

Fundamental Constants as Emergent Functionals in the Acta Universi Hypothesis

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Introduction

1.1 Fundamental Physical Constants: The Problem of Origin and Fine-Tuning

Fundamental physical constants—the speed of light c , Planck's constant $\hbar$, the gravitational constant G , the electron charge e , the masses of elementary particles, the interaction constants (α , G_F , α_s), and the cosmological constant Λ —form the backbone of modern physics. They determine the scales of all known interactions, the structure of atoms and molecules, the evolution of stars and galaxies, and the global dynamics of the Universe. However, within the Standard Model of particle physics and general relativity, these constants are introduced as **external, postulated parameters** whose numerical values are not derived from theory, but rather from experiment. This state of affairs gives rise to three interrelated fundamental problems that have challenged theoretical physics for decades.

The first problem is hierarchical. Why do the constants have such different orders of magnitude? The gravitational constant G is 39 orders of magnitude weaker than the electromagnetic force; $M_{\text{Pl}} \sim 10^{19}$ the GeV Planck mass exceeds the masses of known particles by 17 orders of magnitude; the weak interaction (G_F) is 5 orders of magnitude weaker than the electromagnetic force; and the cosmological constant Λ is 120 orders of magnitude weaker than the predictions of quantum field theory. This hierarchy appears unnatural and requires either fine-tuning, new symmetries, or dynamical mechanisms lacking in the standard paradigm.

The second problem is fine-tuning. Even if we accept the values of the constants as empirical facts, the question remains: why did the Universe end up with precisely the set of parameters that allows for the existence of complex structures, life, and consciousness? The slightest change α (in the fine structure constant) or in the nucleon-to-electron mass ratio would make it impossible for atoms, stars, or heavy elements to form. This anthropic implication is traditionally either ignored or explained by a multiverse, which yields no testable predictions.

The third problem is the cosmological constant. The observed value of $\Lambda \approx 10^{-52} \text{m}^{-2}$ is 120 orders of magnitude smaller than theoretical estimates of the vacuum energy in quantum field theory. This discrepancy—the largest in physics—remains unresolved within the Standard Model and most approaches to quantum gravity. Attempts to explain it using supersymmetry, the anthropic principle, or screening mechanisms either fail to fully work or fail to yield testable consequences.

1.2. Variations of Fundamental Constants as a Window into New Physics

In recent decades, the realization that constants may not be absolutely invariant has led to the emergence of an entire field of research— **the physics of variations of fundamental constants** . Any observed change in a constant over time or space would be direct evidence of the existence of new fields or interactions beyond the Standard Model and General Relativity. Such variations signal a violation of local positional invariance, weak equivalence, or other fundamental principles, opening a window into high-energy physics and cosmology.

Modern experimental constraints on the variations of the constants are becoming increasingly stringent. Atomic clocks based on optical transitions (Yb^+ , Sr , Al^+) allow us to measure relative changes α with an accuracy of up to 10^{-18} 1/year [Uzan, 2025]. Quasar spectroscopy imposes constraints on $\Delta\alpha/\alpha$ the level 10^{-5} – 10^{-6} on cosmological scales [Muller et al., 2026]. Pulsar timing imposes a limit of $\dot{G}/G < 10^{-12}$ 1/year. Data on nucleosynthesis and the cosmic microwave background radiation constrain the variations of the constants in the early Universe. All these measurements have not yet detected statistically significant deviations from constancy, but their accuracy continues to improve, and any future deviation will be a revolutionary discovery.

In 2025–2026, a number of papers appeared that offer new interpretations of existing data or predict possible variations. The paper **“A sub-ppm upper limit on the cosmological variations of the fine structure constant α ”** [Muller et al., 2026] sets an upper limit at the sub-ppm level for variations α based on quasar spectroscopy, which significantly constrains models with strong evolution of the constants. **A cosmographic analysis of the variations α** [Martins, 2025] shows that the data do not provide statistically significant evidence for variations, but allow for slow evolution. The paper **“Cosmic Acceleration from a Simultaneous Variation of Fundamental Constants”** [Malavika & Chakrabarti, 2026] proposes that simultaneous variation G can m_e explain late cosmic acceleration without introducing dark energy. The study **“Refining fundamental constants with white dwarfs”** [Uniyal et al., 2025] uses machine learning to extract constraints on $\Delta\alpha/\alpha$ from white dwarf spectra, achieving an accuracy of 10^{-7} .

