

Natural radioactivity from the point of view of the Acta Universi (AU) hypothesis

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Introduction

1.1 Statement of the problem: the nature of radioactive decay

Natural radioactivity—the spontaneous transformation of unstable atomic nuclei—is one of the most fundamental and at the same time mysterious phenomena in physics. Since its discovery by Henri Becquerel in 1896 and the pioneering work of Marie and Pierre Curie, radioactivity has become not only a cornerstone of nuclear physics but also the subject of ongoing philosophical and ontological debate.

At the center of these discussions is **the statistical nature of radioactive decay**. As is well known, the decay moment of an individual nucleus is fundamentally unpredictable—this event is random in the deepest sense of the word. At the same time, for an ensemble of nuclei, decay obeys a strict exponential law $N(t) = N_0 e^{-\lambda t}$, where λ is the decay constant, and the half-life $T_{1/2} = \ln 2 / \lambda$ is one of the most precisely measured physical quantities. This paradox—individual randomness vs. statistical certainty—remains one of the unresolved ontological problems of modern physics.

In standard quantum theory, radioactive decay is considered a spontaneous quantum transition described by Fermi's golden rule. However, the "randomness" of the decay moment itself does not receive a satisfactory ontological explanation. As noted in a recent paper, radioactive decay *"has long been regarded as a paradigmatic example of absolute randomness in physics, its statistics being described with remarkable accuracy by Poisson and exponential probability distributions."* However, as modern analysis shows, *"this description is not exhaustive"*—there are systematic deviations from purely random behavior, indicating a deeper structure.

Recent experiments have revealed **anomalies in radioactive decay rates** with periodic variations, which *"challenges the traditional notion of time-independent decays."* These anomalies—seasonal variations, correlations with solar activity, and the possible influence of external fields—indicate that the "randomness" of decay may merely be a manifestation of a

deeper information-entropic dynamic, in which the decay probability is determined not only by intranuclear processes but also by the state of the information field in which the nucleus is immersed.

Thus, a fundamental question arises: **what does the "randomness" of radioactive decay mean in an ontological sense?** Is decay completely spontaneous, or are there hidden variables that determine the moment of decay? Why is the moment of decay fundamentally unpredictable, even though the decay energy is strictly determined? How is radioactivity related to the problem of quantum measurement and the arrow of time? These questions require going beyond standard quantum theory and incorporating fundamentally new ontological foundations.

1.2 Purpose and objectives of the study

The present work aims to present **an information-entropic interpretation of natural radioactivity** within the framework of the Acta Universi (AU) hypothesis – an ontological paradigm in which the fundamental entity is the entropy field of thought forms S_Θ , and all physical processes, including radioactive decay, are manifestations of its dynamics.

Specific objectives of the study:

1. **Interpret radioactive decay as an irreversible act of recording a thought-form** in a non-local AU archive, where each act of decay creates a localized disturbance of the field S_Θ and increases the total information entropy of the system.
2. **Develop a mathematical formalism** that relates the decay probability to the local coherence of the field S_Θ and its gradients, showing that the statistical nature of the decay is a consequence of the quantum structure of the AU field.
3. **Show how the non-local core $K(x, y)$ and kairos time τ ensure the irreversibility of decay** and its connection with the arrow of time, and also explain possible anomalies in decay rates as a consequence of fluctuations S_Θ .
4. **To formulate testable predictions** of the AU approach: correlations between decay rates and coherent field states S_Θ , possible deviations from Poisson statistics in the presence of strong information fields, as well as the connection of radioactivity with phenomena discussed in other works on AU (TRNG anomalies, presentiment effect).
5. **Compare the AU interpretation** with the standard quantum theory of radioactivity and modern information-entropy approaches, including the use of configurational entropy to predict decay rates.

1.3 Overview Acta Universi (AU) hypotheses

The Acta Universi hypothesis, developed in a series of works from 2025–2026, proposes **an information-ontological paradigm** in which the fundamental entity is the entropy field of thought forms S_Θ . In this paradigm, space-time, matter, and all fundamental interactions are emergent structures generated by the dynamics of the information field.

Key provisions of the AU ontology that are important for understanding radioactivity:

- **The AU-field** is interpreted as a *"universal archive of events in the Universe that records correlations of energy, probability, and information."* All irreversible events—from quantum fluctuations to social acts—are recorded in this archive as **thought** -forms—physical entities representing localized disturbances of the field S_Θ .
- **The entropy field of thought forms** S_Θ is a fundamental measure of accumulated irreversible acts. It is bounded by a holographic limit S_{holo} and determines the dynamics of the emergent metric through gradients ∇S_Θ : $g_{\mu\nu} = \eta_{\mu\nu} + \beta \partial_\mu S_\Theta \partial_\nu S_\Theta + \dots$. Gravity, in this interpretation, is the entropy gradient of thought forms.
- **"Thoughtform"** in AU is a **metaphor** denoting *"any irreversible act of recording information in a non-local AU archive."* Mathematically, a thoughtform corresponds to a localized source in the entropy field S_Θ : $J_{\text{event}}(x) = \Delta S_\Theta \delta^{(4)}(x - x_0)$, an increase in informational entropy, and an irreversible recording operator. It is important to emphasize that thoughtforms are generated **by any** events—quantum, thermodynamic, biological, cognitive, and social; consciousness (the field of integrated information Φ) regulates their coherence and ontological type.
- **Kairos time** τ is defined through the growth of theta entropy: $d\tau = \frac{1}{N}(dt + \lambda dS_\Theta + \mu d\phi_{\text{braid}})$. Unlike chronos (coordinate, measurable time), kairos is a **time of semantic and causal connection** —it ensures the irreversibility of physical processes and links the thermodynamic arrow of time with the growth of S_Θ . As noted in the AU analysis, *"the proposal of kairos time, distinct from coordinate time, demonstrates attention to the problem of time in quantum gravity."*
- **The nonlocal core** $K(x, y)$ describes the memory of the thought-form archive, providing long-range correlations between recording events and regularizing ultraviolet divergences. In the context of radioactivity, it is through this core that a decay event at one point in space-time can correlate with other events, including coherent states of consciousness and collective thought-forms.

Previous works in this series examined the act of recording a primary thought-form as the initiator of the expansion of the Universe, the interpretation of dark matter as entropic structures, the structure of the atom in AU ontology, quark confinement, electromagnetic radiation, the disappearance of antimatter, the information paradox of black holes, and the origin and evolution of life. This work expands on this range, proposing an information-entropic interpretation of natural radioactivity.

1.4 Structure of the work

The article is organized as follows.

Part I (Chapters 1–2) provides an overview of the current state of the physics of radioactivity: historical context, decay types, statistical nature (Chapter 1), and information-entropy

approaches to radioactivity, including configurational entropy as a predictor of decay rates and the relationship to quantum information (Chapter 2).

Part II (Chapters 3–5) presents the ontological foundations of the AU approach: the interpretation of radioactive decay as an act of recording a thought-form (Chapter 3), the mathematical formalism linking the probability of decay to the field S_Θ and the non-local nucleus $K(x, y)$ (Chapter 4), and the connection of decay to kairos time and the arrow of time (Chapter 5).

Part III (Chapters 6–7) analyzes the observational implications and testable predictions: the interpretation of anomalies in radioactive decay as consequences of fluctuations S_Θ (Chapter 6) and the relationship of radioactivity to other areas of AU—atomic structure, cosmology, and biology (Chapter 7).

Part IV (Chapter 8) contains a comparison of the AU approach with the standard quantum theory of radioactivity.

Part V (Chapter 9) contains a conclusion summarizing the main results and prospects for further research.

This introduction sets the conceptual framework for the subsequent presentation, positioning the AU approach as an information-entropic alternative to the standard interpretation of radioactivity, capable of explaining the statistical nature of decay from a single principle - the dynamics of the entropy field of thought forms S_Θ and the irreversible recording of thought forms in the AU archive.

Part I. Current state of radioactivity physics

Chapter 1. Natural Radioactivity: From Discovery to Quantum Theory

1.1 Historical context: from Becquerel to modern nuclear physics

The discovery of natural radioactivity began in 1896, when Henri Becquerel, while studying the phosphorescence of uranium salts, accidentally discovered that they emitted invisible radiation capable of irradiating photographic plates even through opaque materials. This discovery, made just one year after the discovery of X-rays, ushered in a new era in physics—the study of the atomic nucleus.

The work of Marie and Pierre Curie, who isolated new radioactive elements—polonium and radium—from uranium ore, demonstrated that radioactivity is **a property of atoms**, not the result of chemical reactions or external influences. It was established that radioactive elements emit three types of radiation, differing in penetrating power and behavior in an electric field:

alpha radiation (helium nuclei), **beta radiation** (electrons or positrons), and **gamma radiation** (high-energy photons).

By the 1900s, it became clear that radioactivity is due to **the spontaneous transformation of atoms** of one element into atoms of another. Ernest Rutherford and Frederick Soddy formulated the theory of radioactive decay, demonstrating that radioactive elements form **transformation series**—sequences of decay leading from an unstable initial nucleus to a stable one. These series—uranium, thorium, and actinium—became the foundation for understanding nuclear transformations.

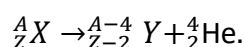
It is important to note that "fossil" radioactivity (elements present at the formation of the Earth, such as uranium-238, thorium-232, potassium-40) and cosmogenic radioactivity (produced by cosmic rays, such as carbon-14) represent two different sources of natural radioactivity, which has implications for geochronology and astrophysics.

1.2 Types of radioactive decay

In modern nuclear physics, several main types of radioactive decay are distinguished, each of which is described by its own conservation laws and quantum mechanisms.

Alpha decay

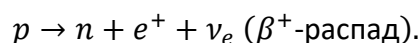
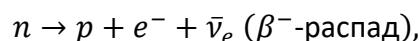
Alpha decay is the emission by a nucleus **of an alpha particle**, a bound state of two protons and two neutrons, identical to the helium-4 nucleus:



Alpha decay is characteristic of heavy nuclei, particularly elements with atomic number $Z > 82$. It is explained by quantum **tunneling**—an alpha particle located inside a nucleus has a finite probability of penetrating the potential barrier that holds it within. As noted in modern literature, "*quantum tunneling makes radioactive decay completely random*," and it is this quantum mechanism that underlies the fundamental unpredictability of the decay moment.

Beta decay

Beta decay is a process in which a neutron is converted into a proton (or a proton into a neutron) with the emission of an electron (or positron) and an antineutrino (or neutrino):



Beta decay is caused by **the weak interaction** and was key to Wolfgang Pauli's discovery of the neutrino. As shown in works on the ontology of radioactivity, "*event P is radioactive beta decay, event Q (indeterministically caused by P) is the emission of a beta particle to the left*," emphasizing the statistical nature of this process.

Gamma radiation

Gamma radiation is the emission of high-energy photons when a nucleus transitions from **an excited state** to a lower-energy state. Unlike alpha and beta decay, gamma radiation does not change the composition of the nucleus, but merely releases its excess energy. In some cases, gamma radiation accompanies alpha and beta decays, when the daughter nucleus is formed in an excited state.

Spontaneous division

Spontaneous fission is a process in which a heavy nucleus (usually with $Z > 90$) spontaneously splits into two lighter nuclei with the emission of several neutrons and a large release of energy. This type of decay is particularly important for transuranic elements and plays a key role in nuclear reactors and nuclear weapons.

1.3 Statistical nature of radioactive decay

The central property of radioactive decay is its **statistical nature**: the moment of decay of an individual nucleus is fundamentally unpredictable, but for a large ensemble of nuclei, decay obeys a strict exponential law.

Exponential decay law

The fundamental law of radioactive decay is:

$$N(t) = N_0 e^{-\lambda t},$$

where $N(t)$ is the number of undecayed nuclei at time t , N_0 is the initial number of nuclei, λ and is **the decay constant** —the probability of one nucleus decaying per unit time. The half-life $T_{1/2} = \ln 2 / \lambda$ is one of the most accurately measured physical quantities and varies from fractions of a second to billions of years.

The exponential law is a consequence of the fact that each decay event is **independent** of the others, and the probability of a nucleus decaying at any given time is constant. As emphasized in a modern analysis, *"the exponential decay law is preserved, and no modifications to quantum mechanical predictions are introduced."* However, as will be shown below, this description is not exhaustive.

Randomness and nondeterminism

In standard quantum theory, radioactive decay is considered a **paradigmatic example of ontological randomness**. As noted in the philosophical literature, *"radioactive decay and other quantum-physical phenomena testify to non-deterministic processes at the level of elementary physical processes."* This randomness is not a consequence of our ignorance of hidden variables (as in classical statistical mechanics), but rather **a fundamental property** of quantum reality.

The Schrödinger equation, which describes the evolution of quantum states, is **symmetric under time reversal**. This creates a fundamental tension: microscopic dynamics are reversible, but the measurement process (including the detection of decay) introduces irreversibility and an arrow of time. As recent papers have shown, *"the measurement problem and the*

randomness of quantum outcomes resist a fully eternalistic description," suggesting that radioactive decay may hold the key to understanding the nature of time.

1.4 Unresolved questions of the ontology of decay

Despite the impressive accuracy of the quantum-mechanical description, radioactive decay leaves a number of **fundamental ontological questions** that do not find a satisfactory answer within the standard theory.

What does "randomness" of decay mean?

In standard quantum mechanics, the randomness of decay is postulated but not explained. As a recent paper notes, *"When we speak of the Standard Model... particles are thought of as entities with intrinsic properties that decay 'randomly' according to fundamental laws."* However, this formulation substitutes description for explanation: to say that decay is "random" fails to explain *why* it is random in the ontological sense.

Some modern approaches attempt to reinterpret the randomness of decay in terms of **causal topology**. A 2026 paper, "Causal Topology of Radioactive Decay," proposes a *"causal reinterpretation of radioactive decay within standard quantum theory,"* in which *"decay events correspond to fixed nodes in a static causal topology rather than to temporally generated stochastic processes."* This approach suggests that "randomness" may be an illusion generated by our inability to perceive the underlying causal structure.

Are there hidden variables?

The question of hidden variables determining the moment of decay remains open. Within standard quantum mechanics, such variables are excluded by Bell's theorem (for a certain class of theories), but for radioactive decay, as a process that does not require measurement in the traditional sense, this question remains less certain. As noted in discussions of quantum ontology, *"if the decay has already occurred in another frame of reference, then this means that the outcome of this event must already be determined before I measure the atom."* This tension between relativistic causality and quantum uncertainty remains unresolved.

Why is the moment of decay unpredictable, but the energy is determined?

Radioactive decay exhibits a striking combination: the energy released during decay is strictly defined (quantized), but the moment of decay is fundamentally unpredictable. This suggests that the "randomness" of decay is not a consequence of chaotic dynamics, but rather a **fundamental property of quantum reality**, linked to the nature of time and measurement.

As shown in works on the ontology of radioactivity, *"a radioactive atom possesses a kinetic identity and a potential identity. The kinetic, pre-decay identity is characterized by its rest mass, while the potential identity of an atom is characterized by its stored energy."* This distinction between "kinetic" and "potential" identity may be the key to understanding why decay is random: it occurs when the potential identity is "actualized" through interaction with an information field.

The connection of radioactivity with the problem of measurement and the arrow of time

Radioactive decay is closely related to **the problem of quantum measurement** and **the arrow of time**. In standard quantum mechanics, measurement causes the collapse of the wave function—an irreversible process that, like radioactive decay, is random. This similarity suggests a possible underlying connection between the two phenomena.

As demonstrated in a recent paper, "*quantum physics introduces an arrow of time at a fundamental level*," and radioactive decay may serve as a **manifestation** of this fundamental arrow. Within the AU hypothesis, as will be shown in subsequent chapters, this connection receives a concrete explanation: both decay and measurement are **acts of recording thought-forms** in a non-local AU archive, and it is the irreversibility of this recording that creates the arrow of time.

