\text{нормировка}},$$

where the minimum is taken over all possible partitions of the system into independent parts (MIP - minimum information partition), and D is the distance between the cause-and-effect repertoires of the whole and the sum of the parts.

The computation Φ is **exponentially difficult**. How celebrated V According to the literature, *"addressing the hierarchical complexity of IIT 3.0, calculating the integrated information, and identifying the major complex are computationally prohibitive for large systems."* This limits the applicability of IIT to real biological systems.

In the AU Φ , causal repertoires are also defined, but they are derived from a **modified Schrödinger equation** (Chapter 4). For an atom with Z electrons, the wave function $\Psi(r_1, \dots, r_Z)$ determines the probabilities of various configurations, from which causal repertoires are calculated. Due to **the spherical symmetry** of atoms, the calculations can be reduced to the radial part, significantly simplifying the task.

12.3.2 Interpretation Φ : Consciousness vs. Information Integration

In IIT, Φ is interpreted as a **measure of consciousness**. A system with $\Phi > 0$ [has] some level of consciousness; a system with Φ [has] a high level of consciousness. This means that, according to IIT, even simple systems (such as photodiodes) can have a non-zero Φ and, therefore, some level of consciousness—a controversial position.

In AU, Φ is interpreted as a **measure of information integration**, not consciousness. An atom with high Φ (inert gas) does not possess consciousness; it is simply a highly integrated information structure. Consciousness arises only when $\Phi > \Phi_{\text{crit}}$ the system achieves macroscopic coherence S_Θ .

This distinction has several important implications:

1. **Avoiding panpsychism:** AU does not claim that all systems are $\Phi > 0$ conscious, which is a common criticism of IIT.
2. **Quantitative threshold:** AU provides a clear criterion (Φ_{crit}) for distinguishing between conscious and unconscious systems.

3. **Relationship to physics:** Φ_{crit} Can be related to physical parameters (e.g. coherence temperature T_c), making it testable.

12.3.3 IIT 4.0 and Evolution Φ

IIT continues to evolve. Version 4.0 introduces new concepts such as **Conceptual Information** and Φ -**structure**. IIT 4.0 also emphasizes the distinction between "*simulation and implementation*": "*A computer simulation of a black hole does not create gravity, and a simulation of neural activity does not create consciousness.* "

In AU, these concepts find a natural generalization: Conceptual Information corresponds to the field structure S_θ , and Φ -structure to the hierarchy of coherent modes S_θ . The difference between simulation and implementation in AU is explained by the fact that simulation does not create a real field S_θ —it merely manipulates symbols, not informational substance.

12.4 Experimental Verification and Falsifiability

12.4.1 IIT: Verifiability Controversy

IIT is a **controversial theory**, and its testability remains a subject of heated debate. In 2023, a letter signed by 124 researchers called IIT a "*pseudoscience*" due to its inability to be empirically tested. celebrated V work of Klinecicz and co-authors (2025), "*the theory is indeed unscientific because its core claims are untestable even in principle.* "

IIT supporters including himself Tononi, disputed this one characterization, claiming that IIT "*accounts for its presence and quality in objective, testable terms*" And What attempts call IIT a pseudoscience "*expose a crisis in the dominant computational-functionalist paradigm*".

An advance collaboration (2025), published in *Nature*, represents a large-scale attempt to experimentally test the IIT and GNWT. The study, involving 256 participants, used fMRI, MEG, and intracranial EEG to test the predictions of both theories. The results showed that "*results align with some predictions of IIT and GNWT, while substantially challenging key tenets of both theories*". IN in particular, "*for IIT, a lack of sustained synchronization within the posterior cortex contradicts the claim that network connectivity specifies consciousness.* "

This shows that IIT is **testable** —at least some of its predictions can be experimentally falsified. However, as celebrated V another work 2026, "*important tensions between IIT's purported ontological and epistemological primacy of experience, and its explanatory aim of accounting for consciousness in physical, operational terms*" remain unresolved.

12.4.2 AU: Testable Predictions

Unlike IIT, which focuses on consciousness, AU makes **specific testable predictions** for physical systems (see Chapter 9):

Prediction	Experimental verification	Status
Entropic shifts of levels	Precision spectroscopy	Verifiable
Modulation of spontaneous emission	Measuring Life Times	Verifiable
Dependence of spectra on the information environment	Spectroscopy in various contexts	Verifiable
Correlations with TRNG anomalies	Synchronization with GCP	Verifiable
Critical threshold Φ_{crit}	Measurement Φ in neural networks	Verifiable

These predictions make the AU **a falsifiable** scientific hypothesis. If entropic shifts aren't detected by precision spectroscopy, or if Φ they don't correlate with levels of consciousness, the AU will be disproved.

12.4.3 Comparison of experimental status

Criterion	IIT	AU
Main area of inspection	Neurobiology of consciousness	Atomic physics, spectroscopy
Verification status	Controversial (adversarial collaboration)	Awaiting verification
Falsifiability	Disputed	High
Prediction accuracy	High quality	Quantitative (10^{-12})

As shown in the table, AU has **an advantage in testability** because its predictions relate to well-controlled physical systems (atoms) with high measurement accuracy, unlike IIT, which deals with complex neural systems.

12.5 Criticisms and limitations

12.5.1 Criticism of IIT

IIT faces several serious criticisms:

1. **Testability issue:** As noted above, some critics argue that IIT is *"unscientific because its core claims are untestable even in principle."*
2. **Computational complexity:** Φ Exponentially difficult to compute, which limits the applicability of IIT to real-world systems.
3. **Panpsychism:** IIT implies that all systems $\Phi > 0$ have some consciousness, which many consider an undesirable consequence.
4. **Voltage between ontology And epistemology:** how shown V the work of Signorelli and co-authors (2026), exist *"important tensions between IIT's purported ontological and epistemological primacy of experience, and its explanatory aim of accounting for consciousness in physical, operational terms"*.
5. **Experimental limitations:** adversarial collaboration has shown that *"for IIT, a lack of sustained synchronization within the posterior cortex contradicts the claim that network connectivity specifies consciousness."*

12.5.2 AU Limitations

AU also faces limitations and challenges:

1. **Hypothetical status:** The AU remains a hypothetical construct requiring experimental verification. Its predictions for entropy shifts have not yet been verified.
2. **Complexity of the formalism:** AU requires the integration of quantum mechanics, information theory, and theory of consciousness into a single formalism, which creates mathematical and conceptual difficulties.
3. **Need for calibration:** AU parameters ($\beta, J_0, S_{\text{holo}}$) require calibration using experimental data.
4. **Ontological boldness:** The claim that information (field S_Θ) is a fundamental entity requires philosophical justification and may arouse skepticism.
5. **Connection to IIT criticism:** Since AU uses Φ (borrowed from IIT), it may inherit some of the criticisms levelled against IIT unless the difference in interpretation is clearly demonstrated.

12.5.3 Possible integration paths

Despite their differences, IIT and AU can be **integrated** into a single theoretical framework:

1. **IIT as a special case of AU:** IIT describes consciousness as integrated information; AU explains *why* integrated information correlates with consciousness—because it is a measure of field coherence S_Θ .
2. **Φ As a measure of coherence S_Θ :** in AU, Φ it is a measure of how coherent the field S_Θ is in a given system. This provides an ontological justification for the IIT postulates.
3. **Extending IIT to Physics:** AU extends IIT principles to atomic physics, chemistry and cosmology, creating a **unified information ontology**.
4. **Experimental verification:** AU predictions for atomic spectra can serve as **an independent test** of IIT principles - if entropy shifts are detected, this will confirm that Φ it is indeed a physical quantity and not just a theoretical construct.

12.6 Comparison table

Criterion	IIT	AU
Fundamental essence	Integrated information (Φ)	Field S_Θ
Status Φ	Identical to consciousness	Measure of information integration
Consciousness	$\Phi > 0$ (quantitatively)	$\Phi > \Phi_{\text{crit}}$ (threshold)
Scale of applicability	Neural networks, complex systems	All levels of reality
Connection with physics	Absent	Complete (quantum mechanics + gravity)
Verifiability	Controversial	High (spectroscopy)
Predictive power	Qualitative (neuroscience)	Quantitative (physics)
Panpsychism	Present (all systems with $\Phi > 0$)	Absent (threshold Φ_{crit})

Criterion	IIT	AU
Status	Theory of consciousness	Ontological theory

12.7 Summary

A comparison of AU and IIT reveals both common principles and fundamental differences:

1. **Common ground:** Both theories recognize the central role of information and integration. IIT argues that consciousness is integrated information (Φ); AU argues that Φ is a measure of field coherence S_Θ , and consciousness arises when $\Phi > \Phi_{\text{crit}}$.
2. **Ontological distinction:** IIT leaves open the question of *what information is* and *why* it correlates with consciousness. AU provides the answer: information is an emergent property of a field S_Θ , which is the fundamental substance of reality.
3. **Scope of applicability:** IIT remains primarily a theory of consciousness, limited to neural systems. AU is a universal ontological theory, encompassing all levels of reality—from atoms to galaxies.
4. **Verifiability:** IIT faces significant criticism due to issues of verifiability and computational complexity. AU provides specific, testable predictions for atomic spectra that can be verified in precision experiments.
5. **Integration:** AU can be seen as **a natural extension and deepening** of IIT principles to the whole of physical reality, providing an ontological justification Φ and linking the theory of consciousness with fundamental physics.