Of particular note is the paper **“Constant Drift, Background Temperature, and a 2026 Prediction for Fundamental Constants”** [Wang, 2026], which offers an interpretation of the shift in CODATA's recommended values between 2018 and 2022 as a manifestation of a systematic drift of the constants over time. The author predicts that CODATA 2026 will yield $\alpha^{-1} \approx 137.035999270$, with decreasing α and increasing electron and proton masses. This prediction is a striking example of how trend analysis in precision measurements can reveal the dynamics of the constants.

Another important approach is **the Running Vacuum Model (RVM)**, developed by Joan Solà Peracaula and co-workers [Solà Peracaula, 2026]. In this model, the vacuum energy density is a function of the Hubble parameter H and its derivatives: $\rho_{\text{vac}}(H, \dot{H}, \ddot{H}, \dots)$, which leads to dynamical dark energy and the evolution of the effective gravitational constant $G = G(\ln H)$. The RVM is naturally consistent with the DESI 2025 data, which favor dynamical dark energy over the hard Λ term, and provides an explanation for Hubble tension through the evolution of G .

Additionally, **emergent constant theories are emerging**, where all fundamental parameters are derived from a single vacuum or information principle. **Temporal Geometry** [2025] proposes a "Vacuum Unity Constant" as the common root of all constants. **Emergent Coherence** [2025] derives constants as coherence-decay relations in quantum systems. **The First Geometry** [Michels, 2025] argues that constants are geometrically necessary via a tetrahedral lattice. **“Structural Variation and the Phenomenology of Physical Constants”** [Ahaneku, 2026]

introduces a scalar structure field that links spatial and temporal variations of constants into a single pattern.

These approaches, although differing in their mathematical apparatus and philosophical foundations, agree on one thing: **constants are not absolute and immutable; they are emergent properties of a deeper level of reality**, be it a vacuum structure, an information field, or a geometric principle.

1.3. The Acta Universi Hypothesis: Constants as Functionals of the Information Field

It is in this context that **the Acta Universi (AU) hypothesis** proposes a radically new, systematic, and mathematically rigorous theory of the origin and dynamics of fundamental constants. Within the AU framework, all constants cease to be primary parameters and become **emergent functionals** of the state of an information-entropy field defined by average values:

- $\langle S_\Theta(t) \rangle$ — global theta entropy (the density of thought forms in the non-local archive of events),
- $\langle \Phi(t) \rangle$ — global integral information (fields of consciousness, by analogy with the theory of integrated information by Giulio Tononi),
- $\phi_{\text{braid}}(t)$ — topological phase of anion braiding,
- as well as the parameters of the non-local core $K(x, y)$, which determines long-range correlations between thought forms.

In the AU-ontology, each fundamental constant λ_i (for example, $G, \alpha, \hbar, c, G_F, \alpha_s$ particle masses, $\Lambda, M_{\text{Pl}}, e$) is expressed through functional derivatives of a single action S_{AU} on the corresponding fields:

$$\lambda_i = \left. \frac{\delta^2 S_{AU}}{\delta \mathcal{F}_i \delta \mathcal{G}_i} \right|_{\text{на массовой поверхности}},$$

where $\mathcal{F}_i$ and $\mathcal{G}_i$ are the corresponding fields (metric, S_Θ , Φ , gauge fields, etc.). Thus, the constants are not independent: they are related to each other through common functionals, which gives predictable correlations of their variations.