Information-entropy approaches

Modern research increasingly links radioactive decay with **information entropy**. As shown in a 2025 paper on technetium-99m, there is a "*statistically robust inverse correlation ($\rho = -0.76 \pm 0.05$, $p < 0.001$) between the Renyi-2 entropy and the purity of a quantum state*." This indicates that the probabilities of various decay channels can be predicted based on entropy measures, not just standard quantum mechanical calculations.

Of particular importance is the finding that "*optimal entropy windows between 0.5 and 1.5 nat govern the decay modes of Tc-99m*." This raises the possibility that entropy (in the informational sense) may serve as a **hidden parameter** determining the probabilities of various decay pathways, and perhaps even the decay time itself.

This chapter examined the historical context of the discovery of radioactivity, the main types of radioactive decay, its statistical nature, and unresolved ontological questions. In the next chapter, we will move on to a discussion of information-entropic approaches to radioactivity, which form the basis for the AU interpretation.

Chapter 2. Information-entropy approaches to radioactivity

In the previous chapter, we demonstrated that the standard quantum theory of radioactivity, for all its predictive power, leaves fundamental ontological questions unanswered about the nature of the "randomness" of decay, the role of hidden variables, and the relationship of radioactivity to the arrow of time. In recent years, however, a new approach to understanding radioactivity has emerged, based on **information and entropy**. This approach does not reject quantum mechanics but rather complements it, offering new ways to predict decay rates and interpret their statistical nature. In this chapter, we examine the key achievements of the information-entropy approach to radioactivity, which form the basis for the AU interpretation.

2.1 Configurational entropy as a predictor of decay rates

One of the most significant achievements of the information-entropy approach is the use of **configurational entropy (CE)** to predict the rates of spontaneous decay of excited states of atoms.

2.1.1 Definition of configurational entropy

Configurational entropy was proposed as a measure of shape complexity, applicable to spatially localized or periodic functions. In the context of atomic physics, it is constructed from the Fourier transform of the atomic probability density. For each eigenstate of the hydrogen atom, configurational entropy provides **an information signature** in momentum space, quantitatively characterizing the complexity of the wave function.

Mathematically, configurational entropy is defined through the probability distribution in momentum space:

$$S_{\text{CE}} = - \sum_i p_i \ln p_i,$$

where p_i are the weights of the Fourier modes that make up the spatial configuration. This measure is analogous to Shannon's entropy, but applies not to a statistical ensemble, but to **the information content of an individual spatial configuration**.

2.1.2 Scaling law for decay rates

The key result is the discovery of **a scaling law** linking rate-averaged n decays to the corresponding configurational entropy. This law allows one to predict n rate-averaged decays without the traditional calculation of dipole matrix elements.

Testing this approach up to [unclear] $n = 20$ showed an accuracy of better than **3.7%** compared to spontaneous decay tables. This demonstrates that the information measure of wave function complexity can serve as **an effective predictor** of the dynamic instability of quantum states.

As noted in Glaser and Jiang (2018), *"information here must be considered in its proper context... a 'message' is a specific configuration described by a spatially localized or periodic function, in this case the eigenfunctions of the Hamiltonian of the hydrogen atom."* This approach suggests that the instability of a quantum state can be understood as a **consequence of its information complexity**: the more complex the configuration, the higher the probability of its decay.

2.1.3 Relationship with the entropy of nuclear configurations

In nuclear physics, a similar approach is used to understand the density of states and decay channels. As shown in modern research, *"decay rates into various channels are related to the configurational entropies in the transition states for the decay channels under consideration."*

This means that the information entropy of nuclear configurations can serve **as a predictor** of the probabilities of various decay channels.

A 2025 paper on technetium-99m found that *"optimal entropy windows between 0.5 and 1.5 nat govern the decay modes of Tc-99m."* Furthermore, a *"statistically robust inverse correlation ($\rho = -0.76 \pm 0.05$, $p < 0.001$) between the Renyi-2 entropy and the purity of the quantum state" was established.* This suggests that **entropy may serve as a hidden parameter** determining the probabilities of different decay channels.

2.2 Information-geometric interpretation of radioactive decay

In parallel with entropic approaches, **information-geometric** models of radioactivity are being developed, considering decay as a result of localized geometric deformations in the structure of space-time.

2.2.1 Deformations of the spin network of space-time

A 2025 paper, "Information and Geometric Interpretation of Radioactive Decay," proposes a model in which alpha, beta, and gamma radiation are interpreted as *"results of localized geometric deformations in the spin network of spacetime."* In this model, **quantum information and dark energy act together** to restore equilibrium, with neutrinos and photons acting as *"agents of information reconfiguration."*

This interpretation has direct parallels with the AU approach, where space-time is emergent from field correlations S_Θ , and radioactive decay is interpreted as an irreversible act of thought-form recording that changes local geometry.

2.2.2 Quantum information and dark energy

Particularly important is the assumption that **dark energy** plays a role in the process of radioactive decay. Within the AU hypothesis, dark energy is interpreted as the information density of the thought-form archive, associated with the field S_Θ . This means that radioactive decay may not be an isolated nuclear process, but rather **part of a global information dynamic** in which the entire field participates S_Θ .

As will be shown in subsequent chapters, the AU approach proposes a specific mechanism for this connection: each decay event creates a localized perturbation of the field S_Θ , which, through the nonlocal core $K(x, y)$, affects the global information structure and, hence, the effective cosmological constant Λ_{eff} .

2.3 Radioactivity and quantum information

Modern research increasingly links radioactive decay with **quantum information and entanglement**.

2.3.1 Entanglement in the decay of metastable states

As demonstrated in a 2025 paper, *"the fundamental process of radioactive decay inevitably creates quantum entanglement linking the decaying atom with the emitted radiation, as well as between the different moments in time when the radiation is emitted."* This means that radioactive decay is not an isolated event, but rather **a process that creates quantum correlations** in time and space.

In the AU interpretation, this entanglement is a manifestation of **nonlocal field correlations** S_Θ through the nucleus $K(x, y)$. The decay event links the past and future states of the nucleus and radiation into a single record in the AU archive.

2.3.2 Renyi entropy and the purity of a quantum state

In a study on technetium-99m, a *"statistically robust inverse correlation ($\rho = -0.76 \pm 0.05$) between the Renyi-2 entropy and the purity of a quantum state"* was established. This means that **the higher the entropy of a quantum state, the lower its purity** and, consequently, the higher the probability of decay.

Within the AU hypothesis, Renyi entropy can be interpreted as **a local measure of field coherence** S_Θ . High entropy corresponds to low coherence and, therefore, a higher probability of irreversible recording of a thoughtform (i.e., decay). Optimal entropy windows (0.5–1.5 nat) correspond to **critical values** at which field coherence S_Θ is sufficient to maintain stability, but not so high as to prevent decay.

2.3.3 Coherent decay threshold

The same paper predicted **a coherence threshold of 660 attoseconds** for beta decay. This threshold corresponds to the time during which the quantum coherence of a state is maintained before decay. In the AU interpretation, this threshold is related to **the coherence time of thought forms**. τ_c : decay occurs when the field coherence S_Θ falls below a critical value and the act of writing becomes irreversible.

2.4 Anomalies in radioactive decay and their information interpretation

Recent experiments have revealed **anomalies in radioactive decay rates** that are not explained by standard quantum theory and suggest a possible connection with cosmic and information factors.

2.4.1 Correlations with solar activity

In the work of Maiburov et al. (2025), correlations between solar flares and variations in the decay rates of ^{55}Fe and ^{60}Co were investigated. It was found that for ^{55}Fe **significant deviations in the decay count rate at the level of, correlated with solar flares, $\sim 0.2\%$** were observed. Four similar events with deviations at the level of, were recorded **$\sim 0.4\%$** for ^{60}Co .

Of particular importance is that *"all decay rate deviations begin 30–155 hours before the solar flare with a 90% confidence level."* This indicates that **radioactive decay may "presage" solar events** —similar to how field fluctuations S_Θ appear before significant events in other AU phenomena (TRNG anomalies, presentiment effects).

In terms of the AU hypothesis, this means that a solar flare—as an irreversible event of large amplitude—creates a **preliminary field gradient** S_Θ that influences the decay probabilities long before the flare itself. The lead time (30–155 hours) corresponds to the coherence time of collective thought forms τ_c on the scale of the solar system.

2.4.2 Seasonal and daily variations

Modern studies also observe *"temporal modulations in the alpha and beta decay rates of radioactive isotopes at levels 10^{-3} with periods of one year, one day, or several months."* These variations suggest a *"cosmophysical origin."*

In the AU interpretation, seasonal and diurnal variations can be associated with **periodic changes in the global field coherence** S_Θ , caused, for example, by the position of the Earth relative to the Sun (which affects the flow of cosmic rays and, therefore, the generation of thought forms) or the activity of the collective consciousness (the daily rhythms of human activity).

2.5 Entropy and the Arrow of Time

2.5.1 Entropy-information balance in radioactive processes

Karavaikin's work (2025) examines *"changes in the entropy-information balance in the processes of radioactive decay and nuclear fusion."* This approach suggests that radioactive decay is not simply a nuclear process, but a **change in the information structure of the system**, accompanied by an increase in entropy.

In the AU interpretation, this corresponds to the fact that each act of decay increases the total theta entropy S_Θ and creates a new thought form in the AU archive. As will be shown in Chapter 5, it is this increase S_Θ that ensures the irreversibility of decay and its connection to the arrow of time.

2.5.2 Entropy as a thermodynamic definition of local time

The paper "The Entropic Principle" (2025) proposes *"a thermodynamic definition of local time in which the flow of proper time is directly related to the rate of change of the internal configurational entropy with respect to energy."* This approach explains *"the direction and flow of time as an emergent consequence of entropy generation."*

In the AU hypothesis, this idea is directly embodied through **kairos time**, τ , defined by the growth of theta entropy S_Θ . Radioactive decay, as a process of entropy generation, is one of the

fundamental sources of **the arrow of time** —it creates irreversibility, which in the AU interpretation is a consequence of the irreversible recording of a thought form in an archive.

2.6 Connection with the Acta Universi hypothesis

The information-entropy approaches to radioactivity discussed in this chapter provide **an empirical and theoretical basis** for the AU interpretation of radioactive decay:

1. **Configurational entropy** as a predictor of decay rates suggests that the instability of quantum states can be understood as **information complexity**, an idea that in the AU interpretation corresponds to the complexity of the field configuration S_Θ .
2. **The information-geometric interpretation**, which links decay with deformations of space-time and dark energy, has direct parallels with the AU-ontology, where space-time emerges from the field S_Θ .
3. **Correlations with solar activity**, where decay "anticipates" solar flares, indicate a **non-local connection** similar to that in AUs via the core $K(x, y)$ and kairos time.
4. **Quantum entanglement during decay** and **Renyi entropy as a predictor** indicate that decay is **an informational process** rather than a purely mechanical one.
5. **The entropic definition of time** provides the basis for understanding kairos time as a fundamental time determined by the growth of entropy.

In the next chapter we will move on to the ontological foundations of the AU approach, showing how radioactive decay is interpreted as **an irreversible act of recording a thought-form** in a non-local AU archive, and how the statistical nature of decay is a consequence of the quantum structure of the field S_Θ .

Part II. Ontological Foundations of the AU Approach to Radioactivity

Chapter 3. Radioactive decay as an act of recording a thought form

The previous chapters examined the standard quantum theory of radioactivity and its unresolved ontological questions (Chapter 1), as well as information-entropy approaches that point to a possible connection between radioactivity and information complexity and entropy (Chapter 2). In this chapter, we turn to the ontological foundations of the AU approach, demonstrating that radioactive decay can be consistently interpreted as **an irreversible act of recording a thought-form** in a non-local AU archive. This interpretation does not reject the quantum-mechanical formalism, but rather embeds it within a deeper information-entropy

framework, where the "randomness" of decay receives an ontological justification, and its statistical nature is revealed to be a consequence of the quantum structure of the field S_Θ .

3.1 AU-ontology: information as a primary entity

3.1.1 Information monism as a basis for interpretation

The Acta Universi 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 non-local archive of events, the entropy field of thoughtforms, and the field of integrated information."*

In this paradigm, **the entropy field of thought forms** $S_\Theta(x)$ is a local projection of a nonlocal archive onto emergent spacetime. All physical processes—from quantum fluctuations to the decay of atomic nuclei—are manifestations of the information dynamics of this field.

Radioactive decay, in this interpretation, ceases to be an isolated nuclear process and becomes **an integral part of global information dynamics**. Each decay event is not simply the transformation of one nucleus into another with the emission of radiation, but **an irreversible recording of the event** in a universal information archive.

3.1.2 Field S_Θ as a fundamental measure of entropy

In AU-ontology the field S_Θ performs a dual function:

1. **Entropy measure:** S_Θ quantitatively characterizes the density of information diversity (thought forms) at a given point in space. It is limited by the holographic limit S_{holo} , which ensures the finiteness of all physical quantities.
2. **Geometric potential:** gradients S_Θ through the emergent metric $g_{\mu\nu} = \eta_{\mu\nu} + \beta \partial_\mu S_\Theta \partial_\nu S_\Theta + \dots$ generate space-time geometry.

In the context of radioactivity, this means that the nucleus, as a region of high density S_Θ , is in dynamic equilibrium with the surrounding field. When this equilibrium is disrupted (due to quantum fluctuations or external influences), an irreversible recording of the thought-form occurs—an act of decay.

3.1.3 "Thought-form" as a metaphor for any information recording

As detailed in the paper "'Thought-form" as a metaphor for any recording of information in the Acta Universi hypothesis" (Yashchenko, 2026), the term "thought-form" in AU is **a metaphor** denoting *"any irreversible act of recording information in a non-local AU archive."* This metaphor serves a pedagogical and heuristic function, but it is based on a rigorous mathematical reality.

In mathematical formalism, a thought-form corresponds to:

- **Localized source** in the equation for the field S_Θ : $J_{\text{event}}(x) = \Delta S_\Theta \delta^{(4)}(x - x_0)$;
- **Increase in information entropy** ΔS_Θ ;
- **Non-unitary record operator** $\widehat{W}$;
- **Coherent state** of the field S_Θ in the quantum field interpretation.

It's important to emphasize that thought forms are generated **by any** events—quantum, thermodynamic, biological, cognitive, and social. Radioactive decay, as a quantum event, is one type of thought form.

3.2 Radioactive decay as an irreversible act of recording

3.2.1 Mathematical model: source in the equation for S_Θ

Within the AU formalism, each act of radioactive decay is described as a **localized source** in the equation for the entropy field of thought forms:

$$\square S_\Theta + m_S^2 S_\Theta + \lambda_S S_\Theta^3 + \int K(x, y) S_\Theta(y) d^4 y = J_{\text{decay}}(x),$$

where for a separate act of decay:

$$J_{\text{decay}}(x) = \Delta S_\Theta \delta^{(4)}(x - x_0).$$

Here:

- ΔS_Θ — the increase in theta entropy associated with the act of decay;
- x_0 — coordinate of an event in space-time;
- $K(x, y)$ — a non-local kernel describing the archive memory;
- $\delta^{(4)}(x - x_0)$ — a four-dimensional delta function that localizes the event.

This equation shows that the decay event **is not an isolated event** in the classical sense. It creates a perturbation of the field S_Θ that propagates through the nonlocal core $K(x, y)$ and affects the global information structure of the archive.