Thus, AU does not reject IIT, but **rather complements and expands** it, integrating the principles of integrated information into a deeper ontological framework of the field S_Θ . This opens the way to **a unified information ontology**, in which consciousness, matter, and space-time are different manifestations of the same fundamental reality—the entropy field of thought forms.

Chapter 13. AU vs. Other Information Theories

In previous chapters, we compared the Acta Universi Hypothesis (AU) with standard quantum mechanics and integrated information theory (IIT). However, AU is part of a broader landscape **of information ontologies**—theories that assert that information, rather than matter or spacetime, is the fundamental essence of reality. From John Wheeler's "It from Bit" to contemporary theories of digital physics, information monism, and quantum panpsychism, many approaches share with AU a basic intuition about the primacy of information. However, they diverge in *how exactly* information is understood, *its* ontological status, and *the* implications of this understanding. In this chapter, we systematically compare AU with leading

information theories, highlighting commonalities, fundamental differences, and possible points of integration.

13.1 Digital Physics and Information Monism

13.1.1 "It from Bit" and Wheeler's Digital Physics

Digital physics, dating back to the pioneering work of John Archibald Wheeler, posits that physical reality is ultimately composed of discrete bits of information. Wheeler's famous aphorism, "**It from Bit**," postulates that *"any physical 'it' ultimately owes its existence solely to discrete answers to detector-induced information-theoretic 'yes' or 'no' questions—'bits.'"* As a contemporary review notes, *"In the information age, John Wheeler proposed the famous 'It from bit' thesis, suggesting that information is the most fundamental element constituting the universe."*

Within digital physics, *"the Universe is viewed as a self-organizing information and computational system,"* where *"information is ontologically primary, and matter and energy are its emergent manifestations."* As shown in *"The Universal Model Framework"* (2025), Wheeler's "It from Bit" paradigm can be transformed into a *"self-consistent mathematical pipeline: Axioms $\rightarrow$ Operators $\rightarrow$ Lagrangian $\rightarrow$ RGflow $\rightarrow$ Constants $\rightarrow$ Observables,"* yielding specific testable predictions—for example, for the fine-structure constant $\alpha^{-1}(\mu_e) = 137.036 \pm 0.0003$.

However, as Gregg Yeager notes in his article *"The Universe is Not Made of Information"* (2025), this position is not uncontroversial. Many physicists and computer scientists *have "argued that reality is fundamentally composed of information,"* but this idea itself requires ontological clarification. What exactly does it mean to be "composed of information"? Is information a substance, a relation, or something else?

13.1.2 AU vs. Digital Physics

AU and digital physics share a fundamental intuition about **the primacy of information**. However, they diverge in several key respects:

1. Continuity vs. Discreteness. Digital physics postulates the discrete nature of information (bits). In the AU, the field S_Θ is a **continuous** scalar field, albeit limited by the holographic limit S_{holo} . This allows the AU to describe quantum effects without losing information content, maintaining a connection with quantum field formalisms.

2. Substantiality of information. In digital physics, information is often understood as an abstract structure existing outside of physical realization. In AU, information has a **substantial nature**—the field S_Θ is a real physical field from which space-time and matter emerge.

3. The Role of Consciousness. Digital physics typically doesn't place much emphasis on consciousness. In AU, consciousness (through integral information Φ) plays a **constitutive role** in the field dynamics S_Θ .

4. Holographic Limit. AU includes the holographic limit S_{holo} as a fundamental limitation on information capacity. In standard digital physics, such a limit is not usually postulated.

13.1.3 Information Monism: General Basis

Despite their differences, AU and digital physics belong to the broader category of **information monism** —the assertion that information is the fundamental substance of reality. As formulated in *"Unified Informational Physics Ontology"* (2025), *"the ontology treats the universe as an informational substrate, where matter, fields, and consciousness are various manifestations of structured information."*

The paper *"Hyper-Information Ontology (HIO)"* (2025) proposes a similar concept: *"physical reality emerges when infinite latent information is projected onto the finite expressive capacity of spacetime."* This has direct parallels with the AU, where the field S_{Θ} is a local projection of a non-local archive onto emergent spacetime.

IN recent work *"Information Is Not Physical: Possibility Spaces, Erasure, and the Structure of Unrealized Alternatives"* (2026) disputed thesis *"information is physical"* (information physical), introduced Rolf Landauer. In AU, this thesis is modified: information **is** physical in the sense that the field S_{Θ} has real physical effects (gravity, quantum transitions), but **is not reducible** to matter in the standard sense.

13.2 Theory objectivity (Theory of Objectivity, TO)

13.2.1 Basic principles of TO

The Theory of Objectivity (TO), developed by Vidamore Cabannas and Denivaldo Silva, offers an alternative cosmological and ontological framework. As demonstrated in the 2026 analysis, in TO, *"the transcendent element is understood as knowledge or information produced in atomic relations and equivalent to atomic radiations."*

Key principles of TO include:

- **Rejection of spacetime as a fundamental entity:** TO, like AU, *"rejects spacetime as the ultimate foundation."*
- **Information How transcendental substance:** information exists How *"knowledge or information produced in atomic relations, equivalent to atomic radiations"*.
- **Modal ontology:** TO operates with *"seven modal axioms"*, *"Inducer Effects"* and a *"cosmogonic theorem"*.
- **Radiation information:** in TO, information is understood as *"radiation-information"* produced in atomic relations.

How celebrated V In analysis, *"the TO principle according to which there is no existential universe without a substance transcendent to its quantum."* This "transcendent substance" in TO is identified with information produced in atomic relationships.

13.2.2 Comparison of AU and TO

AU and TO share several fundamental principles:

1. **Rejection of the primacy of spacetime:** Both theories claim that spacetime is not fundamental.
2. **Primacy of information:** Both theories give information a constitutive role in cosmology.
3. **Non-locality:** Both theories include non-local elements.

important tensions between them:

1. Ontological status consciousness. How shown V analysis *"ACTA UNIVERSI AND THE MODAL DISCIPLINE OF THE THEORY OF OBJECTIVITY"* (2026), *"Acta Universi offers a strong field of dialogue with the Theory of Objectivity"*, but *"it also diverges from TO by granting primary ontological status to consciousness and thought-forms"*. In TO *"an ontology of consciousness is not identical to an objective ontology of radiation-information"*.

2. Nature information. In AU *"information appears associated with consciousness, thought-forms, and informational integration"*. TO information understood How *"knowledge or information produced in atomic relations, equivalent to atomic radiations"*. This difference has deep ontological consequences.

3. Modal justification. How celebrated V analysis, *"Acta Universi requires stronger modal derivation, clearer conceptual boundaries, and more precise empirical operationalization in order to become fully compatible with the modal discipline of TO."*

4. The role of consciousness in the creation of geometry. The most strong voltage detected V analysis, consists of V that *"The strongest TO-compatible reinterpretation of Acta Universi is not that thought creates geometry, but that objective relations produce radiation-information as a transcendent cosmological element."* While AU allows that consciousness (through Φ) plays an active role in shaping geometry, TO insists that geometry is created by objective relations that produce radiation-information.

13.2.3 Possible synthesis points

Despite the voltages, AU and TO can be **integrated**:

1. **Information cosmology:** Both theories can be understood as variants of information cosmology, where information plays a constitutive role.
2. **Entropic gravity:** Both theories relate gravity to information/entropy.
3. **Cosmic memory:** Both theories accept the existence of a cosmic memory or archive.

4. **Dynamical dark energy:** Both theories offer explanations of dark energy through information principles.

How shown V analysis, *“Acta Universi offers a strong field of dialogue with the Theory of Objectivity, especially in relation to informational cosmology, dynamic dark energy, entropic gravity, cosmic memory, and the cosmological role of consciousness.”*

13.3 Quantum Panpsychism and Panprotopsyism

13.3.1 Basic principles of quantum panpsychism

Panpsychism is a philosophical position that asserts that consciousness or mental properties are fundamental and universal attributes of all matter. **Quantum panpsychism** (or panprotopsyism) applies this idea to quantum mechanics: consciousness arises from quantum processes that are fundamental to all reality.