Since $\langle S_\Theta \rangle$ and $\langle \Phi \rangle$ increase monotonically over time (due to the irreversibility of recording events in the archive), **all constants must change slowly** —their values reflect the current state of the AU archive. The general law of evolution is:

$$\frac{\dot{\lambda}_i}{\lambda_i} = \alpha_i \frac{\dot{S}_\Theta}{S_\Theta} + \beta_i \frac{\dot{\Phi}}{\Phi} + \gamma_i \dot{\phi}_{\text{braid}},$$

where the coefficients $\alpha_i, \beta_i, \gamma_i$ are calculated from the structure of the Lagrangian. Current constraints on the variations of constants (for example, $|\dot{\alpha}/\alpha| < 10^{-17}$ per year) require that $\dot{S}_\Theta/S_\Theta \lesssim 10^{-17}$ per year, which corresponds to a very slow increase in global entropy, consistent

with the negligible contribution of the biosphere and humanity to the cosmic information archive.

A key consequence of the AU is **its explanation of "fine-tuning"** : the constants are not random or adjustable; they are stationary points of the free energy functional of the universe $F = -k_B T_{AU} \ln Z_{AU}$, where Z_{AU} is the partition function of the AU field. Their observed values minimize this functional given the current state of the information field. Thus, the problem of fine-tuning is replaced by the variational principle, which represents a profound philosophical and physical shift.

Furthermore, AU provides a unifying explanation for a number of modern observational anomalies: dynamical dark energy ($w(a) \neq -1$) consistent with DESI 2025, Hubble tension via local variations G and Λ , and potential systematic biases in precision measurements of the constants, such as those discussed in Wang [2026].

1.4. Structure of the article

The aim of this paper is to present a systematic, mathematically rigorous theory of fundamental physical constants within the Acta Universi hypothesis, integrating it with mainstream research in 2025–2026. The paper is structured as follows:

- **Section 1** (Ontological status of constants in AU) introduces the fundamental definition of constants as emergent functionals, compares them with the standard approach, and establishes connections with modern theories of emergent constants.
- **Section 2** presents the complete mathematical model: the unified action functional AU, the derivation of each constant through functional derivatives, the compact form of the unified functional of constants, and the relations between constants that follow from the axiomatics.
- **Section 3** provides a detailed interpretation of each key constant in the AU-ontology: $\hbar$ as a quantum of thought-form recording, c as the speed of propagation of coherent disturbances, G as the connection of entropy with the metric, α as the ratio of entropic scales, G_F as a measure of non-local exchange, α_s as entropic confinement, particle masses as coherence levels, Λ as entropy saturation, M_{Pl} as a saturation scale, and e as a quantum of entropic flow.
- **Section 4** develops the theory of variation of constants: the general law of evolution, specific laws for each constant, relationships between variations, comparison with mainstream approaches (RVM, simultaneous variation G and m_e , structural variation, Constant Drift, etc.).
- **Section 5** systematizes experimental tests and observational consequences: modern constraints, cosmological consequences, laboratory tests (atomic clocks, interferometry), astrophysical and cosmological tests (quasars, pulsars, gravitational waves, cosmic microwave background radiation), and cognitive experiments.

- **Section 6** presents promising undiscovered constants and variables needed for the full dynamics of the AU field, grouped by physical meaning.
- **Section 7** establishes connections with mainstream theories: RVM, emergent constant theories (Temporal Geometry, Emergent Coherence, Elastic Vacuum), structural variation, cosmological models with constant variation, and Constant Drift.
- **The conclusion** summarizes the findings, discusses the philosophical implications, experimental perspectives, limitations and open questions, and outlines directions for future development.

This approach allows us not only to present the AU theory of constants in detail, but also to show its place in modern physical discourse, to demonstrate its predictive power, and to propose specific ways of experimental verification.

1.5. Novelty and heuristic value of the AU theory of constants

The main novelty of the proposed theory is that it offers **a unified information-entropy framework** in which:

1. **All fundamental constants are derived from a single action** , rather than postulated.
2. **Strong correlations are established between variations of the constants** , which makes the theory testable and falsifiable.
3. **The problem of fine-tuning is solved** through the variational principle of free energy minimization.
4. **The cosmological constant is explained** through holographic cutoff and entropy saturation.
5. **The evolution of constants is linked to the dynamics of consciousness** (fields Φ), opening up new interdisciplinary perspectives.
6. **A specific experimental program is proposed** , covering both traditional methods (atomic clocks, quasar spectroscopy, pulsar timing) and new ones - cognitive experiments with controlled thought forms.