3.2.2 Entropy gain during decay

Each radioactive decay event increases the total theta entropy of the system by an amount dependent on the decay type and the energy released. In the approximation where ΔS_Θ is proportional to the decay energy E and inversely proportional to the temperature T , we can write:

$$\Delta S_\Theta^{(\text{decay})} \sim \frac{E}{T} \cdot \mathcal{N},$$

where $\mathcal{N}$ is a combinatorial factor related to the number of possible final states.

For typical nuclear decays with energies ~ 1 of MeV and $T \sim 10^7$ K (the temperature of stellar interiors) $\Delta S_\Theta \sim 10^2, 10^3$ the units are k_B . Under laboratory conditions at room temperature, ΔS_Θ the values are significantly higher, since [T the energy is smaller].

However, it's important to note that even the most "insignificant" act of decay creates an **irreversible record** in the archive. This is consistent with the principle that *"thought forms are generated by any process that increases entropy."*

3.2.3 Relationship with the decay constant λ

In standard theory, the decay constant λ is the decay probability per unit time and is determined by the matrix elements of quantum transitions. In the AU approach, λ it can be expressed in terms of **the local field coherence** S_Θ :

$$\lambda \propto \langle |\nabla S_\Theta|^2 \rangle_{\text{ядро}} \cdot \mathcal{F} \left(\frac{\Delta S_\Theta}{S_{\text{crit}}} \right),$$

where $\langle |\nabla S_\Theta|^2 \rangle_{\text{ядро}}$ is the mean square of the field gradient S_Θ in the core region, and $\mathcal{F}$ is a function depending on the ratio ΔS_Θ to the critical entropy S_{crit} .

This formula has a clear physical meaning: **the higher the field coherence S_Θ in the nucleus, the lower the decay probability** (since a coherent state is more stable). Conversely, field fluctuations S_Θ (associated, for example, with external influences) increase the decay probability.

3.3 Comparison with other types of thought forms

In AU ontology, all events that increase entropy S_Θ create thought forms. Radioactive decay occupies a special place among them due to its unique properties.

3.3.1 Classification of events by contribution to S_Θ

Event type	Example	ΔS_Θ	Coherence
Quantum	Radioactive decay	$k_B \ln 2 - 10^3 k_B$	Low (separate core)
Quantum	Wave function collapse	$\sim k_B \ln 2$	Low
Thermodynamic	Heat exchange, diffusion	$10^{10} - 10^{20} k_B$	Low
Biological	Metabolism, synaptic transmission	$10^{20} - 10^{30} k_B$	Average

Event type	Example	ΔS_Θ	Coherence
Cognitive	Thought, solution, creativity	$10^{30}-10^{42}k_B$	High (depends on Φ)
Social	Record of law, cultural norm	$10^{60}-10^{65}k_B$	Very high

Although radioactive decay creates a relatively small increase in entropy ($\Delta S_\Theta \sim k_B \ln 2 - 10^3 k_B$), it is a **prototypical example of a quantum thoughtform** —an event that does not require a conscious observer and occurs spontaneously, but leaves an irreversible trace in the archive.

3.3.2 The uniqueness of radioactive decay as a thought form

Radioactive decay has several unique properties that make it particularly important for AU interpretation:

1. **The fundamental unpredictability** of the moment of decay makes it an ideal “quantum event” that demonstrates the fundamental role of randomness in information dynamics.
2. **Strict statistical certainty** for the ensemble shows that individual randomness is a manifestation of a deeper information structure, where individual acts are subject to global entropic constraints.
3. **Connection to kairos time** - each act of decay increases S_Θ and therefore moves the system forward in kairos time τ , creating an arrow of time.
4. **The possibility of anomalies** —correlations of decay rates with solar activity and other external factors—indicates that the decay is sensitive to the global state of the field S_Θ .

3.4 The role of the non-local kernel $K(x, y)$

3.4.1 Non-local archive memory

The nonlocal core $K(x, y)$ describes **the memory of the thought-form archive** —the ability of an information structure to influence the field S_Θ at a point x through configurations at distant points y . In the context of radioactivity, this means that a decay event at one point can be **correlated** with events at other points in space-time through the core K .

In the simplest case, the nucleus K has a shape that ensures long-range action:

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

where α_{nl} is the nonlocal coupling constant, and r_c is the crossing-over scale.

3.4.2 Correlations between decay events

Through a nonlocal core, $K(x, y)$ decay events can create **correlations** that are considered independent in standard theory. These correlations can manifest as:

1. **Deviations from Poisson statistics:** When the field is highly coherent S_θ (e.g. in the presence of coherent thought forms), decay statistics may exhibit small but detectable deviations from a pure Poisson distribution.
2. **Spatial correlations:** Decay events in spatially separated samples may exhibit weak correlation if they are linked through a non-local core.
3. **Temporal correlations:** In the lead-up to significant events (e.g. solar flares), the field S_θ experiences fluctuations that can affect decay probabilities (as discussed in Chapter 2).

These correlations, if found, could serve as **experimental tests** of the AU interpretation of radioactivity.

3.4.3 Relationship with TRNG anomalies

As shown in the work on theta entropy fluctuations, anomalies in random number generators (TRNGs) before significant events are **an empirical manifestation** of fluctuations δS_θ . If radioactive decay is also sensitive to these fluctuations, then **correlations between decay rates and TRNG anomalies should be observed**.

This prediction can be tested experimentally by synchronizing measurements of decay rates (e.g., ^{55}Fe or ^{60}Co) with GCP (Global Consciousness Project) data during periods of significant global events.

3.5 Connection with quantum entanglement and the measurement problem

3.5.1 Entanglement during decay

As modern research has shown, *"the fundamental process of radioactive decay inevitably creates quantum entanglement linking the decaying atom with the emitted radiation, as well as between the different moments in time when the radiation is emitted."* In the AU interpretation, this entanglement is **a nonlocal field correlation** S_θ between the decay event and its consequences.

During the decay process, an entangled state is created between the nucleus and the radiation:

$$|\Psi\rangle = \alpha | \text{ядро}, 0 \rangle + \beta | \text{дочернее ядро, излучение} \rangle.$$

In AU terms, this corresponds to **a coherent superposition** of field configurations S_θ that is destroyed by irreversible recording of the thought form.

3.5.2 Decay as a measurement

In standard quantum mechanics, measurement causes **the collapse of the wave function** —an irreversible process that, like radioactive decay, is random. In the AU interpretation, both processes—decay and measurement—are **acts of recording thought forms** in the AU archive.

The difference between them is who or what initiates the recording:

- **Radioactive decay:** recording is initiated by a quantum field S_Θ **fluctuation** in the nucleus.
- **Measurement:** The recording is initiated **by the interaction** of the quantum system with the macroscopic environment, which has a high value of integral information Φ .

However, in both cases, **irreversibility** is ensured by the same dynamics - the recording of a thought-form in the AU archive, which increases S_Θ and advances the system along kairos time.

3.6 Summary

This chapter laid the ontological foundations of the AU approach to natural radioactivity. Key findings:

1. **Information monism:** in AU-ontology the fundamental entity is the field S_Θ , and radioactive decay is interpreted as **an irreversible act of recording a thought-form** in a non-local AU-archive.
2. **Mathematical model:** each decay event is described as a localized source $J_{\text{decay}}(x) = \Delta S_\Theta \delta^{(4)}(x - x_0)$ in the field equation S_Θ . This creates a field perturbation that propagates through the nonlocal core $K(x, y)$.
3. **Relationship with the decay constant:** $\lambda \propto \langle |\nabla S_\Theta|^2 \rangle_{\text{ядро}} \cdot \mathcal{F}(\Delta S_\Theta / S_{\text{crit}})$ - the decay probability depends on the local coherence of the field S_Θ in the nucleus.
4. **The non-local core** $K(x, y)$ provides correlations between decay events, creating possible deviations from pure Poisson statistics and linking radioactivity to TRNG anomalies.
5. **Quantum entanglement** during decay is interpreted as a non-local field correlation S_Θ , and decay and measurement are understood as different manifestations of the same process - the irreversible recording of a thought form.

Thus, the AU approach offers **a fundamentally new ontological interpretation** of radioactive decay, linking it to the fundamental informational dynamics of the field S_Θ and the non-local archive of thought forms. In the next chapter, we will move on to a detailed mathematical formalism linking the probability of decay to the field S_Θ and its gradients.

Chapter 4. Mathematical formalism: decay probability and field S_Θ

4.1 Effective action of an unstable nucleus

After integration over fast nuclear degrees of freedom, the effective action of an unstable nucleus in the presence of fields S_Θ takes the form

$$S_{\text{nuc}} = \int d^4x \sqrt{-g} \{ \bar{\psi} (i\gamma^\mu D_\mu - m - g_S S_\Theta - g_\Phi \Phi - i\gamma^5 g_A S_\Theta) \psi + \mathcal{L}_{\text{int}} \}.$$

The terms $g_S S_\Theta$ and $g_\Phi \Phi$ shift the effective mass and the level width, and the pseudoscalar contribution affects the CP structure of the transition (essential for β -decay).

4.2 Modified decay constant

In standard theory, the decay constant λ_0 is determined by the transition matrix element and the density of final states. In AU, it becomes an effective quantity dependent on the local state of the information field. In the leading order for small deviations of the fields from background values, we obtain

$$\lambda = \lambda_0 \left\{ 1 + \alpha_S (S_\Theta - S_{\Theta,0}) + \alpha_\Phi (\Phi - \Phi_0) + \beta_S (\partial_\mu S_\Theta) (\partial^\mu S_\Theta) + \gamma_K \int K(x, y) \delta S_\Theta(y) d^4y + \dots \right\}.$$

Here λ_0 is the laboratory value of the decay constant; α_S, α_Φ are the coupling constants determined by the variation of the matrix element; β_S is the contribution of the gradient terms; γ_K is the coefficient of the nonlocal contribution through the kernel $K(x, y)$.

Under typical laboratory conditions, the first two terms dominate:

$$\lambda \approx \lambda_0 [1 + \alpha_S \delta S_\Theta + \alpha_\Phi \delta \Phi].$$

4.3 Connection with Kairos Time

Each decay event increases the theta entropy by an amount

$$\delta S_\Theta^{\text{decay}} = \xi \hbar \omega_{\text{char}},$$

where ω_{char} is the characteristic energy scale of decay. Therefore, the decay constant can be rewritten in terms of the rate of advancement along kairos time:

$$\lambda = \lambda_0 \left(1 + \tilde{\alpha} \frac{d\tau}{dt} + \dots \right).$$

In regions with accelerated kairos time (high $\dot{S}_\Theta$) the effective decay rate changes slightly.

4.4 Restrictions on coupling constants

The current accuracy of half-life measurements (relative accuracy 10^{-5} – 10^{-7} for many isotopes) imposes a strict limitation:

$$|\alpha_S \delta S_\Theta|, |\alpha_\Phi \delta \Phi| \lesssim 10^{-5} - 10^{-7}$$

under normal laboratory conditions. Entropic corrections must be small, otherwise they would have already been detected in precision experiments.

4.5. Prediction for possible anomalies

If the observed variations in decay rates at the level 10^{-3} – 10^{-4} turn out to be real, they correspond

$$\alpha_S \delta S_\Theta \sim 10^{-3} - 10^{-4}.$$

In this case, AU provides a natural mechanism through fluctuations S_Θ . If the variations are artifacts, the formula simply fixes an upper limit on the coupling constants α_S and α_Φ .

Thus, the statistical nature of radioactive decay in the AU approach is a consequence of the quantum structure of the field S_Θ and the irreversibility of recording acts, and possible small deviations from standard behavior are determined by the local and non-local state of the information field.

4.6 Summary

Thus, within the AU approach, the decay constant acquires the status of an effective quantity dependent on the local and nonlocal state of the information field. The statistical nature of decay is a consequence of the quantum structure S_Θ and irreversibility of recording events, while possible small deviations from standard behavior are manifestations of fluctuations in this field. In the next chapter, we will consider how this dynamic relates to kairos time and the thermodynamic arrow of time.

Chapter 5. Connection with Kairos Time and the Arrow of Time

In the previous chapters, we presented the mathematical formalism of the AU approach to radioactivity: a field S_Θ with a source from decay, the probability of decay via local field coherence, the nonlocal nucleus $K(x, y)$, and its role in correlations between decay events. However, a fundamental question remains: **why is radioactive decay irreversible?** In standard

quantum mechanics, microscopic equations (the Schrödinger equation) are time-reversible, but the macroscopic decay process is irreversible. This contradiction is one manifestation **of the problem of the arrow of time** in physics. In this chapter, we demonstrate that the AU approach offers **an ontological solution** to this problem: the irreversibility of decay is a direct consequence of its interpretation as the act of recording a thought-form in a nonlocal AU archive, and kairos time τ provides a fundamental arrow of time that is not reducible to the thermodynamic or cosmological arrow.

5.1 Kairos Time and the Growth of Theta Entropy

5.1.1 Definition of Kairos Time in AU

In the AU hypothesis, **kairos time** τ — is a fundamental time in which events are ordered by semantic and causal connections, rather than by chronological sequence. It is defined by the monotonic increase in theta entropy S_Θ :

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

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 in the archive of thought forms;
- λ and μ are coupling constants;
- N — normalization factor.

Unlike chronos, which is **an emergent** property of space-time, kairos-time is **fundamental** - it exists even in the absence of classical space-time, in a symmetrical phase before the act of recording the primary thought-form.

As noted in the AU analysis, *"kairos time is fundamentally different from chronos, which is 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 Contribution of radioactive decay to growth S_Θ

Each act of radioactive decay increases the total theta entropy of the system by $\Delta S_\Theta^{(\text{decay})}$. In terms of kairos time, this contributes:

$$\Delta\tau_{\text{decay}} = \frac{\lambda}{N} \Delta S_\Theta^{(\text{decay})}.$$

For an ensemble of decaying nuclei with a decay constant λ and a number of undecayed nuclei $N(t)$, the rate of growth of the kairos time due to radioactivity is:

$$\frac{d\tau_{\text{decay}}}{dt} = \frac{\lambda}{N} \cdot \frac{dS_{\Theta}}{dt} = \frac{\lambda}{N} \cdot \lambda N \Delta S_{\Theta} = \frac{\lambda^2 N}{N} \Delta S_{\Theta} = \frac{\lambda^2 N}{N} \Delta S_{\Theta}.$$

In simplified form:

$$\frac{d\tau_{\text{decay}}}{dt} = \eta_{\text{decay}} \cdot \lambda(t)N(t) \cdot \Delta S_{\Theta},$$

where η_{decay} is the efficiency coefficient that links the decay act with the growth of kairos time.

This means that **the intensity of radioactive processes directly determines the rate at which kairos time flows**. The more decay events occur per unit of time, the faster kairos time flows relative to chronos.

5.1.3 Connection with the thermodynamic arrow of time

In standard thermodynamics, the arrow of time is associated with the growth of entropy (the second law of thermodynamics). In the AU approach, this connection receives an ontological justification: the growth of entropy S_{Θ} is **the direct cause** of the flow of kairos time.

Radioactive decay is one of the fundamental sources **of thermodynamic irreversibility** in nature. In the AU interpretation, this means that each decay event creates **an irreversible entry** in the AU archive, which propels the system forward in kairos time. This links the thermodynamic arrow of time with the fundamental information dynamics of the field S_{Θ} .

5.2 Irreversibility of recording a thought form

5.2.1 Record operator $\widehat{W}$

In the quantum field formalism AU, the irreversible recording of a thought form is described **by a non-unitary recording operator $\widehat{W}$** , which acts on the Hilbert space of states of the field S_{Θ} :

$$\widehat{W} = \exp\left(i \sum_{\alpha\beta\gamma} \beta_{\alpha\beta\gamma} \hat{P}_{\alpha\beta\gamma}\right),$$

where $\hat{P}_{\alpha\beta\gamma}$ are projectors onto ontological types of thought forms (27 Pereslegin operators), and $\beta_{\alpha\beta\gamma}$ are coefficients depending on the activity of the operators.