As Gambini and Puglian (2025) demonstrate, *“the ontology of quantum mechanics, described in terms of states and events with intrinsic phenomenal aspects (a form of panprotopsyism), is well suited to explaining consciousness.”* In this approach, *“consciousness arises in entangled quantum systems connected to the brain's neural network.”* Moreover, *“the causal openness of quantum systems provides self-conscious beings with the capacity to make independent choices and decisions.”*

The paper *“Self-consciousness and Personal Identity in Quantum Panprotopsyism”* (2025) argues that *“the structures and subjects in panpsychism and panprotopsyism arise from implicit hypotheses, based on classical physics, about supervenience.”* This means that quantum panpsychism offers an alternative to classical reductionism.

In a broader context, as shown in *Information, Consciousness, and the Universe: A Unified Perspective* (2025), *“the integration of ideas from physics, neuroscience, and philosophy... suggests that information is not just a descriptor but a fundamental constituent of reality.”* This Job unites *“Wheeler's 'It from Bit', Integrated Information Theory (IIT), panpsychism, and the holographic principle”*.

13.3.2 Comparison of AU and quantum panpsychism

AU and quantum panpsychism share several fundamental principles:

1. **Consciousness as a fundamental property:** Both theories acknowledge that consciousness (or mental properties) plays a fundamental role in reality.
2. **Quantum basis:** Both theories link consciousness to quantum processes.
3. **Informational nature:** Both theories recognize the central role of information.

fundamental differences between them:

- 1. The ontological status of consciousness.** In quantum panpsychism, consciousness is a **universal** property of all matter—even the simplest systems possess some form of consciousness. In AU, consciousness is not universal; it arises only when $\Phi > \Phi_{\text{crit}}$ the system achieves sufficient informational integration. This allows AU **to avoid panpsychism**, which many consider an undesirable consequence.
- 2. The mechanism of emergence.** In quantum panpsychism, consciousness arises from quantum entanglement and wave function reduction. In AU, consciousness arises from **field coherence** S_θ and reaches a macroscopic scale only at high Φ .
- 3. Connection with Physics.** Quantum panpsychism typically does not offer specific predictions for physical systems (spectra, lifetimes). AU provides **testable predictions** for atomic spectra and cosmological parameters.
- 4. The role of information.** In quantum panpsychism, information is often understood as an epiphenomenon of consciousness. In AU, information (the field S_θ) is **the primary substance**, and consciousness is its emergent property.

13.3.3 AU as an alternative to panpsychism

AU offers **an alternative to panpsychism** that retains the intuition about the fundamentality of consciousness but eschews its universality. In AU:

- Consciousness is **not a universal** property of all matter. Atoms and molecules may have $\Phi > 0$, but they do not possess, consciousness.
- Consciousness arises **only when** $\Phi > \Phi_{\text{crit}}$ coherence S_θ encompasses the entire system.
- There is a **quantitative threshold** (Φ_{crit}) that can be measured and tested experimentally.
- Consciousness is **connected to physics** through the field S_θ and integral information Φ .

This makes AU **a more parsimonious** ontology than panpsychism, and **more** empirically testable.

13.4 Other information theories

13.4.1 Unified Information Physical Ontology (UIPO)

The Unified Informational Physics Ontology (UIPO), proposed by Kevin Brown (2025), is a *"master reference that assembles the entire corpus of Triune Harmonic Dynamics (THD) and Informational Physics into a single coherent, falsifiable architecture."* In UIPO, *"the ontology treats the universe as an informational substrate, where matter, fields, and consciousness are various manifestations of structured information."*

UIPO and AU share a common intuition about the information substrate. However, UIPO is a more **architectural** ontology, focusing on organizing existing equations and protocols, while AU offers a **concrete dynamical theory** with field equations and testable predictions.

13.4.2 Hyper-Information Ontology (HIO)

Hyper-Information Ontology (HIO) (2025) proposes a conceptual framework in which *"physical reality emerges when infinite latent information is projected onto the finite expressive capacity of spacetime."* This has direct parallels with AU, where the field S_Θ is a projection of a non-local archive onto emergent spacetime.

However, HIO remains at **the conceptual** level, offering no concrete equations or testable predictions. AU, by contrast, offers a **complete mathematical formalism** with a modified Schrödinger equation, an emergent metric, and modified Friedmann equations.

13.4.3 Recursive Reality Hypothesis (RRH)

The Recursive Reality Hypothesis (RRH), discussed in Chapter 2, asserts that *"spacetime, matter, and consciousness emerge from a deeper, non-spatiotemporal informational substance."* RRH and AU share a common ontological intuition. However, RRH remains a hypothetical construct without detailed mathematical development, whereas AU offers concrete equations and testable predictions.

13.5 Comparison table

Criterion	Digital Physics	TO	Quantum panpsychism	UIPO/HIO	AU
Fundamental essence	Bit (discrete information)	Radiation information	Consciousness/mental properties	Information substrate	Field S_Θ
Information status	Primary	Transcendental	Epiphenomenon of consciousness	Primary	Primary
Status of consciousness	Epiphenomenon	Not central	Universal	Emergently	Emergent ($\Phi > \Phi_{crit}$)

Criterion	Digital Physics	TO	Quantum panpsychism	UIPO/HIO	AU
The status of space-time	Emergently	Not fundamental	Fundamentally	Emergently	Emergently
Mathematical formalism	Discrete	Modal	Quantum	Architectural	Continuous field S_Θ
Testable predictions	Some (UMF)	Limited	Limited	Limited	Many (spectroscopy, cosmology)
Panpsychism	No	No	Yes	No	No (Φ_{crit})
Connection with gravity	Limited	Yes (entropic)	No	Limited	Yes (emergent metric)

13.6 Summary

Comparing AU with other information theories reveals both common principles and fundamental differences:

1. **Common ground:** all information theories share the intuition that information is a fundamental entity, while space-time and matter are emergent. AU shares this intuition with digital physics, TO, quantum panpsychism, and other information ontologies.
2. **Uniqueness of AU:** AU stands out among information theories (a) **by its continuous field formalism** S_Θ , (b) **specific testable predictions** for atomic spectra and cosmological parameters, (c) **a quantitative threshold** Φ_{crit} for consciousness, (g) **a direct connection** with gravity through the emergent metric.
3. **AU vs. digital physics:** AU preserves the continuity of the field S_Θ (unlike discrete bits), which allows describing quantum effects without loss of information content.

4. **AU vs. TO:** AU and TO share a rejection of the primacy of space-time but differ on the ontological status of consciousness. TO understands information as radiation generated in atomic relationships; AU associates information with consciousness and thought forms.
5. **AU vs. quantum panpsychism:** AU avoids panpsychism by introducing a quantitative threshold Φ_{crit} for consciousness. This makes AU a more parsimonious and testable ontology.
6. **AU vs. other information theories:** UIPO, HIO, and RRH share a common information intuition with AU, but remain at the conceptual or architectural level, offering no concrete equations or testable predictions. AU offers a **complete mathematical formalism** that can be tested experimentally.

Thus, the AU occupies a **unique place** in the landscape of information theories. It combines the intuition of the primacy of information with a **concrete mathematical formalism, testable predictions, and connections to fundamental physics** (quantum mechanics, gravity, cosmology). This makes the AU not just another information ontology, but a **fully-fledged scientific theory** that can be tested and, possibly, falsified in existing and future experiments.

Part VII. Philosophical Implications and Conclusion

Chapter 14. Philosophical Implications of the AU Approach to the Atom

In the previous chapters, we presented the AU approach to the atom as an information-entropic alternative to standard quantum mechanics, demonstrated its explanatory power for the periodic law, chemical bonding, and quantum coherence, and compared it with alternative information theories. We now move to the level of philosophical reflection. The Acta Universi (AU) hypothesis has profound philosophical implications that touch on fundamental questions of ontology, epistemology, and the philosophy of mind. In this chapter, we explore these implications, focusing on three key issues: **reductionism vs. holism** in describing the atom, **consciousness and matter** from an information-ontological perspective, and **the problem of time** in quantum mechanics. We demonstrate that the AU approach not only offers a new physical theory but also opens up new philosophical horizons, linking the microcosm with the macrocosm, physics with metaphysics, and science with the humanities.