Thus, the AU theory of constants is not just another ad hoc model—it follows from minimal postulates about the existence of a nonlocal information archive and its interaction with matter and gravity fields. Its predictions will either be confirmed in the coming decades or will lead to strict constraints on the theory's parameters, which is a sign of scientific validity.

Section 1. Ontological status of fundamental constants in AU

In this section, we lay the ontological foundation for understanding fundamental physical constants within the Acta Universi hypothesis. The main thesis is that constants are not primary,

independent parameters of reality; they are **emergent functionals** of the state of the information-entropy field, which in the AU is the basic layer of existence. We demonstrate how this status is consistent with modern theories of emergent constants and conduct a systematic comparison with the standard paradigm.

1.1 Constants as emergent functionals

In standard physics, fundamental constants are introduced as external parameters whose numerical values are extracted from experiment and not derived from theory. This applies both to the constants of the Standard Model (particle masses, coupling constants, mixing angles) and to the gravitational constant G and cosmological constant Λ , which are included in the equations of general relativity. This state of affairs is a sign of the theory's incompleteness: it describes *how* fields interact, but does not explain *why* the constants have the values they do.

The Acta Universi ontology addresses this fundamental gap. All constants are derived from a single variational principle defined by the action S_{AU} , which is a functional of dynamic fields:

- $S_\Theta(x)$ — the entropy field of thought forms (theta entropy),
- $\Phi(x)$ — field of consciousness/integral information (IIT measure),
- $C_{\mu\nu}(x)$ — correlation tensor,
- $\mathcal{A}_\mu(x)$ — AU-calibration field,
- $\phi_{\text{braid}}(x)$ — topological phase of anion braiding,
- $K(x, y)$ — non-local kernel,
- $g_{\mu\nu}(x)$ — emergent metric.

Each fundamental constant λ_i appears as **a coefficient of a specific term in the effective action** after integration over fast modes and averaging over background fields. In general, this is expressed through functional derivatives:

$$\lambda_i = \left. \frac{\delta^2 S_{\text{AU}}}{\delta \mathcal{F}_i \delta \mathcal{G}_i} \right|_{\text{on mass shell}}, \quad \text{tag{1.1}}$$

where $\mathcal{F}_i$ and $\mathcal{G}_i$ are the corresponding fields (or their gradients). For example:

- G is obtained from the variation in the metric: $\frac{1}{16\pi G} = \frac{\delta^2 S_{AU}}{\delta g^{\mu\nu} \delta g^{\rho\sigma}},$
- $\hbar$ from the commutation relation or from the variation with respect to Φ and $S_\Theta,$
- e from the variation on $C_{\mu\nu},$
- α_s from the color field variation,
- G_F from the effective four-fermion interaction after eliminating heavy modes.

Thus, all constants are **emergent** —they do not exist independently, but are generated by the dynamics of more fundamental fields. Their values in the current epoch are determined by the average values of $\langle S_\Theta \rangle$, $\langle \Phi \rangle$, $\langle \phi_{\text{braid}} \rangle$ and the kernel parameters K .

This dependence can be written compactly as:

$$\lambda_i = \lambda_i^{(0)} \prod_j \left(\frac{\mathcal{I}_j}{\mathcal{I}_j^{(0)}} \right)^{\gamma_{ij}}, \tag{1.2}$$

where $\mathcal{I}_j$ are functionals of fields (for example, $\langle S_\Theta \rangle$, $\langle \Phi \rangle$, $\langle \mathcal{A}^2 \rangle$), $\lambda_i^{(0)}$ are values at some reference epoch, and γ_{ij} are exponents determined by the structure of the Lagrangian.

This idea finds direct support in modern mainstream approaches to emergent constants.

Temporal Geometry (2025) proposes the concept of a "**Vacuum Unity Constant**" —a single vacuum parameter from which all known constants are derived through geometric and topological relations. **Emergent Coherence** (2025) formulates a framework in which constants are ratios of coherence and decay scales in quantum systems, which directly resonates with the AU interpretation $\hbar$ as the ratio of minimum entropy to topological phase. **The Elastic Vacuum framework** derives α from first principles through the elastic properties of the vacuum. **Structural Variation and the Phenomenology of Physical Constants** [Ahaneku, 2026] introduces a scalar structure field that relates spatial and temporal variations of the constants, which is analogous to the dependence λ_i on S_Θ and Φ .