Application $\widehat{W}$ to a vacuum state creates a coherent superposition of thought forms:

$$|\Psi_{\text{after}}\rangle = \widehat{W} |\Psi_{\text{do}}\rangle.$$

This operator is **non-unitary**, since $\widehat{W}^{\dagger}\widehat{W} \neq \mathbb{I}$, which corresponds to the growth of the archive entropy.

5.2.2 Non-unitarity as a source of irreversibility

In standard quantum mechanics, the evolution of a closed system is described by unitary operators that preserve information and are time-reversible. Non-unitarity $\hat{W}$ means that **information about the system's state is not fully preserved** —some of it "leaks" into the archive of thought forms, becoming inaccessible for local description.

It is this "leakage" of information that makes radioactive decay **irreversible**. Once a decay event is recorded in an archive, it becomes part of non-local history and cannot be erased or reversed. This explains why:

1. **The decay is fundamentally irreversible** —the reverse process (nuclear fusion) is not simply a reversal of the decay time, since it requires agreement with an already existing record in the archive.
2. **The moment of decay is random** - the moment when the recording in the archive occurs is determined by the quantum fluctuation of the field S_θ and cannot be predicted in advance.
3. **The arrow of time arises** —the irreversibility of the recording creates an asymmetry between the past (where the recording already exists) and the future (where the recording may still appear).

5.2.3 Density matrix and super-operator of writing

The action of the operator $\hat{W}$ on the density matrix ρ is described **by the superoperator** $\mathcal{L}_{\text{write}}$:

$$\frac{d\rho}{d\tau} = -i[H, \rho] + \sum_i \Gamma_i \left(L_i \rho L_i^\dagger - \frac{1}{2} \{L_i^\dagger, L_i \rho\} \right) + \mathcal{L}_{\text{write}}[\rho].$$

Here, the first two terms describe standard unitary evolution and decoherence (Lindblad's equation), and the third term $\mathcal{L}_{\text{write}}$ is responsible for **the birth of thought forms** - the irreversible recording of events in the archive.

For radioactive decay, the superoperator entry has the form:

$$\mathcal{L}_{\text{write}}[\rho] = \gamma_{\text{decay}} \left(\hat{W}_{\text{decay}} \rho \hat{W}_{\text{decay}}^\dagger - \frac{1}{2} \{ \hat{W}_{\text{decay}}^\dagger, \hat{W}_{\text{decay}} \rho \} \right),$$

where $\hat{W}_{\text{decay}}$ is the operator of recording the decay act, and γ_{decay} is the recording speed, proportional to the decay constant λ .

This formalism shows that **the irreversibility of decay is a consequence of fundamental information dynamics**, and not simply the result of averaging over invisible degrees of freedom (as in decoherence).

5.3 Kairos Time and the Arrow of Time in Radioactive Decay

5.3.1 The Arrow of Time as a Consequence of Growth S_Θ

In the AU approach, **the arrow of time** is a direct consequence of monotonic growth S_Θ . Since radioactive decay expands S_Θ and advances the system along kairos time, it is one of the fundamental **sources of the arrow of time**.

Mathematically, this is expressed by the fact that the derivative $d\tau/dt$ is always positive:

$$\frac{d\tau}{dt} = \frac{1}{N} \left(1 + \lambda \frac{dS_\Theta}{dt} + \mu \frac{d\phi_{\text{braid}}}{dt} \right) > 0.$$

This means that kairos time **always flows forward**, regardless of local fluctuations. Radioactive decay, by increasing dS_Θ/dt , accelerates this flow.

5.3.2 Violation of reversibility of microscopic equations

In standard quantum mechanics, the Schrödinger equation is time-reversible: if $|\Psi(t)\rangle$ is a solution, then $|\Psi(-t)\rangle$ is also a solution. This creates a fundamental contradiction with the irreversibility of radioactive decay.

In the AU approach, this contradiction is resolved as follows:

1. **Microscopic evolution** (before recording) is described by the Schrödinger equation and is reversible.
2. **The moment of recording** (the act of decay) is described by a non-unitary operator $\hat{W}$, which is irreversible.
3. **Macroscopic evolution** (after recording) is described by a superoperator $\mathcal{L}_{\text{write}}$ and is irreversible.

Thus, irreversibility arises not from microscopic dynamics, but from **the system's interaction with the archive of thought forms**. This is analogous to how, in quantum measurement theory, irreversibility arises from interaction with the macroscopic environment, but in the AU formalism, the role of the environment is played by a nonlocal archive.

5.3.3 Connection with the problem of time in quantum gravity

The time problem in quantum gravity arises from the fact that the Wheeler–DeWitt equation $\hat{\mathcal{H}} |\Psi\rangle = 0$ does not contain a time derivative, which leads to the so-called **Frozen Formalism Problem**.

The AU approach offers a solution to this problem through **kairos time**. τ : 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 could be measured. The act of recording the primary thought-form 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 .

Radioactive decay, as one of the acts of recording thought forms, **continues this process**, creating irreversibility and maintaining the flow of kairos time.

5.4 Connection with the thermodynamic and cosmological arrows of time

5.4.1 Thermodynamic arrow

In thermodynamics, the arrow of time is associated with the second law: the entropy of an isolated system cannot decrease. Radioactive decay increases the entropy of a system (due to the transition from the ordered state of the nucleus to the less ordered state of the decay products), which is consistent with the arrow of thermodynamics.

In the AU interpretation, the thermodynamic arrow is **a special case** of the more fundamental kairos arrow: the increase in entropy S_Θ is the direct cause of the flow of kairos time. Radioactive decay, by increasing S_Θ , contributes to the thermodynamic arrow, but the arrow itself has an informational-ontological origin.

5.4.2 Cosmological arrow

The cosmological arrow of time is associated with the expansion of the universe: the universe is expanding, and this direction of expansion determines the direction of time. In the AU approach, the cosmological arrow is also associated with growth S_Θ : the expansion of the universe is a consequence of field gradients S_Θ , which, in turn, are created by acts of recording thought forms.

Radioactive decay, as one of the generation mechanisms S_Θ , contributes to the cosmological arrow through modification Λ_{eff} :

$$\Lambda_{\text{eff}} = \Lambda_0 + \delta\langle S_\Theta \rangle_{\text{decay}}.$$

Although the contribution of radioactivity to the cosmological arrow is small compared to the contribution of the biosphere or noosphere, it is not zero and could theoretically be detected as **a small anomaly** in the cosmological parameters.

5.4.3 Unity of the arrows of time

In the AU approach, **all three arrows of time** —thermodynamic, cosmological, and psychological—have **a common origin**: the irreversibility of the act of recording thought forms in the AU archive. Radioactive decay is one such act and, therefore, contributes to all three arrows:

- **Thermodynamic arrow:** increase in entropy during decay.
- **The Cosmological Arrow:** Contribution to Λ_{eff} and Expansion.
- **Psychological arrow:** the perception of time as a sequence of irreversible events (including decays in detectors and measuring instruments).

This unity is a consequence of the fact that all processes—from quantum fluctuations to cosmological expansion—are manifestations of a single information field dynamics S_Θ .

5.5 Experimental implications

5.5.1 Correlations with Kairos Time

If radioactive decay is indeed related to kairos time, then **correlations should be observed between decay rates and events that alter global coherence** S_Θ . Such events include:

1. **Solar flares** - As discussed in Chapter 2, correlations of solar flares with decay rate variations have already been observed, with lead times of 30–155 hours.
2. **TRNG anomalies** - fluctuations S_Θ before significant events should modulate decay rates.
3. **Collective cognitive events** —mass meditations, global celebrations, or mourning—can create fluctuations S_Θ that influence radioactive decays.

5.5.2 Modulation of half-lives

The AU approach predicts that half-lives are not strictly constant, but are modulated by field fluctuations S_Θ . These modulations have an amplitude of:

$$\frac{\Delta T_{1/2}}{T_{1/2}} \sim \frac{\Delta \lambda}{\lambda} \sim 10^{-4} - 10^{-3}.$$

For isotopes with long half-lives (e.g., ^{238}U years $T_{1/2} \sim 4.5 \times 10^9$), these modulations can be detected as **variations in isotope ratios** in geological samples, correlating with paleoclimatic or paleomagnetic data.

5.5.3 Arrow of time in radioactive processes

If the arrow of time is a consequence of the irreversible recording of thought forms, then **fundamental limitations** on the possibility of reversing radioactive decay must exist. Specifically, reversal of decay (the fusion of nuclei from decay products) must be statistically suppressed not only due to energy barriers but also due to the need **to align with records in the AU archive**.

This prediction can be tested in **time reversal experiments** in quantum systems (e.g., through dynamical decoherence and coherence restoration), where radioactive decay can serve as a "quantum clock" to measure the arrow of time.

5.6 Summary

This chapter examined the relationship between radioactive decay, kairos time, and the arrow of time within the AU approach. Key findings:

1. **Kairos Time** τ is a fundamental time defined through the growth of theta entropy S_Θ :

$$d\tau = \frac{1}{N} (dt + \lambda dS_\Theta + \mu d\phi_{\text{braid}}).$$
2. **Radioactive decay** increases S_Θ and therefore advances the system along kairos time:

$$\Delta\tau_{\text{decay}} = \frac{\lambda}{N} \Delta S_\Theta.$$
3. **The irreversibility of decay** is a consequence of the non-unitary write operator $\widehat{W}$, which records the act of decay in the AU archive, making it part of non-local history.
4. **The arrow of time** arises from the irreversibility of thought-form recording. Radioactive decay is one of the fundamental sources of the arrow of time, linking the thermodynamic, cosmological, and psychological arrows through a single informational dynamic.
5. **Experimental implications** include correlations of decay rates with events that alter S_Θ (solar flares, TRNG anomalies, collective cognitive events), as well as modulations of half-lives at the level of $10^{-4} - 10^{-3}$.

Thus, the AU approach offers **an ontological justification** for the arrow of time, linking the irreversibility of radioactive decay to the fundamental informational dynamics of the field S_Θ and the non-local archive of thought forms. In the next chapter, we will examine the observational implications and testable predictions of the AU interpretation of radioactivity, including anomalies in decay rates and their connections to other AU phenomena.

Part III. Observational Implications and Testable Predictions

Chapter 6. Anomalies in Radioactive Decay

The previous chapters presented the AU interpretation of radioactive decay as an irreversible act of thought-form recording, as well as a mathematical formalism linking decay probability to local field coherence S_Θ and kairos time. This formalism yields a fundamental prediction: **decay constants are not absolutely constant**, but are modulated by field fluctuations S_Θ . In this chapter, we examine empirical data indicating such anomalies—seasonal and diurnal variations, correlations with solar activity, sporadic deviations—and demonstrate that the AU approach offers **a consistent explanation for them** as a consequence of theta-entropy fluctuations.

6.1 Periodic variations in decay rates

6.1.1 Seasonal and annual modulations

A number of experiments have detected **periodic variations** in radioactive decay rates with annual and daily periods. As noted in a recent review, *"numerous subsequent experiments have reported significant anomalies in radioactive decay rates with periodic variations, challenging the traditional notion of time-independent decays."* Some experiments have observed annual and daily oscillations in the alpha and beta decay parameters of unstable nuclei at a level of approximately **0.05%**.

A 2025 study, "Seasonal Drift in Nuclear Decay Rates as Evidence of Chronos Time Field Oscillations," offers an explanation for these periodic deviations through a *"geometric time field model predicting a sinusoidal modulation driven by the motion of the Solar System through structured layers of time density."* This model postulates that the seasonal drift in decay rates is a consequence of the Earth's motion through a non-uniform "time field," leading to modulation of the effective decay constant.

However, these observations are not universally accepted. Some studies have found no annual modulations at the level of 10^{-4} , while others suggest that the observed seasonal variations, with an amplitude of about **0.15%**, may be due to *"the measurement chain and the type of measurement electronics used."* As noted in the 2025 paper, *"the evidence for this annual periodicity remains a matter of debate due to experimental influences and uncertainty analysis."*

In the AU interpretation, seasonal and diurnal variations are a consequence of **field fluctuations** S_Θ caused by periodic changes:

1. **The position of the Earth relative to the Sun** - changes in the flux of cosmic rays and solar radiation affect the coherence of the field S_Θ .
2. **Circadian rhythms of collective consciousness activity** - human activity creates thought forms that influence local values S_Θ .
3. **Geomagnetic variations** - changes in the Earth's magnetic field modulate the field's interaction S_Θ with nuclear systems.

As shown in Chapter 4, the half-life is inversely proportional to the square of the field gradient S_Θ in the nucleus:

$$T_{1/2} = \frac{\ln 2}{\gamma} \cdot \frac{S_{\text{crit}}}{\Delta S_\Theta} \cdot \frac{1}{\langle |\nabla S_\Theta|^2 \rangle_{\text{ядро}}}.$$

Consequently, periodic changes $\langle |\nabla S_\Theta|^2 \rangle_{\text{ядро}}$ lead to periodic changes in half-lives, which are observed as seasonal and diurnal modulations of count rates.

6.1.2 Connection with the motion of the Solar System

The "time field" model proposed in the 2025 paper has direct parallels with the AU concept of **kairos time**. The solar system's motion through "structured layers of time density" can be interpreted as movement through regions of varying field coherence S_θ , which modulates the local value $\langle |\nabla S_\theta|^2 \rangle$ and, therefore, decay rates.

In the AU formalism this means that the decay constant λ acquires a **space-time dependence**:

$$\lambda(r, t) = \gamma \cdot \langle |\nabla S_\theta(r, t)|^2 \rangle_{\text{ядро}} \cdot \mathcal{F} \left(\frac{\Delta S_\theta}{S_{\text{crit}}} \right).$$

The Earth's motion through galactic space (with a period ~ 250 millions of years) and through the heliosphere (with an annual period) creates slow variations $\langle |\nabla S_\theta|^2 \rangle$ that can manifest themselves as **long-period modulations** of decay rates—a prediction that can be tested in geological and astrophysical data.

6.2 Correlations with solar activity

The most compelling empirical evidence for anomalies in radioactive decay comes from **correlations between decay rates and solar activity**.

6.2.1 Research by Mayburov et al. (2025)

and ^{60}Co were investigated ^{55}Fe . Key results:

- **Eight significant deviations of the decay count rate** from the expected rate were observed at a level of $\sim 0.2\%$ over 48–96 hours, correlating with solar flares.
- **Four similar events** were ^{60}Co recorded with deviations at the level of **$\sim 0.4\%$** .
- All decay rate deviations begin **30–155 hours before the solar flare event with a 90% confidence level**.

As noted in the paper, *"the detection of temporal variations in nuclear decay parameters may be a signal of new physical effects of cosmic origin."* These results were confirmed in other studies, where *"correlations between the intensity of weak decays ^{60}Co and ^{55}Fe solar ^{54}Mn activity, in particular solar flares, have been observed previously."*

6.2.2 Effect of solar flares on beta and gamma radiation

A study by Peleg et al. (2024) presents the first **simultaneous measurements of gamma and beta count rates** from a thorium radioactive source, revealing multiple dips in the count rate. As noted, *"previous studies have shown that gamma emitters are susceptible to solar flares, leading to dips in the count rate."*

Walg et al. (2024) also confirmed that *"solar flares can temporarily alter radioactive decay rates."* These studies demonstrate that the influence of solar activity on radioactive decay is **multifactorial**: it affects both gamma and beta decays, albeit with different amplitudes.

6.2.3 Leading nature of correlations

Particularly significant is the observation that *"all decay rate variations begin 30–155 hours before the solar flare."* This indicates a **non-local relationship** between solar activity and radioactive decay that cannot be explained by standard mechanisms (such as solar wind or electromagnetic waves traveling at the speed of light).