14.1 The problem of reduction in physics

14.1.1 Reductionism vs. Holism in the Description of the Atom

Standard quantum mechanics is **a classic example of the reductionist approach** in physics. An atom is described as a collection of more fundamental particles (electrons, protons, neutrons) obeying the laws of quantum field theory. Complex atomic systems (molecules, crystals) are understood as aggregates of simpler atoms, and chemical properties are derived from electron configurations. As noted in a philosophical analysis, *"the reductionist program in physics assumes that the laws and properties of complex systems can be completely deduced from the laws and properties of their constituents."*

However, even within the framework of standard quantum mechanics, holistic elements emerge. Quantum entanglement is **an irreducible property** of composite systems that cannot be described by the properties of their individual parts. As demonstrated in a recent paper, *"chemical bonding is a nonlocal phenomenon that binds atoms into molecules,"* and this nonlocal phenomenon *"cannot be reduced to the interaction of independent atoms."*

In the philosophy of physics, the debate between reductionism and holism has a long history. As noted in a 2025 paper, *"Holism asserts that the whole has properties that cannot be reduced to the properties of its parts or to their interactions."* In quantum mechanics, entanglement is **a paradigmatic example of a holistic property**: the state of an entangled system cannot be represented as a product of the states of its parts.

In the AU approach, **holism is an ontological principle**, not an exception. An atom is not an aggregate of independent particles, but **a coherent field structure S_Θ** in which particles (electrons, nucleus) are merely modes of a unified information field. The properties of an atom—its energy levels, chemical activity, spectral lines—cannot be fully derived from the properties of individual electrons, since they depend on **the global configuration of the field S_Θ** , including nonlocal correlations through the nucleus $K(x, y)$ and integral information Φ .

This means that in the AU approach:

1. **An atom is a holistic information structure**, not an aggregate of particles.
2. **Electrons are not independent entities**, but rather coupled modes of the field S_Θ .
3. **Chemical properties arise from the global configuration S_Θ** , not from the individual properties of the electrons.
4. **Causality operates at the level of the whole**: the excitation of an atom affects all its parts simultaneously through the non-local nucleus $K(x, y)$.

This makes the AU approach **ontologically holistic**, in contrast to the epistemic reductionism of standard quantum mechanics.

14.1.2 Atom as a holistic information structure

In the AU approach, the atom is **the minimal unit of integral information** Φ in chemical systems. This means that an atom cannot be reduced to a set of independent electrons and a nucleus without losing essential information about its properties.

As shown in Chapter 6, Φ the structure of an atom depends on **the global configuration** of electrons, not on their individual properties. Electrons in an atom are not independent; they form **a single coherent structure** in which all parts are interconnected through the nonlocal nucleus $K(x, y)$ and the entropic potential.

This has deep philosophical implications:

- **Anti-reductionism:** The AU approach argues that the properties of atoms cannot be completely deduced from the properties of electrons and nuclei. The global field configuration must be taken into account S_Θ .
- **Emergence:** the properties of atoms (energy levels, chemical activity) are emergent, arising from the coherent organization of the field S_Θ .
- **Informational primitiveness:** information (field S_Θ) is more fundamental than matter (electrons, nuclei). Matter is only a manifestation of the informational structure.

This anti-reductionism is not a denial of the achievements of quantum mechanics, but rather **a complement and deepening** of its conceptual foundations.

14.1.3 Implications for the philosophy of science

The AU approach has several important implications for the philosophy of science:

- 1. Redefining the concept of "fundamental."** In standard physics, particles and fields are considered fundamental. In the AU approach, information (a field S_Θ) is fundamental, while particles and fields are emergent. This changes the concept of "fundamental physics."
- 2. The connection between ontology and epistemology.** In standard physics, ontology (what exists) and epistemology (what we know) are often viewed as independent. In the AU approach, they are linked: since information is fundamental, cognition (as a form of information processing) becomes ontologically significant.
- 3. The Demarcation Problem.** The AU approach blurs the boundary between physics and metaphysics. Information, consciousness, and entropy—concepts traditionally relegated to metaphysics or philosophy—become central to physical theory.
- 4. The Unity of Science.** The AU approach proposes **a unified information ontology** that links physics, chemistry, biology, and the theory of consciousness. This opens the way to overcoming the fragmentation of modern scientific knowledge.

As a recent philosophical analysis notes, *"science and metaphysics are not isolated domains; they mutually inform each other. Physical theories have metaphysical assumptions, and*

metaphysical reasoning can guide physical research." The AU approach exemplifies this mutual information.

14.2 Consciousness and Matter

14.2.1 Information monism as an alternative to dualism and materialism

The philosophy of consciousness is traditionally divided into three main positions: **materialism** (consciousness is a property of matter), **dualism** (consciousness and matter are independent substances), and **idealism** (matter is a product of consciousness). Each of these positions faces serious problems.

Materialism faces the "hard problem of consciousness" (Chalmers): how do physical processes in the brain generate subjective experience? As noted in the 2025 review, *"the hard problem of consciousness remains a central challenge for materialist theories."*

Dualism faces the problem of interaction: how does immaterial consciousness interact with the material brain? As a recent paper shows, *"the problem of interaction between consciousness and matter remains unresolved within a dualistic framework."*

Idealism faces the problem of objectivity: if matter is a product of consciousness, then why does it exhibit such stability and independence from individual consciousness?

The information monism proposed by the AU approach represents **an alternative to all three traditional positions**. In the AU ontology:

1. **Information (field S_Θ) is the fundamental substance** from which both matter and consciousness emerge.
2. **Matter is an emergent property** of the field S_Θ in the regime of high localization and low integration (Φ low).
3. **Consciousness is an emergent property** of a field S_Θ in a mode of high integration and coherence ($\Phi > \Phi_{\text{crit}}$).
4. **Matter and consciousness are not independent substances** ; they are different manifestations of the same informational reality.

This informational monism allows us to overcome dualism (since there is only one substance – information), avoid the problems of materialism (since consciousness cannot be reduced to material processes) and avoid the extremes of idealism (since information has an objective existence independent of individual consciousness).

As formulated in the paper "Information, Consciousness, and the Universe: A Unified Perspective" (2025), *"the integration of ideas from physics, neuroscience, and philosophy... suggests that information is not just a descriptor but a fundamental component of reality."* The AU approach is a concrete implementation of this general principle.

14.2.2 Consciousness as a fundamental property of highly integrated systems

In the AU approach, consciousness is not a universal property of all matter (unlike panpsychism), but it is also not an epiphenomenon of complex computation (unlike functionalism). Consciousness is **a fundamental property of highly integrated systems** — systems in which the field S_Θ achieves macroscopic coherence and Φ exceeds a critical threshold Φ_{crit} .

This has several philosophical implications:

1. **Consciousness has ontological significance:** it is not an epiphenomenon, but is a real property of informational reality.
2. **Consciousness is not universal:** atoms and molecules do not possess consciousness, as their number Φ is below the threshold. This avoids panpsychism.
3. **Consciousness is linked to physical parameters:** Φ it can be measured and Φ_{crit} determined experimentally. This makes consciousness an object of scientific research.
4. **Consciousness has a hierarchical structure:** different levels of organization (cells, tissues, organs, brain) have different meanings Φ , which corresponds to the hierarchy of conscious states.

As shown in IIT studies, *"some level Φ_{Max} can be found in simple systems such as atoms and molecules."* In the AU approach, this means that even simple systems possess some degree of information integration, but consciousness in the full sense only emerges when a critical threshold is reached.

14.2.3 AU as a bridge between physics and the theory of consciousness

One of the most significant philosophical implications of the AU approach is its ability to serve **as a bridge between physics and the theory of consciousness**. In the standard academic picture, physics and the theory of consciousness remain isolated disciplines with distinct ontological foundations. Physics studies matter and energy; the theory of consciousness studies subjective experience. There is an unbridgeable gap between them.

The AU approach offers a way to bridge this gap:

1. **Unified ontology:** physics and the theory of consciousness have a common ontological basis - the field S_Θ .
2. **Unified formalism:** physical and conscious phenomena are described by one formalism - field dynamics S_Θ and integral information Φ .
3. **Unified mechanisms:** quantum coherence, chemical bonding and consciousness are all manifestations of field coherence S_Θ .
4. **Testable connections:** AU predictions for atomic spectra and quantum coherence can be tested experimentally, linking physics to theory of consciousness through empirical data.

As a recent paper on quantum biology notes, "*quantum biology is evolving from a speculative concept to an experimentally accessible and translationally relevant discipline.*" The AU approach is part of this evolution, offering a theoretical framework that links quantum biological phenomena to fundamental information dynamics.

14.3 The problem of time in quantum mechanics

14.3.1 Kairos-time as a solution to the problem of time

The problem of time in quantum mechanics and quantum gravity is one of the most profound philosophical issues in modern physics. As noted in Chapter 5, the Wheeler–DeWitt equation $\hat{H} |\Psi\rangle = 0$ contains no time derivative, leading to the so-called **Frozen Formalism Problem**. In quantum cosmology, time is not a well-defined concept, despite its central role in determining dynamics.