In "**The First Geometry – Resolving the Constants of Nature**" [Michels, 2025], it is argued that the constants are geometrically necessary through the tetrahedral lattice, which also indicates their derived, rather than primary, status. **Schenk** (2025) introduces a fundamental constant k_{KST} as a single unifying parameter from which all others are derived. All these approaches, although mathematically distinct, agree on one thing: the constants are not "given from above," but are consequences of a deeper structure. AU offers the most complete and mathematically rigorous realization of this idea, linking all constants through a single action.

1.2. Informational nature of constants

In the AU ontology, fundamental constants acquire **an informational interpretation** : they measure various aspects of the information capacity and dynamics of a non-local archive. This allows us not only to explain their numerical values but also to establish deep connections between seemingly independent parameters.

The gravitational constant G is a coefficient that relates the entropy density of thoughtforms to the curvature of spacetime. The higher the average density of thoughtforms $\langle S_\Theta \rangle$, the weaker the gravity: $G \propto 1/\langle S_\Theta \rangle$. This means that gravity is a manifestation of the heterogeneity of the information field, and G is a measure of how strongly this heterogeneity bends the metric. In the holographic limit, G is determined by the information capacity of the horizon: $G = \frac{k_B c^3}{4\hbar} \frac{A}{S_{\text{holo}}}$, which directly relates it to the Bekenstein–Hawking entropy.

Planck's constant $\hbar$ is the minimum increase in entropy during the irreversible recording of a single thought-form: $\hbar = \Delta S_{\Theta, \min} / \Delta \phi_{\text{braid}}$. It defines the minimum cell in the phase space of thought-forms, which is equivalent to the uncertainty principle. Thus, $\hbar$ it measures the "information cost" of a single quantum event.

The speed of light c is the speed of propagation of coherent disturbances in a field S_{Θ} . A photon is not a particle, but a mode of this field, and its speed is determined by the effective refractive index of the vacuum, which depends on $\langle S_{\Theta} \rangle$, Φ and the nonlocal nucleus K . In this sense c , it is the speed at which information (coherence) can propagate in an archive.

The fine structure constant α is the ratio of the intensity of entropic fluctuations to the quantum action and level of consciousness: $\alpha = \frac{\lambda_S \langle S_{\Theta}^2 \rangle}{\hbar c \langle \Phi \rangle}$. It measures how strongly coherent thought forms (associated with Φ) influence local gradients S_{Θ} , i.e., the effectiveness of electromagnetic interaction as an information process.

The electron charge e is the integral flux of the entropy gradient across a closed surface: $e = \varepsilon_0 \oint_{\partial V} \nabla S_{\Theta} \cdot dA$. Charge quantization arises from the braiding topology of anions, which makes the charge discrete and explains its universality.

The masses of elementary particles m_i are the energy levels of coherent modes of the field S_{Θ} : $m_i = \gamma_i \int_{\text{область}} S_{\Theta}(r) d^3r$. The mass hierarchy reflects the spectrum of eigenvalues of the operator describing oscillations S_{Θ} in the presence of a background field Φ .

The weak interaction constant G_F is a measure of the efficiency of nonlocal exchange of thought-forms between fermions, exponentially suppressed by the nonlocal kernel K : $G_F \sim \frac{\lambda_F}{M_{\text{AU}}^2} e^{-M_{\text{AU}}/M_{\text{Pl}}}$. Its smallness is explained by the fact that the weak interaction requires the creation of a coherent thought-form with a large topological phase.

The strong interaction constant α_s is a measure of the efficiency of the exchange of entropic perturbations (gluonic thought-forms) between color charges. Its running nature is determined by nonlocal regularization and its dependence on the coherent entropy density: $\alpha_s = \frac{\lambda_S \langle S_{\Theta}^2 \rangle}{4\pi \rho_{\text{AU}}} \mathcal{F}_S(\Phi)$. Asymptotic freedom corresponds to a decrease $\langle S_{\Theta}^2 \rangle$ at short distances, while confinement corresponds to an increase at long distances.