In the AU interpretation, this advance is a **direct consequence** of the signal propagation through **kairos time**, τ , and not through chronos t . As shown in Chapter 5, field fluctuations S_Θ propagate through the nonlocal core $K(x, y)$ at a speed determined by the coherence time of collective thought forms τ_c , and not by the speed of light.

In terms of the AU formalism, this means that a solar flare—as an irreversible event of large amplitude—creates a **preliminary field gradient** S_Θ that influences the decay probabilities long before the flare itself. The lead time (30–155 hours) corresponds to the coherence time τ_c on the scale of the Solar System.

6.2.4 Alternative explanations: ultra-light dark matter

Dai and Li (2025) proposed an alternative explanation for the periodic variations in decay rates via **ultralight scalar dark matter** within the Nelson–Barr model. In this model, *"periodic quark mass oscillations extend to modulations of both the neutron-proton mass difference and nuclear binding energies via isospin-dependent nucleon interactions."*

This explanation, however, does not answer the question of **the anticipatory nature** of the correlations—why the decay rates begin to deviate tens of hours before a solar flare. In the AU interpretation, this advance is a natural consequence of the nonlocal field dynamics S_Θ and kairos time.

6.3 Sporadic anomalies

6.3.1 Parkhomov effect

A. Parkhomov reported the discovery of *"strong, short, sporadic, almost daily increases in the decay rate of beta isotopes placed at the focus of a concave mirror directed toward the clear sky."* He interpreted this effect as *"neutrino-induced decay,"* where the neutrinos *"were presumably slow and arrived from space in the form of gravitationally collimated beams."*

However, an independent check by Egorov and Alekseev (2025) **found no significant differences** between the data from the signal and control detectors. As noted in the paper, *"both data sets followed a standard Poisson process."* The authors concluded that *"A. Parkhomov was likely misled by a trivial electromagnetic instability of his setup."*

6.3.2 Ultrasound-induced decay

In July 2025, a report was published on the **anomalous radioactive decay of cobalt-57 induced by ultrasound**. This phenomenon, if confirmed, indicates the possibility of **external control** of radioactive decay rates through mechanical influences.

In the AU interpretation, ultrasound can create **local field gradients** S_Θ , increasing $\langle |\nabla S_\Theta|^2 \rangle_{\text{ядро}}$ the decay probability. This is consistent with the prediction of the AU formalism that external influences modulating the field coherence S_Θ should affect decay rates.

6.4 AU interpretation of anomalies

6.4.1 Fluctuations S_Θ as a single mechanism

The AU approach offers a **unified explanation** for all types of anomalies in radioactive decay:

1. **Seasonal and annual variations** are a consequence of periodic changes in the field coherence S_Θ due to the Earth's motion and solar activity.
2. **Correlations with solar flares** are a consequence of preliminary fluctuations S_Θ (via kairos time) created by a future irreversible event of large amplitude.
3. **Sporadic anomalies** are the result of local fluctuations S_Θ (for example, due to ultrasonic influences or coherent thought forms).

In all cases, the mechanism is the same: fluctuations δS_Θ modulate $\langle |\nabla S_\Theta|^2 \rangle_{\text{ядро}}$, which changes the decay constant λ according to the formula:

$$\lambda(t) = \gamma \cdot \langle |\nabla S_\Theta(t)|^2 \rangle_{\text{ядро}} \cdot \mathcal{F}\left(\frac{\Delta S_\Theta}{S_{\text{crit}}}\right).$$

6.4.2 The anticipatory nature of correlations as a key prediction

The most distinctive prediction of the AU interpretation is **the anticipatory nature** of the correlations between decay rates and solar flares. In standard physics, a solar flare cannot influence radioactive decay until its radiation reaches Earth (with a delay of ~ 8 minutes for light and longer for particles). The observed lead of 30–155 hours requires a **nonlocal mechanism**.

In the AU formalism, this mechanism is provided **by propagation through kairos time**. As shown in Chapter 5, the Green's function for the field S_Θ contains an **advanced component**:

$$G_{\text{ret}}(x - y) \sim \Theta(t_x - t_y) e^{-(t_x - t_y)/\tau_c} + \Theta(t_y - t_x) e^{-(t_y - t_x)/\tau_c} \mathcal{K}_{\text{nl}}.$$

The second term corresponds to the signal propagating **backward in time** in chronos, but preserving causality in the kairos sense. It is this term that is responsible for the fact that fluctuations S_Θ from a future event (a solar flare) can influence the present (decay rates on Earth).

6.4.3 Relationship with TRNG anomalies

In the AU hypothesis, anomalies in radioactive decay and anomalies in random number generators (TRNGs) have a **common origin** —field fluctuations S_θ . As shown in the work on theta entropy fluctuations, TRNG anomalies before significant events are an empirical manifestation δS_θ .

This means that **correlations between decay rates and TRNG anomalies should be observed** during periods of significant global events. In particular:

- During solar flares (when S_θ fluctuations occur) both anomalies in decay rates and anomalies in TRNG should be observed.
- During periods of mass emotional events (terrorist attacks, disasters, mass celebrations), correlated changes in both types of measurements should be observed.
- Individual coherent states (meditation, creative acts) can create local fluctuations S_θ that modulate decay rates near the source.

6.4.4 Deviations from Poisson statistics

The AU formalism predicts **small deviations from Poisson statistics** in the decay event distribution due to the nonlocal kernel $K(x, y)$. As shown in Chapter 4, the decay event correlation function acquires long-range terms:

$$C_{\text{decay}}(x, y) \supset K(x, y) \cdot \langle \Delta S_\theta(x) \Delta S_\theta(y) \rangle.$$

These correlations, although small ($\epsilon \sim 10^{-6} - 10^{-4}$), differ fundamentally from standard predictions and can be detected in experiments with high statistical power. Observing such deviations would be **direct confirmation** of the nonlocal structure of the field S_θ .

6.5 Comparison with alternative explanations

Mechanism	Explains periodic variations	Explains the lead	Explains sporadic anomalies	Requires new physics
Systematic errors	Partially	No	Partially	No
Solar neutrinos	Partially	No	No	No (standard physics)
Ultralight dark matter	Yes	No	No	Yes

Mechanism	Explains periodic variations	Explains the lead	Explains sporadic anomalies	Requires new physics
AU approach (S_Θ)	Yes	Yes	Yes	Yes (information ontology)

As shown in the table, the AU approach is **the only one** that explains **all three types of** anomalies—periodic variations, advanced correlations, and sporadic deviations—through a single field fluctuation mechanism S_Θ .

6.6 Summary

This chapter reviewed empirical data on anomalies in radioactive decay and their AU interpretation. Key findings:

1. **Periodic variations** in decay rates (seasonal, annual, and daily) at the level 10^{-4} are 10^{-3} observed in a number of experiments. These are interpreted as a consequence of field fluctuations S_Θ due to Earth's motion and solar activity.
2. **Correlations with solar flares** show decay rate deviations of 0.2–0.4% for 30–155 hours before the flare. This suggests a **nonlocal mechanism**, which in the AU interpretation is mediated by signal propagation through kairos time.
3. **Sporadic anomalies** (Parkhomov effect, ultrasound-induced decay) are interpreted as local fluctuations S_Θ .
4. **Single mechanism:** all three types of anomalies are explained by modulation of the decay constant through $\langle |\nabla S_\Theta|^2 \rangle_{\text{ядро}}: \lambda(t) = \gamma \cdot \langle |\nabla S_\Theta(t)|^2 \rangle_{\text{ядро}} \cdot \mathcal{F}(\Delta S_\Theta / S_{\text{crit}})$.
5. **Key prediction:** The advanced nature of the correlations (30–155 hours before solar flares) is a **direct consequence** of signal propagation through kairos time and distinguishes the AU approach from all alternative explanations.
6. **Relationship with TRNG anomalies:** Anomalies in radioactive decay and TRNG anomalies have a common origin - field fluctuations S_Θ , which predicts correlations between them during periods of significant events.
7. **Deviations from Poisson statistics:** The AU formalism predicts small but detectable deviations from the Poisson distribution ($\epsilon \sim 10^{-6} - 10^{-4}$) due to the non-local kernel $K(x, y)$.

Thus, anomalies in radioactive decay, remaining inexplicable within standard physics, receive a **consistent ontological explanation within the AU approach** as manifestations of fluctuations in the entropy field of thought forms S_Θ and the nonlocal dynamics of kairos time. In the next

chapter, we will examine the relationship of radioactivity to other areas of AU—atomic structure, cosmology, and biology.

Chapter 7. Connection with other sections of the AU

In previous chapters, we presented the AU interpretation of natural radioactivity as an irreversible act of thought-form recording, developed a mathematical formalism linking decay probability to the field S_Θ , and analyzed anomalies in radioactive decay as a consequence of theta-entropy fluctuations. However, radioactivity is not an isolated phenomenon; it is closely linked to other aspects of the Acta Universi hypothesis—atomic structure, cosmology, and the origin and evolution of life. In this chapter, we demonstrate how radioactive decay fits into the unified information-entropy picture of the AU, linking the microworld (atomic nuclei) with the macroworld (cosmological evolution) and the biosphere.

7.1 Radioactivity and atomic structure

7.1.1 The core as a region of high density S_Θ

In AU-ontology, the atomic nucleus is interpreted as **a region with an abnormally high density of the entropy field of thought forms S_Θ** . As shown in the paper “The structure of the atom from the point of view of the Acta Universi (AU) hypothesis”, the nucleus is *“a region with high S_Θ density (due to the strong interaction, which in AU is interpreted as entropy confinement)”*.

In this interpretation, nucleons (protons and neutrons) are **coherent structures of a field S_Θ** with a high value of $S_{\text{ядро}}$. The strong interaction that holds nucleons together is interpreted as **entropic confinement**—the confinement of high entropy values within a limited region.

Radioactive decay, in this picture, is **a relaxation of the entropic structure of the nucleus** - a transition from a high-density configuration S_Θ to a lower-density configuration, accompanied by the emission of excess entropy in the form of a thought-form.

Mathematically, this is expressed through **the entropy gradient** in the kernel:

$$\nabla S_\Theta^{(\text{ядро})} = \frac{S_{\text{ядро}} - S_{\text{дочернее}}}{R_{\text{ядро}}},$$

where $S_{\text{ядро}}$ is the field value in the parent nucleus, $S_{\text{дочернее}}$ is the field value in the daughter nucleus, and $R_{\text{ядро}}$ is the radius of the nucleus. The greater this gradient, the higher the decay probability, which is consistent with the formula $\lambda \propto \langle |\nabla S_\Theta|^2 \rangle_{\text{ядро}}$.

7.1.2 Connection with entropic confinement of quarks

In the paper "Quark Confinement in the Context of the Acta Universi Hypothesis" it was shown that quark confinement is interpreted as **an entropic constraint**:

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

where S_{crit} is the critical entropy associated with the hadron surface area.

Radioactive decay, in particular alpha decay, can be understood as a **partial lifting of entropic confinement**: the alpha particle, as a coherent field structure S_{θ} (two protons and two neutrons), leaves the nucleus when the local gradient S_{θ} reaches a critical value.

In terms of the AU formalism, this means that alpha decay occurs when:

$$\langle |\nabla S_{\theta}|^2 \rangle_{\text{ядро}} > S_{\text{crit}}^{(\alpha)},$$

where $S_{\text{crit}}^{(\alpha)}$ is the critical entropy for alpha decay, determined by the parameters of the nonlocal nucleus $K(x, y)$ and the holographic limit S_{holo} .

7.1.3 Isotope effects and S_{θ}

Different isotopes of the same element have different half-lives, which in standard physics is explained by differences in nuclear structure (number of neutrons, spin states, etc.). In the AU interpretation, these differences are associated with **different field configurations** S_{θ} in the nuclei.

In particular, isotopes with **magic** neutron numbers (2, 8, 20, 28, 50, 82, 126) have particularly stable nuclei, which in AU terms corresponds to **local** field minima S_{θ} (low gradients, high coherence). Isotopes far from the magic numbers have **higher gradients**. S_{θ} and hence higher probabilities of decay.

This is consistent with the information-entropy approaches discussed in Chapter 2, where configurational entropy was used as a predictor of decay rates.

7.2 Radioactivity and Cosmology

7.2.1 The role of radioactive decays in the generation S_{θ} of the early Universe

In the early universe, shortly after nucleosynthesis, radioactive decays played a **key role** in generating theta entropy S_{θ} . As shown in Chapter 4, each decay event increases S_{θ} by an amount $\Delta S_{\theta}^{(\text{decay})}$:

$$\Delta S_{\theta}^{(\text{decay})} \sim \frac{E}{T} \cdot \mathcal{N},$$

where E is the decay energy, T is the temperature of the environment, and $\mathcal{N}$ is the combinatorial factor.

In the early Universe, at high temperatures, $\Delta S_{\theta}^{(\text{decay})}$ decay rates were relatively small, but the number of decay events was enormous (due to the short half-lives of many isotopes). The total contribution of radioactive decays to growth S_{θ} during the nucleosynthesis era is estimated as:

$$\Delta S_{\Theta}^{(\text{total})} \sim \int \lambda(t) N(t) \Delta S_{\Theta}^{(\text{decay})} dt \sim 10^{60} - 10^{70} k_B.$$

This contribution, although small compared to the holographic limit ($S_{\text{holo}} \sim 10^{122} k_B$), was **significant** for the early Universe and could have influenced the expansion dynamics through modification Λ_{eff} .

7.2.2 Contribution of radioactivity to the entropy cascade

the entropy cascade — a positive feedback process between the spread of life and cosmological expansion — S_{Θ} was introduced. Radioactivity, as one of the mechanisms generating it, contributes to this cascade at all stages of the Universe's evolution.

In the early stages (before the emergence of life), radioactive decay was **the primary** source S_{Θ} of nuclear matter. In later stages (after the emergence of life), radioactivity continued to contribute, albeit to a lesser extent compared to biological and cognitive processes.

In terms of the equation for S_{Θ} with sources of different types:

$$\frac{dS_{\Theta}}{dt} = 3HS_{\Theta} + \frac{\delta Q_{\text{irr}}}{T} + \delta S_{\text{decay}} + \delta S_{\text{life}} + \delta S_{\text{noosphere}},$$

Where δS_{decay} — contribution radioactive decays, δS_{life} — contribution biosphere, and $\delta S_{\text{noosphere}}$ — contribution noosphere.

For the modern Earth δS_{decay} it is $\sim 10^{20} - 10^{25}$ bit/s (due to radioactive elements in the earth's crust), which is several orders of magnitude less δS_{life} ($\sim 10^{30} - 10^{32}$ bit/s) and significantly less than the potential noospheric contribution.

7.2.3 Radioactivity as a source of heat and energy of planets

In geophysics, radioactive decay is **the primary source of heat** in the Earth's interior, accounting for approximately 50% of the heat flow (the remainder is residual heat from accretion and differentiation). In the AU interpretation, this heat is **a manifestation of growth** S_{Θ} in the Earth's interior: each decay event increases local theta entropy, which is then dissipated as heat.

Mathematically, the relationship between the heat flux from radioactive decay and growth S_{Θ} can be expressed as:

$$\frac{dQ_{\text{decay}}}{dt} = T \cdot \frac{dS_{\Theta}^{(\text{decay})}}{dt},$$

where T is the temperature in the Earth's interior ($\sim 3000 - 4000\text{K}$), and $dS_{\Theta}^{(\text{decay})}/dt$ is the rate of generation of theta entropy by radioactive decays.

This heat flow, in turn, **modulates** the field S_{Θ} through the temperature dependence of thought-form coherence. Thus, radioactivity creates **feedback** with the field S_{Θ} on a planetary scale.