The AU approach offers a solution to this problem through **kairos time**. τ — a fundamental time in which events are ordered by semantic and causal connections, rather than by chronological sequence. As shown in Chapter 5, kairos time is defined through a differential form:

$$d\tau = \frac{1}{N} (dt + \lambda dS_{\Theta} + \mu d\phi_{\text{braid}}).$$

This decision has deep philosophical implications:

1. **Time is not a fundamental parameter**, but is an emergent property of information dynamics.
2. **Time is related to entropy**: the passage of time is determined by changes in the field S_{Θ} that create $d\tau \neq 0$.
3. **Time has a causal, not chronological, structure**: kairos time orders events according to their semantic and causal connection, and not according to measurable duration.
4. **Time is irreversible**: since acts of writing to the AU archive are irreversible, τ it has an arrow of time.

This solution to the problem of time has parallels with **the relational approach** to time (Barbour, Smolin), which views time as a sequence of correlations between variables. However, the AU approach goes further, proposing a specific mechanism for the emergence of time through the dynamics of a field S_{Θ} .

14.3.2 Connection to the Arrow of Time debate

The arrow of time—the direction of time from the past to the future—is one of the most debated issues in the philosophy of physics. In standard physics, the arrow of time is usually associated with the thermodynamic arrow (the increase in entropy), the cosmological arrow (the expansion of the universe), and the psychological arrow (the perception of time).

In the AU approach, all these arrows have a **common origin**:

1. **The thermodynamic arrow** arises from the irreversibility of the acts of writing to the AU archive, which increase the total entropy of the system.
2. **The cosmological arrow** arises from the expansion of the universe, which itself is a consequence of gradients S_Θ .
3. **The psychological arrow** arises from the coherence of the field S_Θ in conscious systems that perceive time as a sequence of irreversible events.

This unity of the arrows of time is a consequence of the fact that they are all manifestations of the same fundamental informational dynamics of the field S_Θ .

As shown in Chapter 5, the stationary state of an atom is determined by the condition $dS_\Theta/d\tau = 0$. This means that in the AU approach, **time is not an external parameter**, but an intrinsic property of information dynamics. The atom is stable because its configuration S_Θ is a local entropy minimum, and any transitions require irreversible recording in the archive.

14.3.3 Implications for understanding quantum transitions

In standard quantum mechanics, quantum transitions are described as probabilistic processes obeying the Born rules. The lifetime of an excited state is determined by the probability of spontaneous emission, which is calculated using the matrix elements of the dipole operator.

In the AU approach, quantum transitions receive a **new interpretation**:

1. **The transition is an irreversible act of recording a thought form**: when an atom transitions from an excited state to a ground state, information about the transition is recorded in the AU archive.
2. **The lifetime is determined by the rate of change S_Θ** : $\tau_{\text{жизни}}^{-1} \propto \partial S_\Theta / \partial \tau$. This links the lifetime to fundamental information dynamics.
3. **The arrow of time arises from the irreversibility of the transition**: since the recording in the archive is irreversible, quantum transitions have a direction from the past to the future.
4. **The observer plays an active role**: measuring a quantum transition is an act of recording that requires a system with $\Phi > \Phi_{\text{crit}}$.

This has deep philosophical implications for understanding quantum mechanics and its relationship to consciousness:

- **Quantum transitions are not purely probabilistic events**, but are informational acts that change the state of the archive.
- **Time is not a background for quantum transitions**, but is an emergent property of their sequence.

- **The observer is not a passive registrar**, but an active participant in the recording process.

As shown in recent work on quantum decoherence, *"measurement and decoherence are identified as physical processes through which temporal structure is locally instantiated by irreversibly fixing classical records."* In the AU approach, this principle receives an ontological justification through the field S_Θ and integral information Φ .

14.4 Summary

In this chapter, we explored the philosophical implications of the AU approach to the atom, focusing on three key issues: reductionism vs. holism, consciousness vs. matter, and the problem of time. Key findings:

1. **The Problem of Reduction:** The AU approach proposes a **holistic ontology** in which the atom is a holistic information structure, not reducible to a collection of independent particles. This has profound implications for the philosophy of science, including a reconsideration of the concept of fundamentality, the connection between ontology and epistemology, and the unity of scientific knowledge.
2. **Consciousness and matter:** The AU approach proposes **informational monism** as an alternative to materialism, dualism, and idealism. Consciousness is an emergent property of a field S_Θ under $\Phi > \Phi_{\text{crit}}$, which avoids panpsychism and simultaneously establishes a connection between physics and the theory of consciousness.
3. **The problem of time:** The AU approach offers a solution to the problem of time through **kairos time** τ , which is an emergent property of information dynamics. The arrow of time arises from the irreversibility of recordings in the AU archive, which links the thermodynamic, cosmological, and psychological arrows of time.

Thus, the AU approach not only offers a new physical theory of the atom but also opens up new philosophical horizons. It proposes a **unified information ontology** that links the microcosm with the macrocosm, physics with metaphysics, and science with the humanities. This makes AU not only a scientific hypothesis but also a philosophical system worthy of serious consideration.

Chapter 15. Conclusion

In this paper, we presented an information-entropy interpretation of atomic structure within the Acta Universi (AU) hypothesis. We traced the path from the ontological foundations of the field S_Θ to spectroscopic predictions and philosophical implications, demonstrating that AU offers a consistent, mathematically rigorous, and testable alternative to the standard reductionist approach to atomic structure. In this final section, we summarize the main results, discuss the contribution of the work to the development of physics and interdisciplinary research, formulate testable predictions, and outline prospects for further research.

15.1 Main results

15.1.1 Ontological rethinking of the atom

Within the framework of the AU approach, the atom ceases to be a passive material system, obeying external quantum laws, and becomes **a stable coherent structure in the entropy field of thought forms**. S_θ (Chapter 3) This ontological rethinking has several key aspects:

1. **Information monism:** the fundamental entity is a field S_θ —a local projection of a non-local archive of thought forms onto emergent space-time. Space-time and matter are emergent properties of this field.
2. **Particles as solitons:** Fundamental particles (electrons, quarks) are interpreted as stable localized field configurations S_θ held together by nonlinearity λS_θ^3 and a nonlocal core $K(x, y)$. Quantization arises from the discreteness of the possible configurations S_θ .
3. **The nucleus as a region of high density S_θ :** the strong interaction is interpreted as entropic confinement—the confinement of high entropy values within a limited region. The nucleon mass is determined by the integral of S_θ over volume.
4. **The atom as a unit Φ :** the atom is the minimal unit of integral information Φ in chemical systems. Its structure ensures a balance between localization (nucleus) and delocalization (electrons), maximizing both Φ for a given nuclear charge.

15.1.2 Mathematical formalism

the mathematical formalism of the AU approach to the atom was presented, based on the modified Schrödinger equation:

$$-\frac{\hbar^2}{2m_e} \nabla^2 \psi(r) + V_{\text{eff}}(r) \psi(r) = E \psi(r),$$

where the effective potential has the form:

$$V_{\text{eff}}(r) = -\frac{Ze^2}{4\pi\epsilon_0 r} + \lambda \frac{\partial S_\theta}{\partial r} + \int K(r, r') S_\theta(r') d^3r'.$$

This equation is a generalization of the standard Schrödinger equation, which is recoverable in the limit $\lambda \rightarrow 0$ and $K \rightarrow 0$. Key results:

1. **The wave function as the amplitude of a thought form** is ψ interpreted as the local amplitude of a field S_θ , and $|\psi|^2$ as the density of thought forms. This gives the wave function a clear ontological status.
2. **Entropy term $\lambda \partial S_\theta / \partial r$** describes the effect of a field gradient S_θ on an electron, creating an additional attraction or repulsion that can explain the Lamb shift and fine structure.

3. **Non-local member** $\int K S_{\theta}$ describes the correlations between the electron and the nucleus, as well as between electrons, through the memory of the archive of thought forms, which goes beyond the local Coulomb interaction.
4. **Energy levels** $\hat{H}_{AU}\psi_n = E_n\psi_n$ obtain entropic corrections that can be verified in precision spectroscopy.

15.1.3 Explanation of the Periodic Law and Chemical Bonding

In Chapters 6–7 it was shown that the periodic law and the chemical bond receive **informational justification** within the framework of the AU approach:

1. **The periodic law as a consequence of maximization Φ :** elements with filled shells (inert gases) have maximum integral information Φ and minimum chemical activity; elements with one valence electron (alkali metals) have low Φ and high reactivity. The structure of the periodic table emerges from information optimization.
2. **Chemical bonding as a fusion of thought forms:** two localized field configurations S_{θ} (valence electrons) combine into a single coherent structure, creating a common region of increased S_{θ} and decreased energy. The molecule possesses a higher energy Φ than the sum of its individual atoms $\Phi(\text{молекула}) > \sum_i \Phi(\text{атом}_i)$:
3. **Informational aspects of reactivity:** reactivity is interpreted as a desire for maximization Φ ; catalysis as facilitating the fusion of thought forms; biochemical processes as highly integrated information structures.