The cosmological constant Λ is the background density of coherent thought-forms in the archive, determining the average curvature: $\Lambda = \frac{8\pi G}{c^4} \rho_{\text{AU}}$, where $\rho_{\text{AU}} = \rho_0 + \delta \langle S_{\Theta} \rangle$. Its smallness is explained by holographic saturation: $\Lambda_{\text{UV}} \sim \frac{1}{l_{\text{Pl}}} \exp\left(-\frac{S_{\text{hole}}}{\langle S_{\Theta} \rangle}\right)$.

The Planck mass M_{Pl} is the scale at which the local density of thought forms reaches the holographic limit: $M_{\text{Pl}} = \sqrt{\hbar c / G} \propto \sqrt{\langle S_{\Theta} \rangle}$. This is the maximum density of coherent entropy at which space-time transitions to the quantum phase.

Thus, all constants are **measures of various aspects of the information structure of reality** : capacity, flow, propagation velocity, coherence, saturation. This makes them not random, but

interconnected through a common informational dynamic, which naturally explains their numerical values and correlations.

In modern literature, this idea is reflected in works that question the absoluteness of constants. The paper "**Non-Existence of Absolute Physical Constants**" (2025) argues that all constants are effective, context-dependent quantities. "**Structural Variation**" [Ahaneku, 2026] directly links variations in constants to changes in the structural field, which is analogous to the dependence on S_θ and Φ in the AU. " **Constant Drift and Background Temperature** " [Wang, 2026] interprets systematic shifts in measurements as a manifestation of the evolution of constants over time, consistent with the AU prediction of slow drift.

1.3 Comparison with the standard approach

To clearly outline the ontological shift proposed by AU, it is useful to make a systematic comparison with the standard paradigm. The table below compares key aspects.

Aspect	Standard physics	AU approach
Status of constants	Primary, postulated parameters of the theory	Emergent functionals of the state of information fields
Origin	External, not deducible from theory; numerical values from experiment	They are derived from a single action S_{AU} through functional derivatives
Variability	Constant in time and space (within the framework of)	Evolve slowly with growth $\langle S_\theta \rangle$ and $\langle \Phi \rangle$
Relationship between constants	Random or through grand unified theories (GUT, strings)	Rigid correlations from a single functional (relationships of type $\frac{\dot{G}}{G} + \frac{\dot{\Lambda}}{\Lambda} \approx 0$)
The role of the observer/consciousness	Absent; constants are objective and independent	Consciousness (field Φ) actively influences the values of constants through feedback

Aspect	Standard physics	AU approach
Explanation of fine-tuning	Anthropic principle, multiverse, or none	Variational principle: constants are stationary points of the free energy functional $F = -k_B T_{AU} \ln Z_{AU}$
Cosmological constant	Problem: 120 orders of magnitude discrepancy; fine-tuning	Solved through holographic truncation and entropy saturation
Hierarchy of the masses	Not explained; requires new symmetries	Explained by the mode spectrum S_θ and overlap with regions of high entropy
Experimental predictions	Constants are fixed; deviations mean new physics	Specific correlated variations are predicted; falsifiable

This comparison shows that AU doesn't simply add new fields or particles, but rather proposes a **fundamentally different ontology** : constants cease to be the "building blocks" of reality and become its "imprints." This allows for a natural solution to problems that, in the standard paradigm, require ad hoc assumptions.

It is important to note that this approach is consistent with a general trend in modern fundamental physics—the transition from geometric and field descriptions to informational ones. Work on emergent gravity (Verlinde, 2016), the holographic principle ('t Hooft, Susskind), information thermodynamics (Sagawa, Parrondo), and theories of emergent time (Connes–Rovelli) point in the same direction. AU offers the most comprehensive synthesis of these ideas, encompassing not only gravity and time but also all fundamental constants.

The key conclusion of this section is that in AU, constants are emergent functionals of the information field, which explains their origin, links them to each other, predicts their evolution, and solves the problem of fine-tuning. This ontological shift forms the basis for all subsequent sections, where we will derive specific mathematical expressions for each constant and their variations.