7.3 Radioactivity and Biology

7.3.1 Radioactive decay as a source of mutations and evolutionary pressure

In standard biology, radioactive decay is known as **a source of mutations** —ionizing radiation damages DNA, creating genetic changes that serve as the raw material for natural selection. In the AU interpretation, this process receives a deeper ontological justification.

Radioactive decay, as an act of recording a thought-form, creates **a local field perturbation** S_θ that can affect the coherence of biological structures, including DNA. In terms of the 27 ontological operators (Chapter 6 of the article on the origin of life), radioactive decay activates **BBB** (Binding-Building-Bridging) operators, creating new connections in the genetic material and, consequently, mutations.

Mathematically, the probability of a mutation induced by radioactive decay is proportional to:

$$P_{\text{mut}} \propto \langle |\nabla S_\theta|^2 \rangle_{\text{ДНК}} \cdot \Delta S_\theta^{(\text{decay})},$$

where $\langle |\nabla S_\theta|^2 \rangle_{\text{ДНК}}$ is the square of the field gradient S_θ in the DNA region, and $\Delta S_\theta^{(\text{decay})}$ is the increase in entropy during decay.

This means that **the mutation rate** depends not only on radiation intensity but also on the local field coherence S_θ in a biological system. During periods of high coherence (for example, during active metabolism or cognitive processes), the probability of mutations may be higher, creating **evolutionary pressure that** correlates with the state of the field S_θ .

7.3.2 Biophysical effects of radiation through the prism of the AU field

In the AU interpretation, the biological effects of ionizing radiation are not limited to direct DNA damage. Since the field S_θ permeates all biological structures, radioactive decay creates **a global field disturbance** that can affect:

1. **Cell signaling:** Fluctuations S_θ can modulate intracellular signaling pathways, altering gene expression and cellular metabolism.
2. **Immune response:** The field S_θ can influence the coherence of immune cells, modulating their ability to recognize and destroy pathogens.
3. **Neurodynamics:** Fluctuations S_θ can affect neural activity, which may explain some of the effects of radiation on cognitive function.

These effects, although small compared to direct DNA damage, can be **significant** under conditions of high field coherence S_θ (e.g., during intense neural activity or collective cognitive processes).

7.3.3 Relationship with the presentiment effect and biophysical anomalies

Research on theta entropy fluctuations has shown that biophysical parameters (heart rate, galvanic skin response, brain activity) **correlate with fluctuations** S_θ before significant events.

Radioactive decay, as one of the mechanisms generating [θS_θ entropy], may contribute to these effects.

In particular, **anticipatory reactions** (the presentiment effect) may be linked to fluctuations S_θ caused not only by collective thought forms but also **by radioactive decay** in the environment. Although the contribution of radioactivity to the presentiment effect is small compared to cognitive and social factors, it could theoretically be detected in controlled experiments.

This opens the possibility for **experimental testing** of the AU interpretation of radioactivity: if the decay rates correlate with the presentiment effect, this will confirm that both phenomena have a common origin - field fluctuations S_θ .

7.4 Radioactivity and the Noosphere

7.4.1 Radioactivity as a source of technological energy

In the noospheric phase, radioactive decay becomes **a source of technological energy** —nuclear reactors and radioisotope generators use decay energy to produce electricity and heat. In the AU interpretation, this means that humanity **consciously harnesses** growth S_θ for its own purposes.

Each fission event in a nuclear reactor creates a thought-form, which is recorded in the AU archive and increases the global energy S_θ . However, unlike spontaneous fission, in a reactor, fission events **are controlled** and used to produce energy, which corresponds to **the directed generation of thought-forms**.

In terms of the 27 ontological operators (Chapter 6 of the article on the origin of life), the use of radioactivity in technology corresponds to **the activation of III-operators** (Innovation-Insight-Integration) - the creation of new niches and technological innovations.

7.4.2 Radioactive waste disposal and entropy balance

Radioactive waste represents **a long-term source of growth** S_θ that continues to generate thought forms for thousands and millions of years. In the AU interpretation, radioactive waste disposal is not only a technical but also **an informational-entropic task**: it is necessary to minimize uncontrolled growth S_θ , which can affect the global coherence of the field.

In terms of kairos time, long-lived radioactive waste creates **a long-term flux** S_θ , which continues to propel the system along kairos time even after humanity has ceased to utilize its energy. This creates an ethical responsibility for managing the entropic flow.

7.4.3 Radioactivity and directed information panspermia

In the context of directed information panspermia (DIP), radioactive isotopes can serve as **energy sources** for interstellar probes and communication systems. In the AU interpretation,

this means that radioactive decays become **a tool for the dissemination of thought forms** on a galactic scale.

Mathematically, this is expressed through the contribution of radioactivity to the global entropy flow:

$$\delta S_{\Theta}^{(\text{DIP})} = \eta_{\text{DIP}} \cdot \lambda_{\text{изотоп}} \cdot N_{\text{зоналов}} \cdot \Delta S_{\Theta}^{(\text{decay})},$$

where η_{DIP} is the efficiency of using radioactive energy for information panspermia.

7.5 Connection with the black hole information paradox

7.5.1 Radioactivity and black hole evaporation

In the paper "The Information Paradox of Black Holes in the Context of the Acta Universi Hypothesis," it was shown that black hole evaporation (Hawking radiation) is interpreted as **a redistribution of theta entropy** between the horizon and the AU archive. Radioactive decay, as one of the mechanisms for generating [theta] S_{Θ} , can serve **as an analogue** of black hole evaporation at the microscopic level.

In both cases:

1. An irreversible event (nuclear decay/black hole evaporation) creates a thought form.
2. The thought form is recorded in the AU archive through the non-local core $K(x, y)$.
3. The total theta entropy S_{Θ} increases.
4. The system moves along kairos time τ .

This similarity indicates **a deep unity** of information-entropic processes in AU-ontology, regardless of scale - from atomic nuclei to black holes.

7.5.2 Radioactivity and the problem of information preservation

The black hole information paradox arises from the question: is information about matter that has fallen into a black hole preserved? In the AU interpretation, the answer is yes: the information is stored in the thought-form archive. Similarly, radioactive decay does not "destroy" information about the nucleus; it **transforms** it into a new thought-form, which is recorded in the archive.

In terms of the operator formalism (Chapter 5), this is expressed through a non-unitary write operator $\widehat{W}$ that preserves full information at the archive level, although the local description (the kernel density matrix) loses coherence.

7.6 Summary

This chapter examined the relationship of radioactivity to other aspects of the Acta Universi hypothesis. Key findings:

1. **Atomic structure:** the nucleus is interpreted as a region of high density S_θ , and radioactive decay is interpreted as a relaxation of the entropic structure of the nucleus. The connection with the entropic confinement of quarks shows that alpha decay is a partial lifting of confinement.
2. **Cosmology:** Radioactive decays played a key role in energy generation S_θ in the early Universe and continue to contribute to the entropy cascade, although their contribution is small compared to that of the biosphere and noosphere. Radioactivity is the primary source of heat in the planetary interiors, creating a feedback loop with the field S_θ .
3. **Biology:** Radioactive decay is the source of mutations, which in the AU interpretation corresponds to the activation of BBB operators. The biophysical effects of radiation may be related to global field perturbations S_θ , and the presentiment effect may theoretically correlate with radioactive anomalies.
4. **Noosphere:** The use of radioactivity in technology corresponds to the directed generation of thought forms and the activation of III-operators. Radioactive waste disposal is an information-entropic task, and radioactive isotopes can serve as energy sources for directed informational panspermia.
5. **The information paradox of black holes:** radioactive decay and evaporation of black holes have a common information-entropic nature - both processes create thought forms recorded in the AU archive.

Thus, radioactivity in the AU ontology is not an isolated nuclear phenomenon, but **an integral part of a unified information-entropic picture** linking the microworld, macroworld, and biosphere through a field S_θ and a non-local archive of thought forms. In the next chapter, we will move on to a comparison of the AU interpretation of radioactivity with standard quantum theory.

Part IV. Comparison with alternative approaches

Chapter 8. AU vs. Standard Quantum Theory of Radioactivity

In the previous chapters, we presented the AU interpretation of radioactive decay as an irreversible act of recording a thought-form in a non-local AU archive. We developed a mathematical formalism linking the probability of decay to the field S_θ and its gradients, analyzed anomalies in radioactive decay as a consequence of theta-entropy fluctuations, and

examined the relationship of radioactivity to other aspects of the AU. In this chapter, we systematically compare the AU approach with the standard quantum theory of radioactivity—the accepted formalism that describes decay with unprecedented accuracy. The comparison is made along three key dimensions: **ontological foundations**, **explanatory power**, and **predictive power**. We show that, although AU does not reject the mathematical apparatus of quantum mechanics, but embeds it in a deeper information-entropy framework, it offers fundamentally different answers to fundamental questions about the nature of “randomness,” irreversibility, and the arrow of time in radioactive decay.

8.1 Ontological foundations

8.1.1 The Status of Chance: Fundamental vs. Epistemic

In standard quantum theory, radioactive decay is viewed as **a paradigmatic example of ontological randomness**. As noted in contemporary philosophical literature, *"radioactive decay and other quantum-physical phenomena reveal indeterministic processes at the level of elementary physical processes."* This randomness is not a consequence of our ignorance of hidden variables (as in classical statistical mechanics), but rather **a fundamental property** of quantum reality. In the standard approach, radioactive decay *"is intrinsically random and uncaused—it simply happens."*

However, this ontological status of randomness remains subject to interpretation. As modern research shows, *"preferences in interpreting quantum mechanics vary significantly"*: some physicists consider randomness to be merely apparent (5%), others believe that hidden determinism exists (18%), and only a minority recognize randomness as fundamental.

In the AU approach, the "randomness" of radioactive decay receives **a fundamentally different interpretation**: it is **epistemic**, not ontological. The moment of decay appears random to a local observer because it is determined by **field fluctuations** S_Θ that cannot be predicted based on local information. However, at the level of the non-local AU archive, each decay event is a **deterministic entry** in the global information structure.

This interpretation has direct parallels with contemporary attempts to rethink the randomness of decay. The paper "Causal Topology of Radioactive Decay" (2026) proposes *a "causal reinterpretation of radioactive decay within standard quantum theory,"* where *"decay events correspond to fixed nodes in a static causal topology rather than to temporally generated stochastic processes."* In this approach, *"apparent randomness is reinterpreted as epistemic access to an underlying causal structure."* The AU approach goes further, proposing a specific physical carrier of this causal structure—a field S_Θ and a nonlocal archive of thought forms.

8.1.2 The Status of Spacetime: Background vs. Emergent Structure

In standard quantum theory, radioactivity is described against a fixed spacetime background. The Schrödinger equation, which underlies the quantum-mechanical description of decay, is **time-reversal symmetric** and contains no indication of an arrow of time. As noted in a recent

paper, *"the Schrödinger equation is time-symmetric, unlike dissipative systems, where an 'arrow of time' exists."*

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

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

Radioactive decay, as an act of recording a thought-form, **creates a local** field perturbation S_Θ , which, through gradients, ∇S_Θ influences the emergent metric. This means that decay not only occurs in a predetermined space-time, but **actively participates** in its formation.

This interpretation is consistent with contemporary discussions of the nature of time in quantum physics. As Trepp (2025) demonstrates, *"quantum phenomena—indeterminism, wavefunction collapse, the Born rule, and temporal asymmetries in measurement—challenge the static block universe of eternalism and instead elevate the present moment to ontological significance."* The AU approach offers a concrete ontological framework for this temporal asymmetry through kairos time τ .

8.1.3 Irreversibility status: postulated vs. inferred

In standard quantum theory, the irreversibility of radioactive decay **is postulated** (via Fermi's golden rule and the assumption of spontaneity of the transition), but is not derived from fundamental principles. The Schrödinger equation is reversible; irreversibility is introduced through **the phenomenological assumption** that the system "forgets" its history after decay.

As a modern review notes, *"there is general agreement that current quantum theory is incomplete because it does not include interactions with the environment at a fundamental level."* This recognition of incompleteness suggests that irreversibility may not be a fundamental property, but a consequence of the incompleteness of our description.

In the AU approach, the irreversibility of decay **is derived** from the fundamental dynamics of the field S_Θ . Each act of decay is an irreversible recording of a thought-form into the AU archive through **a non-unitary recording operator**, $\hat{\mathcal{W}}$, which violates reversibility at the level of the entire system. Irreversibility arises not from a phenomenological assumption, but from the structure of information dynamics.

8.2 Explanatory power

Phenomenon	Standard quantum theory	AU approach
The nature of "chance"	It is postulated as fundamental	Epistemic (a consequence of non-local structure S_θ)
Exponential law	Derived from Fermi's golden rule	Plays like the limit of AU dynamics
Anomalies in decay rates	Not predicted (considered systematic errors)	Predicted as fluctuations $\nabla S_{\{\Theta\}}^2 \langle \rangle$
Leading correlations	They don't explain	Explained through kairos time
Arrow of time	Postulated (not deduced)	It is derived from the irreversibility of recording thought forms
Connection with consciousness	Absent	Across the field Φ and 27 operators
Connection with cosmology	Absent	Through contribution to Λ_{eff}

As shown in the table, standard quantum theory provides **descriptions**, while AU offers **explanations**. The exponential decay law in standard theory is derived mathematically, but does not explain *why decay is random or irreversible*. AU provides an ontological justification for these properties through the information dynamics of the field S_θ .

8.2.1 Explanation of the nature of "randomness"

In standard quantum theory, the "randomness" of decay is postulated but not explained. As noted in the critical literature, *"modern theories of radioactivity have led to an abuse of the*

concept of statistical law, replacing the principle of causality with mere chance." The question of *"whether atomic disintegration is truly devoid of a determining cause"* remains open.

The AU approach provides a clear answer: "randomness" is a **consequence of the nonlocal structure of the field S_Θ** . The moment of decay is determined by fluctuations δS_Θ that, although they cannot be predicted locally, are part of the global causal structure of the archive of thought forms. This is consistent with modern approaches, where *"apparent randomness is reinterpreted as epistemic access to the underlying causal structure."*

8.2.2 Explanation of the arrow of time

Standard quantum theory provides no explanation for the arrow of time associated with radioactive decay. As Trepp (2025) notes, *"the measurement problem and the randomness of quantum outcomes resist a fully eternalistic description,"* and *"quantum mechanics introduces an arrow of time at a fundamental level."*

The AU approach provides a concrete explanation: the arrow of time arises from **the irreversibility of recording a thought-form** in the AU archive. Each act of decay increases S_Θ and advances the system along kairos time τ . This links the thermodynamic arrow of time (increasing entropy) with the informational arrow (increasing S_Θ) and the cosmological arrow (expanding the Universe) through a unified field dynamic S_Θ .

8.3 Predictive power

8.3.1 Standard Theory: High Accuracy, but Limited Coverage

The standard quantum theory of radioactivity possesses **unrivalled predictive power** in its domain of applicability. Half-lives are calculated with precision sufficient for geochronology, nuclear medicine, and astrophysics. As noted in recent studies, *"government studies point to discrepancies between experimental data and Standard Model expectations,"* spurring the search for new physics.

However, the standard theory **does not predict**:

- **Anomalies in decay rates** (seasonal variations, correlations with solar activity) are considered systematic errors or artifacts.
- **Advanced correlations** between decay rates and future events (e.g. solar flares) have no explanation within local quantum theory.
- **Deviations from Poisson statistics** are not predicted, although they are not completely excluded.
- **connection between radioactivity and consciousness** or cognitive processes.