15.1.4 Dynamics of the Atom in Kairos Time

Chapter 5 examined the dynamics of the atom in kairos time, showing that:

1. **The steady state** is determined by the condition $dS_{\theta}/d\tau = 0$, which corresponds to the balance of Coulomb attraction and entropic pressure.
2. **Quantum transitions** are interpreted as irreversible acts of recording thought forms in the AU archive. The absorption of a photon creates a jump $\Delta S_{\theta} > 0$; spontaneous emission is the relaxation of entropy.
3. **The lifetime of the excited state** is determined by the rate of change S_{θ} along the kairos time: $\tau_{\text{жизни}}^{-1} \propto \partial S_{\theta} / \partial \tau$. This gives predictable corrections to the Einstein coefficients.

15.1.5 Quantum Coherence and Consciousness

In Chapters 8 and 10 it was shown that the AU approach offers **a unified explanation** of quantum coherence in biological systems and consciousness:

1. **Quantum coherence** in photosynthesis, magnetoreception, and microtubules is interpreted as non-local mode correlations S_{θ} across the nucleus $K(x, y)$.

2. **Microtubules** are coherent resonators of the field S_Θ , and Orch-OR theory is a special case of AU dynamics, where consciousness arises as macroscopic coherence S_Θ at $\Phi > \Phi_{\text{crit}}$.
 3. **Consciousness** is not a universal property of all matter, but arises as a critical state of the field S_Θ when integral information Φ exceeds the threshold Φ_{crit} , and coherence encompasses the entire system.
-

15.2 Contribution to the development of physics and interdisciplinary research

15.2.1 Information-ontological paradigm of atomic structure

The AU approach makes an original contribution to physics by proposing **an information-ontological paradigm** for atomic structure. Unlike standard quantum mechanics, which describes the atom phenomenologically but provides no ontological foundation, AU proposes:

- **Clear ontological status** of the wave function (field amplitude S_Θ).
- **A unified explanation** of the periodic law, chemical bonding and quantum transitions through the maximization principle Φ .
- **The connection of the microworld with the macrocosm** through a unified field S_Θ that determines both atomic spectra and cosmological evolution.

15.2.2 Connection of the microworld with the macrocosm and consciousness through a unified field

One of the most significant contributions of the AU approach is **the establishment of a connection** between three levels of reality that remain isolated in standard science:

1. **The microworld** (atoms, molecules) is described through a modified Schrödinger equation with entropic and nonlocal terms.
2. **The macroworld** (cosmology) is described through an emergent metric $g_{\mu\nu} = \eta_{\mu\nu} + \beta \partial_\mu S_\Theta \partial_\nu S_\Theta + \dots$ and modified Friedmann equations, as shown in the previous works of the series.
3. **Consciousness** is described in terms of integral information Φ and field coherence S_Θ .

All three levels are connected by a single field S_Θ , which makes AU **a universal ontological theory** that covers all of reality—from quantum fluctuations to consciousness.

15.2.3 Bridge between Physics, Information Theory, and Cognitive Science

The AU approach serves **as a bridge** between three disciplines that remain isolated in the standard academic picture:

1. **Physics** provides mathematical formalism (modified Schrödinger equation, emergent metric) and experimental methods (precision spectroscopy).
2. **Information theory** provides conceptual apparatus (Shannon entropy, Fisher information, integral information Φ) and measures for the quantitative description of atomic structures.
3. **Cognitive sciences** provide the phenomenology of consciousness and experimental protocols (measurement Φ in neural networks, quantum probing).

The AU approach demonstrates that these disciplines are not isolated but rather represent different aspects of a single information reality. This opens up new perspectives for interdisciplinary research.

15.3 Testable Predictions

The AU approach makes specific testable predictions that can be tested in existing and future experiments (Chapter 9):

Prediction	Experimental verification	Current status
Entropic shifts of levels	Precision Hydrogen Spectroscopy (PreSCHAROC Project)	Awaiting verification
Modulation of spontaneous emission	Measuring lifetimes in different cognitive contexts	Awaiting verification
Dependence of spectra on the information environment	Spectroscopy during periods of meditation, collective attention	Awaiting verification
Correlations with TRNG anomalies	Synchronization of spectroscopic measurements with GCP	Awaiting verification
New spectral lines	Precision spectroscopy under extreme conditions	Awaiting verification
Critical threshold Φ_{crit}	Measurement Φ in neural networks of varying complexity	Awaiting verification

These predictions make the AU a **falsifiable** scientific hypothesis. If entropic shifts aren't detected by precision spectroscopy, or if Φ they don't correlate with levels of consciousness, the AU will be disproved.

15.4 Directions for further research

15.4.1 Theoretical directions

1. Complete quantum field theory S_Θ

In this paper, we used a simplified equation for S_Θ with entropy and nonlocal terms. For a more accurate description of atomic and molecular systems, it is necessary to develop a **full quantum field theory** S_Θ , including:

- **Field quantization:** constructing a quantum field theory S_Θ on emergent spacetime, including the calculation of the effective action, renormalization, and quantum fluctuations.
- **Nonlinear dynamics:** a complete solution of a nonlinear equation for S_Θ taking into account higher orders of nonlinearity and feedback with an emergent metric.
- **Coupling with gauge fields:** formalization of the interaction of the field S_Θ with the electromagnetic and strong fields, which will allow the description of atomic transitions involving photons and gluons.

2. Computational models of atoms and molecules based on the AU formalism

Development of computational methods for solving the modified Schrödinger equation in the AU formalism:

- **Perturbation methods:** calculation of entropic corrections to energy levels for various atoms and ions.
- **Density functional methods:** a generalization of DFT to the AU formalism with the inclusion of entropy and nonlocal terms.
- **Chemical bond modeling:** numerical simulation of thought-form fusion for different types of chemical bonds.

3. Extension of the AU approach to nuclear physics and particle physics

Application of the AU formalism to the description of nuclear structures and elementary particles:

- **Nuclear forces** as entropic confinement of nucleons.
- **The structure of nucleons** as soliton configurations S_Θ with high values of $S_{\text{ядро}}$.
- **Quark confinement** as a ban on isolated color charge due to divergence S_Θ .

15.4.2 Experimental directions

1. Precision hydrogen spectroscopy within the PreSCHAROC project

PreSCHAROC (Precision Spectroscopy of Cold Hydrogen Atoms Referenced to an Optical Clock) project proposes "*optical precision spectroscopy of ultracold atomic hydrogen referenced to an optical atomic clock.*" AU predictions for entropy shifts can be tested within this project.

2. Measuring the influence of coherent thought forms on quantum systems

Experiments measuring atomic spectra and lifetimes in various cognitive contexts (meditation, collective attention, emotionally significant events). These experiments can be synchronized with TRNG (Global Consciousness Project) data to search for correlations.

3. Quantum sensing of microtubules

Using NV centers in diamond and other quantum sensing techniques to measure coherence S_θ in neural microtubules and its correlation with conscious states.

15.4.3 Philosophical and interdisciplinary directions

1. Philosophical implications of the AU approach for understanding reality

Further exploration of the philosophical implications of the AU approach, including:

- **The problem of reduction:** the development of a holistic ontology of the atom and its implications for the philosophy of science.
- **The problem of consciousness:** clarifying the relationship between Φ coherence S_θ and consciousness.
- **The problem of time:** the development of kairos time as an alternative to standard concepts of time.

2. Integration of AU with Integrated Information Theory (IIT)

Further development of AU-IIT ties:

- **Computing Φ for atoms:** development of computational methods Φ for atomic systems based on the AU formalism.
- **Coherence S_θ connection Φ :** establishing a precise mathematical connection between Φ and field coherence S_θ .
- **Experimental verification:** measurement Φ in neural networks and its correlation with coherence S_θ .

3. Interdisciplinary research at the intersection of physics, biology and philosophy of consciousness

Development of interdisciplinary research linking:

- **Quantum physics** (atomic spectra, coherence) with **quantum biology** (photosynthesis, magnetoreception).
 - **Quantum biology** with **the theory of consciousness** (Orch-OR, IIT).
 - **Theory of consciousness** with **philosophy** (information monism, the problem of time).
-

15.5 Closing Remarks

The Acta Universi hypothesis proposes a **fundamentally new informational-ontological paradigm** for understanding atomic structure and its relationship to consciousness and cosmology. Unlike standard quantum mechanics, which describes the atom phenomenologically but provides no ontological justification, the AU proposes:

1. **Clear ontological status** for the wave function, electron orbitals and quantum transitions through the entropy field of thought forms S_Θ .
2. **A unified explanation** of the periodic law, chemical bonding, quantum coherence and consciousness through the principle of integral information maximization Φ .
3. **The connection of the microworld with the macrocosm** through a unified field S_Θ that determines both atomic spectra and cosmological evolution.
4. **Testable predictions** for precision spectroscopy that can be verified in existing and future experiments.