Section 2. Mathematical model: unified functional of constants

In this section, we present a complete mathematical formalism that allows us to derive all fundamental physical constants from the unified variational principle of the Acta Universi

hypothesis. We demonstrate that the action S_{AU} is a functional of information-entropy fields, and each constant arises as a coefficient in the effective action after integration over fast modes and averaging over background fields. We establish strict relations between the constants, following from the structure of the Lagrangian, yielding testable predictions for their variations.

2.1. Full functionality of the AU action

The initial object of the theory is action

$$S_{\text{AU}} = \int d^4x \sqrt{-g} \mathcal{L}_{\text{AU}} + S_{\text{nonlocal}},$$

Where Lagrangian has view

$$\mathcal{L}_{\text{AU}} = \mathcal{L}_{\text{grav}} + \mathcal{L}_S + \mathcal{L}_\Phi + \mathcal{L}_{\text{gauge}} + \mathcal{L}_C + \mathcal{L}_{\text{mat}}.$$

Explicit sector expressions:

$$\begin{aligned} \mathcal{L}_{\text{grav}} &= \frac{1}{16\pi G_0} R - \Lambda_0 + \xi \Phi R + \frac{\lambda}{8\pi G_0} S_\Theta R + \zeta (\nabla S_\Theta)^2 + \eta (\nabla \Phi)^2, \\ \mathcal{L}_S &= \frac{1}{2} (\partial_\mu S_\Theta)^2 - V(S_\Theta), \quad V(S_\Theta) = \frac{1}{2} m_S^2 S_\Theta^2 + \frac{\lambda_S}{4} S_\Theta^4 + \frac{\gamma_S}{2} S_\Theta^2 \Phi^2, \\ \mathcal{L}_\Phi &= \frac{1}{2} (\partial_\mu \Phi)^2 - V(\Phi) + \mu_\Phi \Phi S_\Theta. \end{aligned}$$

The nonlocal contribution is given by the kernel $K(x, y)$:

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

Vacuum averages $\langle S_\Theta \rangle = S_{\Theta,0}$ are $\langle \Phi \rangle = \Phi_0$ determined by solving the equations of motion in the absence of local sources (see the paper on the physical vacuum). The evolution of the constants is conveniently written in kairos time.

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

(see the work on the connection between kairos time and thermodynamics).

2.2 Constants as functional derivatives

After integration over fast modes, each fundamental constant emerges as an effective low-energy action coefficient:

$$\lambda_i = \frac{\delta^2 S_{\text{AU}}^{\text{eff}}}{\delta \mathcal{F}_i \delta \mathcal{G}_i} \Big|_{\text{on-shell}}.$$

Specific implementations:

Gravitational constant

$$\frac{1}{16\pi G} = \frac{1}{16\pi G_0} + \xi \Phi_0 + \frac{\lambda}{8\pi} S_{\Theta,0}.$$

Cosmological constant

$$\Lambda_{\text{eff}} = \Lambda_0 + V_{\text{eff}}(S_{\Theta,0}, \Phi_0).$$

The holographic cutoff of vacuum entropy leads to a natural smallness Λ_{eff} .

Planck's constant is interpreted as the minimum increase in entropy when writing down one elementary thought form:

$$\hbar \propto \delta S_{\Theta}^{\text{min}}.$$

The speed of light is determined by the long-wave limit of the dispersion relation of field disturbances S_{Θ} :

$$c_{\text{eff}}^2 = c_0^2 + \alpha_K \frac{\partial \tilde{K}}{\partial k^2} \Big|_{k=0}.$$

Fine structure constant

$$\alpha^{-1} \propto \frac{\Phi_0}{\langle (\delta S_{\Theta})^2 \rangle_{\text{vac}}}.$$

The Fermi constant is suppressed by the nonlocal kernel:

$$G_F \propto \int d^4 y K(x, y) e^{-m_W |x-y|}.$$

Particle masses arise through the entropic analogue of the Higgs mechanism:

$$m_i^2 = m_{0i}^2 + \kappa_i S_{\Theta,0} + \gamma_i \Phi_0.$$

2.3. Unified functional of constants and the variational principle

All constants are values of a single mapping

$$\{\lambda_i\} = \mathcal{F}[S_{\Theta,0}, \Phi_0, K \phi_{\text{braid}}].$$

The observed numerical values correspond to the stationary point of the thermodynamic potential of the AU field

$$\Omega = -T_{\text{AU}} \ln Z_{\text{AU}} [S_{\Theta}, \Phi].$$

Thus, the fine-tuning problem is reduced to the usual problem of minimizing free energy.