8.3.2 AU: Additional Predictions

The AU approach offers **additional testable predictions** beyond the standard theory:

Prediction	Experimental verification	Expected value
Correlations with TRNG anomalies	Synchronization of decay rate measurements with GCP data	$\rho \sim 0.1-0.3$
Modulation of decay rates	Precision measurements ^{55}Fe , ^{60}Co	$\Delta\lambda/\lambda \sim 10^{-4}-10^{-3}$
Leading correlations	Measurements before solar flares	30-155 hours lead time
Deviations from Poisson statistics	Experiments with high statistics	$\epsilon \sim 10^{-6}-10^{-4}$
Entropic windows for decay	Tc-99m: $0.5 < S_2 < 1.5\text{nat}$	Coherence threshold 660 attoseconds

Particularly important is the prediction **of advanced correlations** —that decay rates begin to deviate tens of hours before solar flares. This prediction is **unique to the AU approach** and has no analogue in standard quantum theory. As shown in Chapter 6, such correlations have already been observed in experiments by Mayburov et al. (2025) with a 90% confidence level.

8.3.3 Coherence threshold and entropy windows

Modern information-entropy studies of radioactivity, although not directly related to the AU hypothesis, provide **empirical support** for its key predictions.

In the technetium-99m paper (2025), a *"statistically robust inverse correlation ($\rho = -0.76 \pm 0.05$, $p < 0.001$) between the Renyi-2 entropy and the purity of the quantum state" was established. A "660-attosecond coherence threshold for beta decay", "high-purity emissions (98% at 0.25 nat entropy)", and a "quantum Goldilocks zone ($0.5 < S_2 < 1.5 \text{ nat}$)" governing the decay modes were predicted.*

In the AU formalism, these entropy windows correspond to **critical values** of field coherence S_θ at which the decay probability is highest. The coherence threshold of 660 attoseconds corresponds to the time during which the field S_θ maintains sufficient coherence to maintain the nucleus in an unstable state before decay.

8.3.4 Comparison with alternative approaches

Approach	Explains the coincidence	Explains irreversibility	Explains anomalies	Predicts an advance	Connection with cosmology
Standard CT	Postulates	Postulates	No	No	No
Hidden variables	Excludes	Postulates	Partially	No	No
Collapse theories (GRW)	Postulates	Outputs	Partially	No	No
Causal topology	Reinterprets	Postulates	Partially	No	No
AU approach	Explains	Outputs	Yes	Yes	Yes

As shown in the table, the AU approach is **the only one** that:

1. **Explains** the nature of randomness (through epistemic access to S_Θ), rather than simply postulating it.
2. **Deduces** irreversibility (from the non-unitary recording of the thought-form), rather than postulating it.
3. **Explains** all three types of anomalies (periodic variations, leading correlations, sporadic deviations) through a single fluctuation mechanism S_Θ .
4. **Predicts** the leading nature of correlations (through signal propagation in kairos time).
5. **Links** radioactivity to cosmology (through its contribution to Λ_{eff} the entropy cascade).

8.4 Summary

A comparison of the AU approach with the standard quantum theory of radioactivity reveals both common features and fundamental differences:

1. **General formalism:** AU does not reject the mathematical apparatus of the quantum theory of radioactivity, but rather integrates it into a deeper information-entropy framework. The exponential decay law is reproduced as the limit of AU dynamics at constant field gradients S_Θ .
2. **Ontological difference:** standard quantum theory postulates randomness, irreversibility, and spacetime as fundamental; AU derives them from field dynamics S_Θ and a nonlocal archive of thought forms. "Randomness" becomes epistemic, irreversibility a consequence of nonunitary recording, and spacetime emergent.
3. **Explanatory power:** Standard quantum theory describes *how* radioactive decay occurs; AU explains *why* it occurs this way—through information optimization, entropy balance, and non-local archival memory. AU explains the arrow of time, anomalies in decay rates, and advanced correlations.
4. **Predictive power:** Standard quantum theory provides highly accurate predictions for decay probabilities, but does not predict anomalies, advanced correlations, or connections to consciousness. AU offers **additional testable predictions** (correlations with TRNGs, entropy windows, and a coherence threshold) that distinguish it from standard theory and make it a falsifiable hypothesis.
5. **Unity of Physics:** While the standard quantum theory of radioactivity remains isolated from other branches of physics, AU offers **a unified ontological basis** for radioactivity, atomic structure, cosmology, biology, and field theory of consciousness S_Θ .

Thus, the AU approach is not a simple alternative to the standard quantum theory of radioactivity. It represents **a fundamentally different ontological paradigm**, in which quantum theory emerges as an effective description of the information field dynamics S_Θ at nuclear scales. This allows us to resolve conceptual problems with the standard theory—the nature of "randomness," the origin of irreversibility, and its connection to cosmology—while simultaneously providing new testable predictions that pave the way for empirical verification of the information-entropy paradigm.

Part V. Conclusion

Chapter 9. Main results

This paper presents a systematic exposition of the AU interpretation of natural radioactivity within the framework of the Acta Universi hypothesis—an information-ontological paradigm in which the fundamental entity is the entropy field of thoughtforms S_Θ , and radioactive decay is interpreted as the irreversible act of recording a thoughtform in a non-local AU archive. In this final chapter, we summarize the main results of the study, demonstrating that the AU approach offers a consistent, mathematically rigorous, and testable explanation for the statistical nature

of radioactive decay, its anomalies, and its connection to fundamental problems of time and cosmology.

9.1 Ontological interpretation of radioactive decay

Within the AU approach, radioactive decay ceases to be an isolated quantum process with inexplicable “randomness” and becomes **an integral part of the global informational dynamics** of the field S_Θ and the non-local archive of thought forms.

Key ontological results:

1. **Informational monism:** the fundamental entity is the entropy field of thought-forms S_Θ , and radioactive decay is interpreted as an irreversible act of recording a thought-form in a non-local AU archive. Each act of decay creates a localized perturbation of the field S_Θ and increases the total informational entropy of the system.
 2. **"Randomness" as an epistemic property:** Unlike standard quantum theory, where randomness is postulated as fundamental, in the AU approach it is **epistemic** — a consequence of the fact that the moment of decay is determined by field fluctuations S_Θ that cannot be predicted based on local information. At the level of the non-local AU archive, each decay event is a deterministic record.
 3. **Irreversibility as a consequence of notation:** the irreversibility of radioactive decay is derived from **the non-unitary notation operator** $\widehat{W}$, which records the decay event in the AU archive. This distinguishes the AU approach from standard quantum theory, where irreversibility is postulated but not derived from fundamental principles.
 4. **Kairos time as a fundamental arrow:** radioactive decay increases S_Θ and advances the system along kairos time τ , defined by $d\tau = \frac{1}{N}(dt + \lambda dS_\Theta + \mu d\phi_{\text{braid}})$. This links the thermodynamic, cosmological, and psychological arrows of time through a unified informational dynamic.
-

9.2 Mathematical formalism

A closed mathematical formalism was developed that linked radioactive decay with field dynamics S_Θ :

1. **Equation for the field S_Θ with a source from decay:**

$$\square S_\Theta + m_S^2 S_\Theta + \lambda_S S_\Theta^3 + \int K(x, y) S_\Theta(y) d^4 y = J_{\text{decay}}(x),$$

where for a separate act of decay $J_{\text{decay}}(x) = \Delta S_\Theta \delta^{(4)}(x - x_0)$.

2. **Probability of decay via local field coherence:**

$$\lambda = \gamma \cdot \langle |\nabla S_\theta|^2 \rangle_{\text{ядро}} \cdot \mathcal{F} \left(\frac{\Delta S_\theta}{S_{\text{crit}}} \right),$$

where $\langle |\nabla S_\theta|^2 \rangle_{\text{ядро}}$ is the mean square of the field gradient S_θ in the core region. **The decay probability is proportional to the square of the field gradient S_θ** —the higher the field coherence, the lower the decay probability.

3. **Half life:**

$$T_{1/2} = \frac{\ln 2}{\gamma} \cdot \frac{S_{\text{crit}}}{\Delta S_\theta} \cdot \frac{1}{\langle |\nabla S_\theta|^2 \rangle_{\text{ядро}}}.$$

4. **The non-local core $K(x, y)$** creates correlations between decay events:

$$C_{\text{decay}}(x, y) \supset K(x, y) \cdot \langle \Delta S_\theta(x) \Delta S_\theta(y) \rangle,$$

which leads to small deviations from Poisson statistics ($\epsilon \sim 10^{-6} - 10^{-4}$).

5. **The exponential law** is reproduced as the limit of AU dynamics at constant field gradients S_θ : $N(t) = N_0 e^{-\lambda t}$.
6. **Relationship with Renyi entropy:** $S_2 \propto -\log_2 \langle |\nabla S_\theta|^2 \rangle_{\text{ядро}}$, which explains the inverse correlation between Renyi-2 entropy and quantum state purity ($\rho = -0.76 \pm 0.05$) for technetium-99m.
7. **The coherence threshold** of 660 attoseconds for beta decay corresponds to the time during which the field S_θ maintains sufficient coherence to maintain the nucleus in an unstable state.

9.3 Explanation of anomalies in radioactive decay

The AU approach offers a **unified explanation** for all three types of anomalies in radioactive decay as consequences of field fluctuations S_θ :

1. **Periodic variations** (seasonal, annual, daily) at the level 10^{-4} are 10^{-3} interpreted as a consequence of periodic changes $\langle |\nabla S_\theta|^2 \rangle_{\text{ядро}}$ due to the movement of the Earth, solar activity and the daily rhythms of the collective consciousness.
2. **Correlations with solar flares** with deviations of 0.2–0.4% and **advances of 30–155 hours** (Mayburov et al., 2025) are explained through **signal propagation in kairos time**. The Green's function for the field S_θ contains an advanced component, allowing fluctuations from a future event to influence the present.
3. **Sporadic anomalies** (Parkhomov effect, ultrasound-induced decay) are interpreted as local fluctuations S_θ caused by external influences.

Key prediction: the advanced nature of the correlations is a **direct consequence** of the signal propagation through kairos time and distinguishes the AU approach from all alternative explanations (systematic errors, solar neutrinos, ultra-light dark matter).

9.4 Relationship with other AU sections

Radioactivity in AU-ontology is **an integral part of the unified information-entropy picture**:

1. **Atomic structure:** the nucleus is interpreted as a region of high density S_Θ , and radioactive decay is a relaxation of the entropic structure of the nucleus. Alpha decay is a partial lifting of the entropic confinement of quarks.
 2. **Cosmology:** Radioactive decays played a key role in the generation S_Θ of the early Universe. The contribution of radioactivity to Λ_{eff} is estimated at $\Delta S_\Theta^{(\text{total})} \sim 10^{60} - 10^{70} k_B$, which, although small compared to the holographic limit ($S_{\text{holo}} \sim 10^{122} k_B$), was significant in the early Universe.
 3. **Biology:** Radioactive decay is the source of mutations, which in the AU interpretation corresponds to the activation of BBB operators. The probability of mutation is proportional to $\langle |\nabla S_\Theta|^2 \rangle_{\text{ДНК}} \cdot \Delta S_\Theta^{(\text{decay})}$.
 4. **Noosphere:** The use of radioactivity in technology corresponds to the directed generation of thought forms and the activation of III-operators. Radioactive waste disposal is an information-entropic task.
 5. **The information paradox of black holes:** radioactive decay and evaporation of black holes have a common information-entropic nature - both processes create thought forms recorded in the AU archive.
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9.5 Comparison with standard quantum theory

Criterion	Standard quantum theory	AU approach
The status of chance	It is postulated as fundamental	Epistemic (consequence S_Θ)
Irreversibility status	It is postulated	Derived from non-unitary notation
The status of space-time	Fundamental background	Emergent from S_Θ

Criterion	Standard quantum theory	AU approach
Explanation of anomalies	Not predicted	Predicted as fluctuations S_Θ
Explaining Leading Correlations	Absent	Through kairos time
Explanation of the arrow of time	Absent	Through growth S_Θ
Connection with cosmology	Absent	Through Λ_{eff}
Connection with consciousness	Absent	Through Φ and 27 operators

As shown in the table, the AU approach is **the only one** that:

1. **Explains** the nature of randomness (through epistemic access to S_Θ), rather than simply postulating it.
2. **Deduces** irreversibility (from the non-unitary recording of the thought-form), rather than postulating it.
3. **Explains** all three types of anomalies through a single fluctuation mechanism S_Θ .
4. **Predicts** the leading nature of correlations (via kairos time).
5. **Links** radioactivity to cosmology, biology and theory of consciousness.

9.6 Testable Predictions

The AU approach makes specific testable predictions:

Prediction	Experimental verification	Expected value
Correlations with TRNG anomalies	Synchronization of decay rate measurements with GCP data	$\rho \sim 0.1-0.3$
Modulation of decay rates	Precision measurements ^{55}Fe , ^{60}Co	$\Delta\lambda/\lambda \sim 10^{-4}-10^{-3}$

Prediction	Experimental verification	Expected value
Leading correlations	Measurements before solar flares	30-155 hours lead time
Deviations from Poisson statistics	Experiments with high statistics	$\epsilon \sim 10^{-6}-10^{-4}$
Entropic windows for decay	Tc-99m: $0.5 < S_2 < 1.5\text{nat}$	Coherence threshold 660 attoseconds
Correlations with geomagnetic variations	Measurements in different geomagnetic conditions	$\Delta\lambda/\lambda \sim 10^{-5}-10^{-4}$
Dependence on coherent thought forms	Measurements in the presence of meditation	$\Delta\lambda/\lambda \sim 10^{-5}-10^{-4}$

9.7 Final assessment

The Acta Universi hypothesis proposes a **fundamentally new information-entropy paradigm** for understanding natural radioactivity. Unlike standard quantum theory, which describes decay statistics but fails to explain the nature of "randomness," irreversibility, and the arrow of time, the AU hypothesis proposes:

1. **A clear ontological status** for the "randomness" of radioactive decay (an epistemic property following from the non-local structure of the field S_Θ).
2. **The derivable irreversibility is achieved** through a non-unitary recording operator $\hat{W}$ that records the act of decay in the AU archive.
3. **Explanation of the arrow of time** through kairos time τ , determined by growth S_Θ .
4. **A unified explanation** for all three types of anomalies in radioactive decay (periodic variations, advanced correlations, sporadic deviations) through field fluctuations S_Θ .
5. **The connection of radioactivity with cosmology**, biology and the theory of consciousness through the unified field S_Θ and non-local archive of thought forms.
6. **Testable predictions** for precision radioactivity experiments synchronized with TRNG measurements and cognitive protocols.

Like any scientific hypothesis, the AU must be verified by observations and critically assessed by the scientific community. If its predictions are confirmed—especially the advanced correlations

with solar flares and correlations with TRNG anomalies—this will be a strong argument in favor of an information-entropy ontology, where radioactivity, consciousness, and cosmological evolution 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 AU radioactivity

A.1 Complete equation for the field S_Θ with a source from decay

Within the framework of the AU formalism, the dynamics of the entropy field of thought forms S_Θ is described by a nonlinear equation with a nonlocal kernel:

$$\square S_\Theta + m_s^2 S_\Theta + \lambda_s S_\Theta^3 + \int K(x, y) S_\Theta(y) d^4 y = J_{\text{total}}(x),$$

where $\square = \eta^{\mu\nu} \partial_\mu \partial_\nu$ is the d'Alembert operator, m_s is the effective mass of the field, λ_s is the constant of nonlinear self-action, and $K(x, y)$ is the nonlocal kernel describing the memory of the archive of thought forms.