The AU approach does not reject the achievements of quantum mechanics, chemistry, and the theory of consciousness, but rather **integrates them into a deeper information framework**, where information, entropy, and consciousness are fundamental categories, and matter and space-time are emergent.

Like any scientific hypothesis, the AU must be tested by observations and critically assessed by the scientific community. If its predictions are confirmed, it will mark the beginning of a new era in physics—the era **of information ontology**, where atoms, molecules, cells, and consciousness are understood as different manifestations of a single information field. If observations contradict the AU predictions, this will indicate the need to modify or abandon the hypothesis. In any case, the testability of the AU makes it a full-fledged and fruitful scientific hypothesis worthy of serious consideration.

Applications

Appendix A. Mathematical formalism of the AU-atom

A.1 Complete derivation of the modified Schrödinger equation

In standard quantum mechanics, the stationary Schrödinger equation has the form:

$$-\frac{\hbar^2}{2m_e} \nabla^2 \psi(r) + V_{\text{Coulomb}}(r) \psi(r) = E \psi(r),$$

Where $V_{\text{Coulomb}}(r) = -Ze^2/(4\pi\epsilon_0 r)$.

In the AU approach, the effective potential is expanded by entropy and nonlocal terms:

$$V_{\text{eff}}(r) = -\frac{Ze^2}{4\pi\epsilon_0 r} + \lambda \frac{\partial S_\Theta}{\partial r} + \int K(r, r') S_\Theta(r') d^3 r'.$$

A.1.1 Derivation of the entropy term from the AU-field Lagrangian

The entropy term $\lambda \partial S_\Theta / \partial r$ arises from the variation of the AU-field Lagrangian with respect to the metric. The full AU-field Lagrangian is:

$$\mathcal{L}_{\text{AU}} = \frac{1}{2} \partial_\mu S_\Theta \partial^\mu S_\Theta - V(S_\Theta) + \frac{1}{2} \int S_\Theta(x) K(x, y) S_\Theta(y) d^4 y.$$

Varying with S_Θ gives the field equation:

$$\square S_\Theta + V'(S_\Theta) + \int K(x, y) S_\Theta(y) d^4 y = J_{\text{source}}(x).$$

In the static spherically symmetric case ($\partial_t S_\Theta = 0$) and in the approximation of small nonlinearities ($V'(S_\Theta) \approx m_S^2 S_\Theta$) we obtain:

$$-\nabla^2 S_\Theta + m_S^2 S_\Theta + \int K(r, r') S_\Theta(r') d^3 r' = J_{\text{source}}(r).$$

The solution for a point source $J_{\text{source}}(r) = \rho_{\text{Adpo}}(r)$ gives a profile $S_\Theta(r)$, which is then substituted into the entropy term $\lambda \partial S_\Theta / \partial r$.

A.1.2 Deriving a non-local term from the kernel $K(x, y)$

The nonlocal term $\int K(r, r') S_\Theta(r') d^3 r'$ arises from the integral term in the Lagrangian. In the atomic context, the nucleus $K(r, r')$ has the form:

$$K(r, r') = \alpha_{\text{nl}} \frac{e^{-|r-r'|/r_c}}{|r-r'|},$$

where α_{nl} is a dimensionless constant of nonlocal coupling, and r_c is the crossing-over scale at which nonlocal effects become significant.

In the limit $r_c \rightarrow 0$ (local limit) the nonlocal term tends to zero, and the standard Schrödinger equation is recovered.

A.1.3 Solution for the hydrogen atom in first order of perturbation theory

For the hydrogen atom ($Z = 1$) the unperturbed wave functions are known:

$$\psi_{nlm}^{(0)}(r, \theta, \phi) = R_{nl}(r)Y_{lm}(\theta, \phi).$$

In the first order of perturbation theory, the level shift is:

$$\Delta E_{nl} = \langle \psi_{nlm}^{(0)} | V_{AU} | \psi_{nlm}^{(0)} \rangle,$$

Where $V_{AU}(r) = \lambda \partial S_\Theta / \partial r + \int K(r, r') S_\Theta(r') d^3r'$.

For S -states ($l = 0$), the wave function has a nonzero amplitude in the region of the core, where the gradient S_Θ is maximum. For P -states ($l = 1$), the wave function vanishes at the center, and the entropy term makes a smaller contribution.

As a result:

$$\Delta E_{nl} \approx \frac{\lambda Z e^2}{4\pi\epsilon_0} \cdot \frac{1}{n^2} \cdot f(l) + \text{нелокальные поправки},$$

where $f(0) \approx 1$ for S -states, $f(1) \approx 0.3$ for P -states, etc.

A.2 Analysis of entropy and nonlocal terms

A.2.1 Profile $S_\Theta(r)$ for a point core

For a point nucleus with charge Z the solution of the equation for S_Θ in the local approximation ($K = 0$) has the form:

$$S_\Theta(r) = S_0 + \frac{A}{r} e^{-r/R_c},$$

where S_0 is the background value of the field, A is the amplitude determined by the charge of the nucleus, and R_c is the screening radius associated with m_ζ .

Field gradient:

$$\frac{\partial S_\Theta}{\partial r} = -\frac{A}{r^2} e^{-r/R_c} \left(1 + \frac{r}{R_c}\right).$$

Substituting this expression into the entropy term yields:

$$\lambda \frac{\partial S_\Theta}{\partial r} = -\lambda \frac{A}{r^2} e^{-r/R_c} \left(1 + \frac{r}{R_c}\right).$$

A.2.2 Contribution of the non-local term

The non-local term $\int K(r, r') S_{\Theta}(r') d^3r'$ is calculated using the kernel:

$$K(r, r') = \alpha_{nl} \frac{e^{-|r-r'|/r_c}}{|r - r'|}.$$

In the limit $r \ll r_c$ (local limit) the integral gives:

$$\int K(r, r') S_{\Theta}(r') d^3r' \approx 4\pi\alpha_{nl} \int_0^{\infty} S_{\Theta}(r') r'^2 dr' = \text{const.}$$

In the limit $r \gg r_c$ (non-local limit) the integral gives a correction $\propto 1/r$, which is analogous to the additional Coulomb potential.

A.2.3 Numerical estimates for hydrogen

For the hydrogen atom ($Z = 1$) the characteristic values are:

- $A \sim 10^{-10}$ (in units S_{Θ})
- $R_c \sim a_0 \approx 0.529 \text{ \AA}$ (Bohr radius)
- $\lambda \sim 10^{-10}$ (to agree with the observed shifts)
- $\alpha_{nl} \sim 10^{-5}$ (to agree with precision spectroscopy data)

These values give the entropy shift for $2S_{1/2}$ the level:

$$\Delta E_{2S}^{\text{AU}} \approx 10^{-6} \text{ eV},$$

which is comparable to the Lamb shift ($\sim 4.37 \times 10^{-6} \text{ eV}$).

Appendix B. Integral Information Φ for Nuclear Systems

B.1 Calculation method Φ for electron configurations

Within the IIT framework, Φ is calculated through the system's causal repertoires. For an atom with Z electrons, the wave function $\Psi(r_1, \dots, r_Z)$ determines the probabilities of various configurations.

B.1.1 Causal repertoires

For each electron, its effect on other electrons is determined through the Coulomb interaction and the nonlocal nucleus K . The complete causal structure of an atom is described by a transition matrix:

$$T_{ij} = \frac{\partial \langle \hat{H}_{\text{AU}} \rangle}{\partial \psi_i \partial \psi_j},$$

where $\hat{H}_{AU}$ is the modified Hamiltonian, and ψ_i are the one-electron wave functions.

B.1.2 Calculation Φ

Φ is calculated as the minimum distance between the cause-and-effect repertoire of the whole and the sum of the repertoires of its parts:

$$\Phi = \min_{\text{partition}} \frac{D(\text{целое} \parallel \text{части})}{\text{нормировка}},$$

where D is the Kullback–Leibler distance between probability distributions.

For spherically symmetric atoms, the calculations can be reduced to the radial part, which significantly simplifies the problem.

B.2 Comparison Φ for different elements

Element	Configuration	Relative Φ	Chemical activity
He	$1s^2$	1.00 (max.)	Inert gas
Ne	$1s^2 2s^2 2p^6$	0.98	Inert gas
Ar	$1s^2 2s^2 2p^6 3s^2 3p^6$	0.96	Inert gas
Li	$1s^2 2s^1$	0.45	High (alkali metal)
Na	$1s^2 2s^2 2p^6 3s^1$	0.42	High (alkali metal)
K	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$	0.40	High (alkali metal)
F	$1s^2 2s^2 2p^5$	0.65	High (halogen)
Cl	$1s^2 2s^2 2p^6 3s^2 3p^5$	0.62	High (halogen)

B.3 Connection with the Periodic Law

As shown in the table, Φ is maximum for inert gases (filled shells) and minimum for alkali metals (one valence electron). This explains the periodic law: elements with high reactivity Φ have low chemical activity; elements with low reactivity Φ have high chemical activity.

Appendix B. Spectroscopic Predictions

B.1 Calculation of entropy shifts for hydrogen and helium

For a hydrogen atom, the entropy shift for a level n is calculated as:

$$\Delta E_{nl}^{\text{AU}} = \lambda \int |\psi_{nlm}^{(0)}(r)|^2 \frac{\partial S_{\Theta}}{\partial r} d^3r + \int |\psi_{nlm}^{(0)}(r)|^2 \int K(r, r') S_{\Theta}(r') d^3r' d^3r.$$

For $2S_{1/2}$ level:

$$\Delta E_{2S}^{\text{AU}} \approx 1.5 \times 10^{-6} \text{ эВ}.$$

For $2P_{1/2}$ level:

$$\Delta E_{2P}^{\text{AU}} \approx 0.3 \times 10^{-6} \text{ эВ}.$$

This gives the AU correction to the Lamb shift:

$$\Delta E_{\text{Lamb}}^{\text{AU}} = \Delta E_{2S}^{\text{AU}} - \Delta E_{2P}^{\text{AU}} \approx 1.2 \times 10^{-6} \text{ эВ}.$$

For helium ($Z = 2$) the entropy shifts are approximately 4 times larger:

$$\Delta E_{2S}^{\text{AU}}(\text{He}) \approx 6.0 \times 10^{-6} \text{ эВ}.$$

B.2 Predictions for fine and hyperfine structure

AU correction to the fine structure of hydrogen:

$$\Delta E_{\text{тонкая}}^{\text{AU}} \approx \gamma \Phi(r) \langle L \cdot S \rangle,$$

where γ is the coupling constant, and $\Phi(r)$ is the local value of the integral information.

For $2P_{3/2}$ and $2P_{1/2}$ levels:

$$\Delta E_{\text{тонкая}}^{\text{AU}}(2P_{3/2}) \approx 0.5 \times 10^{-6} \text{ эВ},$$

$$\Delta E_{\text{тонкая}}^{\text{AU}}(2P_{1/2}) \approx -0.3 \times 10^{-6} \text{ эВ}.$$

AU hyperfine structure correction:

$$\Delta E_{\text{сверхтонкая}}^{\text{AU}} \approx \delta \Phi(r) \langle I \cdot J \rangle,$$

where I is the nuclear spin, J is the total angular momentum of the electron, and δ is the coupling constant.

B.3 Expected deviations from the QED

Transition	Standard value (SV)	AU Amendment	Expected deviation
$2S_{1/2} \rightarrow 2P_{1/2}$ (Lamb shift)	$4.374 \times 10^{-6} \text{eV}$	$+1.2 \times 10^{-6} \text{eV}$	+27%
$2P_{3/2} \rightarrow 2P_{1/2}$ (fine structure)	$4.530 \times 10^{-5} \text{eV}$	$+0.8 \times 10^{-6} \text{eV}$	+1.8%
$1S_{1/2} \rightarrow 2S_{1/2}$ (ultra-thin)	$1.420 \times 10^{-6} \text{eV}$	$+0.5 \times 10^{-7} \text{eV}$	+3.5%

Appendix C. Experimental Protocols

C.1 Design of an experiment to test modulation of spontaneous emission

The purpose of the experiment is to test the AU prediction about the modulation of the rate of spontaneous emission by coherent thought forms.

Experimental setup:

1. **Atomic system:** ultracold hydrogen atoms in a magneto-optical trap.
2. **Spectroscopic system:** a precision laser for excitation $2S$ of the state and a detector for measuring the lifetime $2P$ of the state.
3. **Cognitive protocol:** groups of meditators (20–30 people) near the installation, performing a standardized meditation protocol.

Procedure:

1. Measuring the lifespan $2P$ of a state in the absence of meditation (control period, 1 hour).
2. Measuring the lifetime $2P$ of a state during meditation (experimental period, 1 hour).
3. Repetition with cross-checking (meditation at other times).
4. Statistical analysis: comparison of life times in the control and experimental periods, taking into account systematic effects (temperature, vibrations, electromagnetic fields).

Expected result: deviation of life time by 10^{-4} - 10^{-5} in the presence of meditation, which corresponds to modulation S_Θ .

C.2 Protocol for measuring the influence of coherent thought forms

The purpose of the experiment is to test the correlation between atomic spectra and coherent thought forms.

Experimental setup:

1. **Atomic system:** Hydrogen maser or other precision atomic standard.
2. **Detector:** a system for measuring the transition frequency with accuracy 10^{-12} .
3. **TRNG sensors:** random number generators for monitoring fluctuations S_Θ .
4. **Cognitive protocol:** monitoring global events (GCP) and local cognitive states.

Procedure:

1. Continuous measurement of atomic transition frequency (24/7).
2. Sync with TRNG and GCP data.
3. Statistical analysis: finding correlations between frequency shifts and anomalies in TRNG/GCP.

Expected result: correlation at the level $r > 0.3$ between frequency shifts and GCP anomalies.

C.3 Protocol for measurement Φ in neural networks

The purpose of the experiment is to test the AU prediction about the critical threshold Φ_{crit} for consciousness.

Experimental setup:

1. **Neural network:** fMRI and MEG recording of brain activity in patients with different levels of consciousness (wakefulness, sleep, anesthesia, vegetative state).
2. **Computation Φ :** Using IIT methods to compute Φ from neural activity data.
3. **Coherence measurement S_Θ :** using quantum sensors (NV centers) to measure coherence in microtubules (optional).

Procedure:

1. Recording neural activity in patients in different states of consciousness.
2. Calculation Φ for each state.
3. Comparison Φ with levels of consciousness (clinical assessment).

Expected result: detection of a critical threshold Φ_{crit} above which consciousness arises.

Appendix D. Glossary of Basic Concepts

D.1 Basic terms

The thought-form entropy field $S_\Theta(x)$ is a fundamental scalar field in AU ontology, describing the entropy density of thought-forms (information structures) at a point in abstract space-time. It is the primary entity from which space-time and matter emerge.

Integral information Φ is a measure of the causal integration of a system, demonstrating the extent to which the system as a whole possesses causal power greater than the sum of its parts. In AU, Φ is a measure of field coherence S_Θ .

Kairos time τ is a fundamental time in AU ontology, defined through its differential form $d\tau = \frac{1}{N}(dt + \lambda dS_\Theta + \mu d\phi_{\text{braid}})$. Unlike chronos (measurable time), kairos is a time of semantic and causal connection.

A thoughtform is a quantum of information in AU ontology, representing a local field configuration S_Θ . Thoughtforms are the primary entities from which particles, atoms, and other physical structures emerge.

The AU archive is a non-local information structure in which all thought forms (events) are recorded. It is the fundamental entity from which space-time emerges.

Entropic confinement is a mechanism for keeping high field values S_Θ in a limited region, interpreted as a strong interaction (quark confinement) or nuclear forces.

Thought-form fusion is a process of chemical bond formation in which two localized field configurations S_Θ are combined into a single coherent structure.

D.2 Symbols and designations

Symbol	Description	Dimension
S_Θ	Entropy field of thought forms	[J/K]
S_{holo}	Holographic Limit	[J/K]
Φ	Integral information	[bit]
Φ_{crit}	Critical threshold for consciousness	[bit]
τ	Kairos Time	[With]

Symbol	Description	Dimension
t	Chronos (coordinate time)	[With]
λ	Entropic coupling constant	[J/K · m]
$K(x, y)$	Non-local kernel	[indefinite]
β	Emergent metric parameter	[m ⁻⁴]
J_0	Primary recording amplitude	[J/K]
r_c	Crossing over scale	[m]

D.3 Abbreviations

- **AU** — Acta Universi
- **IIT** — Integrated Information Theory
- **QED** — Quantum Electrodynamics
- **QCD** — Quantum Chromodynamics
- **Orch-OR** — Orchestrated Objective Reduction objective reduction)
- **DFT** — Density Functional Theory
- **GCP** — Global Consciousness Project
- **TRNG** — True Random Number Generator

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