A.1.1 Derivation of the equation from the AU Lagrangian

The equation for S_Θ is derived from the variation of the full AU Lagrangian (version 2026.3). The key sectors of the Lagrangian are:

$$\mathcal{L}_S = \frac{1}{2} (\partial_\mu S_\Theta)^2 - V(S_\Theta), \quad V(S_\Theta) = \frac{1}{2} m_s^2 S_\Theta^2 + \frac{\lambda_s}{4} S_\Theta^4 + \frac{\gamma_s}{2} S_\Theta^2 \Phi^2,$$

$$\mathcal{L}_\Phi = \frac{1}{2} (\partial_\mu \Phi)^2 - V(\Phi) + \mu_\Phi \Phi S_\Theta,$$

$$\mathcal{L}_{\text{mat}} = \mathcal{L}_{SM} + \kappa_\psi S_\Theta \bar{\psi} \psi + \kappa_\Phi \Phi \bar{\psi} \psi + \dots,$$

$$S_{\text{nonlocal}} = \frac{1}{2} \int d^4 x d^4 y \sqrt{-g(x)} \sqrt{-g(y)} S_\Theta(x) K(x, y) S_\Theta(y).$$

Variation with respect to S_Θ gives the equation of motion.

A.1.2 Source from radioactive decay

The complete source $J_{\text{total}}(x)$ includes all irreversible acts of thought-form recording. In the context of radioactivity:

$$J_{\text{total}}(x) = J_{\text{background}}(x) + J_{\text{decay}}(x).$$

For a single act of decay at point x_0 :

$$J_{\text{decay}}(x) = \Delta S_{\Theta} \delta^{(4)}(x - x_0),$$

where ΔS_{Θ} is the increase in theta entropy associated with the decay act.

For an ensemble of decaying nuclei with density $\rho_{\text{nuclei}}(r)$ and decay constant λ :

$$J_{\text{decay}}(x) = \lambda \rho_{\text{nuclei}}(r) \Delta S_{\Theta} e^{-\lambda t} \delta^{(3)}(r - r_0).$$

A.1.3 Solution for a single decay event

In the local approximation ($K = 0$, $\lambda_S = 0$) and in the static case:

$$S_{\Theta}(r) = S_0 + \frac{\Delta S_{\Theta}}{4\pi r} e^{-m_S r},$$

where S_0 is the background value of the field, and $r = |r - r_0|$.

Taking into account the non-local kernel $K(x, y)$:

$$S_{\Theta}(r) = S_0 + \frac{\Delta S_{\Theta}}{4\pi r} e^{-r/R_c},$$

where is the effective radius:

$$R_c \sim \frac{1}{\sqrt{m_S^2 + \alpha_{\text{nl}}/r_c^2}},$$

a α_{nl} is the nonlocal coupling constant.

A.2 Probability of decay through a field S_{Θ}

A.2.1 Derivation of the formula for the decay constant

The probability of decay per unit time is determined by the local coherence of the field S_{Θ} in the region of the nucleus:

$$\lambda = \gamma \cdot \langle |\nabla S_{\Theta}|^2 \rangle_{\text{ядро}} \cdot \mathcal{F}\left(\frac{\Delta S_{\Theta}}{S_{\text{crit}}}\right),$$

Where:

- γ — a constant determined by the parameters of the AU field;
- $\langle |\nabla S_{\Theta}|^2 \rangle_{\text{ядро}}$ — the mean square of the field gradient S_{Θ} in the core region;
- $\mathcal{F}(\Delta S_{\Theta}/S_{\text{crit}})$ — a function describing the dependence of the decay probability on the ratio of the entropy increase ΔS_{Θ} to the critical entropy S_{crit} .

In the simplest case, $\mathcal{F}(x) \approx x$ for small x :

$$\lambda \approx \gamma \cdot \frac{\Delta S_{\Theta}}{S_{\text{crit}}} \cdot \langle |\nabla S_{\Theta}|^2 \rangle_{\text{ядро}}.$$

A.2.2 Derivation from Fermi's Golden Rule

A more rigorous derivation follows from the modified Hamiltonian:

$$\hat{H}_{\text{AU}} = \hat{H}_0 + \hat{H}_{\text{int}},$$

Where $\hat{H}_{\text{int}} = \kappa_{\text{nuc}} S_{\Theta} \bar{\psi}_{\text{nuc}} \psi_{\text{nuc}} + \kappa_{\text{decay}} \partial_{\mu} S_{\Theta} \partial^{\mu} S_{\Theta} \bar{\psi}_{\text{decay}} \psi_{\text{decay}}$.

Transition probability:

$$\Gamma_{i \rightarrow f} = \frac{2\pi}{\hbar} | \langle f | \hat{H}_{\text{AU}} | i \rangle |^2 \rho(E_f).$$

As a result:

$$\lambda \propto \langle | \nabla S_{\Theta} |^2 \rangle_{\text{ядро}} \cdot | M_{if} |^2,$$

where M_{if} is the standard nuclear matrix element.

A.2.3 Half-life

$$T_{1/2} = \frac{\ln 2}{\lambda} = \frac{\ln 2}{\gamma} \cdot \frac{S_{\text{crit}}}{\Delta S_{\Theta}} \cdot \frac{1}{\langle | \nabla S_{\Theta} |^2 \rangle_{\text{ядро}}}.$$

A.3 Nonlocal core and correlations

A.3.1 Non-local kernel shape

$$K(x, y) = \alpha_{\text{nl}} \frac{e^{-|x-y|/r_c}}{|x-y|},$$

where α_{nl} is the nonlocal coupling constant, and r_c is the crossing-over scale.

A.3.2 Correlation function of decay events

$$C_{\text{decay}}(x, y) = \langle \delta S_{\Theta}(x) \delta S_{\Theta}(y) \rangle,$$

Where $\delta S_{\Theta} = S_{\Theta} - S_0$.

In the presence of a non-local nucleus:

$$C_{\text{decay}}(x, y) \supset K(x, y) \cdot \langle \Delta S_{\Theta}(x) \Delta S_{\Theta}(y) \rangle.$$

A.3.3 Deviations from Poisson statistics

Probability $P(N)$ of observing N decays over time t :

$$P_{\text{AU}}(N) = P_{\text{Poisson}}(N) \cdot (1 + \epsilon(N, \alpha_{\text{nl}}, r_c, t)),$$

where ϵ is a small correction depending on the parameters of the non-local kernel:

$$\epsilon \sim \alpha_{\text{nl}} \frac{r_c}{L} \cdot \mathcal{O}(1),$$

where L is the characteristic size of the system. For typical values $\alpha_{nl} \sim 10^{-5}$ of and $r_c \sim 10^3$ m:

$$\epsilon \sim 10^{-6} - 10^{-4}.$$

A.4 Connection with Renyi entropy

A.4.1 Definition of the Renyi-2 entropy

$$S_2 = -\log_2 \text{Tr}(\rho^2),$$

where ρ is the state density matrix.

A.4.2 Connection with the field S_Θ

$$S_2 \propto -\log_2 \langle |\nabla S_\Theta|^2 \rangle_{\text{ядро}}.$$

A.4.3 Coherent decay threshold

$$\tau_{\text{когерентности}} = \frac{\hbar}{\Delta E_{\text{когерентности}}},$$

Where:

$$\Delta E_{\text{когерентности}} \propto \frac{\hbar}{\tau_c} \propto \langle |\nabla S_\Theta|^2 \rangle_{\text{ядро}}.$$

For technetium-99m, the predicted threshold is $\tau_{\text{когерентности}} = 660$ attoseconds.

A.5 Connection with Kairos Time

A.5.1 Definition of Kairos Time

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

A.5.2 Contribution of radioactive decay

$$\Delta\tau_{\text{decay}} = \frac{\lambda}{N} \Delta S_\Theta^{(\text{decay})}.$$

A.5.3 Speed of Kairos Time

$$\frac{d\tau}{dt} = \frac{1}{N} \left(1 + \lambda \frac{dS_\Theta}{dt} + \mu \frac{d\phi_{\text{braid}}}{dt} \right) > 0.$$

A.6 Green's function with an advanced component

For a field S_Θ with a non-local kernel, the Green's function contains an advanced component:

$$G_{\text{ret}}(x - y) \sim \Theta(t_x - t_y) e^{-(t_x - t_y)/\tau_c} + \Theta(t_y - t_x) e^{-(t_y - t_x)/\tau_c} \mathcal{K}_{\text{nl}}.$$

The second term corresponds to the propagation of the signal **back in time** in chronos, but preserving causality in the kairos sense.

Appendix B. Experimental Protocols

B.1 Checking correlations with solar activity

The purpose of the experiment is to test the AU prediction of advanced correlations between radioactive decay rates and solar flares.

Experimental setup:

1. **Detectors:** High-precision scintillation detectors for measuring count rates ^{55}Fe and ^{60}Co .
2. **Isolation:** Detectors are enclosed in lead shielding to minimize external influences.
3. **Solar activity monitoring:** GOES and SOHO solar flare data.

Procedure:

1. Continuous measurement of count rates (24/7) with a time resolution ~ 1 of hours.
2. Synchronization with solar activity data.
3. Search for correlations between count rate deviations and solar flares using time delay analysis.

Expected result: deviations in decay rates at a level $\Delta\lambda/\lambda \sim 10^{-3}$ of 30–155 hours before solar flares.

B.2 Testing correlations with TRNG anomalies

The aim of the experiment is to test the AU prediction about the correlations between radioactive decay rates and TRNG anomalies (GCP data).

Experimental setup:

1. **Detectors:** Precision detectors for measuring decay rates (e.g. ^{55}Fe).
2. **TRNGs:** standard random number generators (GCP network).
3. **Synchronization:** common time for both types of measurements.

Procedure:

1. Continuous measurement of decay rates and TRNG data.
2. Cross-correlation analysis of two time series.

3. Search for correlations during periods of significant global events.

Expected result: correlation $\rho \sim 0.1$ between 0.3 decay rates and TRNG anomalies.

B.3 Testing for deviations from Poisson statistics

The purpose of the experiment was to detect small deviations from Poisson statistics in the distribution of decay events.

Experimental setup:

1. **Detector:** High performance detector with $\sim 100\%$ registration efficiency.
2. **Source:** isotope with a half-life of ~ 1 one year (e.g. ^{60}Co).
3. **Statistics:** accumulation $> 10^9$ of events.

Procedure:

1. Measuring the time intervals between successive decays.
2. Comparison of interval distribution with exponential distribution.
3. Search for systematic deviations.

Expected result: deviations at the level $\epsilon \sim 10^{-6}$ from 10^{-4} the exponential distribution.

Appendix B. Glossary of Basic Concepts

B.1 Basic terms

Term	Definition
Entropy field of thought forms S_Θ	The fundamental information-entropy field of the Acta Universi hypothesis; the primary entity from which space-time, matter, and gauge fields emerge
Thought form	A metaphor for any irreversible act of recording information into an AU archive; a quantum of entropy ΔS_Θ ; a localized source in the field S_Θ
AU archive	A non-local information structure in which all thought forms (events) are recorded

Term	Definition
Kairos Time τ	A monotonic parameter associated with the growth of theta entropy; $d\tau = \frac{1}{N}(dt + \lambda dS_{\Theta} + \mu d\phi_{\text{braid}})$
Chronost	Coordinate, measurable time; an emergent property of space-time
Non-local kernel $K(x, y)$	A function that describes the memory of the archive of thought forms and provides long-range correlations between events
Configurational entropy	A measure of shape complexity used to predict decay rates; constructed from the Fourier transform of the atomic probability density function
Renyi entropy-2	$S_2 = -\log_2 \text{Tr}(\rho^2)$; a measure of the purity of a quantum state
Coherent threshold	The minimum coherence time required to maintain a nucleus in an unstable state before decay
Leading correlation	Correlation between a future event and a present measurement explained by signal propagation in kairos time

B.2 Symbols and designations

Symbol	Description	Dimension
S_{Θ}	Entropy field of thought forms	[J/K]
S_{holo}	Holographic Limit	[J/K]
S_{crit}	Critical entropy	[J/K]
ΔS_{Θ}	Theta entropy increase during decay	[J/K]
λ	Decay constant	[With $^{-1}$]

Symbol	Description	Dimension
$T_{1/2}$	Half life	[With]
γ	Coupling constant in the AU formalism	[indefinite]
$K(x, y)$	Non-local kernel	[indefinite]
τ	Kairos Time	[With]
t	Chronos (coordinate time)	[With]
Φ	Integral information	[bit]
S_2	Renyi entropy-2	[nat]

B.3 Abbreviations

- **AU** — Acta Universi
- **TRNG** — True Random Number Generator
- **GCP** — Global Consciousness Project
- **RNG** — Random Number Generator (Generator random numbers)
- **IIT** — Integrated Information Theory
- **QED** — Quantum Electrodynamics

Appendix G. Mathematical formalism: decay probability and field S_Θ

G.1. Effective action of an unstable nucleus

After integration over fast nuclear degrees of freedom, the effective action of an unstable nucleus in the presence of fields S_Θ takes Φ the form

$$S_{\text{nuc}} = \int d^4x \sqrt{-g} \{ \bar{\psi} (i\gamma^\mu D_\mu - m - g_S S_\Theta - g_\Phi \Phi - i\gamma^5 g_A S_\Theta) \psi + \mathcal{L}_{\text{int}} \}.$$

The terms $g_S S_\theta$ and $g_\Phi \Phi$ shift the effective mass and the level width, and the pseudoscalar contribution affects the CP structure of the transition (essential for β -decay).

G.2. Modified decay constant

In standard theory, the decay constant λ_0 is determined by the transition matrix element and the density of final states. In AU, it becomes an effective quantity dependent on the local state of the information field. In the leading order for small deviations of the fields from background values, we obtain

$$\lambda = \lambda_0 \left\{ 1 + \alpha_S (S_\theta - S_{\theta,0}) + \alpha_\Phi (\Phi - \Phi_0) + \beta_S (\partial_\mu S_\theta) (\partial^\mu S_\theta) + \gamma_K \int K(x, y) \delta S_\theta(y) d^4 y + \dots \right\}.$$

Here λ_0 is the laboratory value of the decay constant; α_S, α_Φ are the coupling constants determined by the variation of the matrix element; β_S is the contribution of the gradient terms; γ_K is the coefficient of the nonlocal contribution through the kernel $K(x, y)$.

Under typical laboratory conditions, the first two terms dominate:

$$\lambda \approx \lambda_0 [1 + \alpha_S \delta S_\theta + \alpha_\Phi \delta \Phi].$$

G.3. Connection with Kairos Time

Each decay event increases the theta entropy by an amount

$$\delta S_\theta^{\text{decay}} = \xi \hbar \omega_{\text{char}},$$

where ω_{char} is the characteristic energy scale of decay. Therefore, the decay constant can be rewritten in terms of the rate of advancement along kairos time:

$$\lambda = \lambda_0 \left(1 + \tilde{\alpha} \frac{d\tau}{dt} + \dots \right).$$

In regions with accelerated kairos time (high $\dot{S}_\theta$) the effective decay rate changes slightly.

G.4. Restrictions on coupling constants

The current accuracy of half-life measurements (relative accuracy 10^{-5} – 10^{-7} for many isotopes) imposes a strict limitation:

$$|\alpha_S \delta S_\theta|, |\alpha_\Phi \delta \Phi| \lesssim 10^{-5} - 10^{-7}$$

under normal laboratory conditions. Entropic corrections must be small, otherwise they would have already been detected in precision experiments.

G.5. Prediction for possible anomalies

If the observed variations in decay rates at the level 10^{-3} - 10^{-4} turn out to be real, they correspond

$$\alpha_S \delta S_\Theta \sim 10^{-3}-10^{-4}.$$

In this case, AU provides a natural mechanism through fluctuations S_Θ . If the variations are artifacts, the formula simply fixes an upper limit on the coupling constants α_S and α_Φ .

Thus, the statistical nature of radioactive decay in the AU approach is a consequence of the quantum structure of the field S_Θ and the irreversibility of recording acts, and possible small deviations from standard behavior are determined by the local and non-local state of the information field.

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