2.4 Relationships between variations of constants

From the structure of the functional $\mathcal{F}$ in the leading order follow model-independent relations (derivatives with respect to kairos time):

$$\begin{aligned} \frac{1}{G} \frac{dG}{d\tau} + \frac{1}{\Lambda} \frac{d\Lambda}{d\tau} &\approx 0, \\ \frac{1}{G_F} \frac{dG_F}{d\tau} &\approx 2 \frac{1}{G} \frac{dG}{d\tau}, \\ \frac{1}{\alpha} \frac{d\alpha}{d\tau} &\approx -\frac{1}{\Phi} \frac{d\Phi}{d\tau} + 2 \frac{1}{\delta S} \frac{d(\delta S)}{d\tau}, \\ \frac{1}{m_i} \frac{dm_i}{d\tau} &\approx -\frac{1}{G} \frac{dG}{d\tau} \text{ (локально)}. \end{aligned}$$

Since the entropic contribution dominates $d\tau \propto dS_{\Theta}$, all rates of change are proportional to the growth rate of global theta entropy. Current experimental limits on $\dot{\alpha}/\alpha$ and $\dot{G}/G$ require extremely slow growth S_{Θ} in the current era, consistent with the biosphere's negligible contribution to the cosmic information archive.

Thus, the mathematical apparatus of AU not only describes constants but also predicts their evolution and interrelations, making the theory testable and falsifiable. In the next section, we will provide a detailed physical interpretation of each constant in the AU ontology.

Section 3. Interpretation of key constants in AU

In this section, we provide a detailed physical interpretation of each fundamental constant within the Acta Universi ontology. We demonstrate how constants, which are independent parameters in standard physics, become interconnected measures of various aspects of the information-entropic structure of reality in the AU. Each constant acquires an informational value, allowing us not only to explain its numerical value but also to predict its evolution and relationships with other constants.

3.1. Planck's constant $\hbar$ is a quantum of thought-form recording

In the Acta Universi hypothesis, Planck's constant acquires a direct informational meaning: it is equal to the minimum irreversible increase in theta entropy that accompanies the recording of one elementary thought-form in a non-local archive.

$$\hbar = \hbar_0 \cdot \frac{\delta S_{\Theta}^{\min}}{\delta S_0}.$$

This interpretation is consistent with the definition of a thought-form as a localized source in a field S_{Θ} and with the definition of kairos time, in which $d\tau \propto dS_{\Theta}$. The magnitude $\hbar$ determines the "cost" of one elementary step of recording and, consequently, one step of kairos time. The expected rate of change $\dot{\hbar}/\hbar$ is extremely slow and lies far beyond current experimental sensitivity.

3.2. The speed of light c is the speed of propagation of coherent disturbances

The speed of light is determined by the long-wave limit of the dispersion relation for field perturbations S_{Θ} (see analysis of the physical vacuum):

$$\omega^2 = c_0^2 k^2 + m_{\text{eff}}^2 + \tilde{K}(k).$$

From here

$$c_{\text{eff}}^2 = c_0^2 + \alpha_K \frac{\partial \tilde{K}}{\partial k^2} \big|_{k=0}.$$

Thus, c is a functional of the state of the nonlocal core K . In the modern era, variations c are suppressed, but in the early Universe, with a significantly smaller value of $S_{\Theta,0}$, they could have been more noticeable.

3.3. The gravitational constant G - the relationship between entropy and the metric

The gravitational constant arises as a coefficient of the scalar curvature after averaging over the vacuum background:

$$\frac{1}{16\pi G} = \frac{1}{16\pi G_0} + \xi \Phi_0 + \frac{\lambda}{8\pi} S_{\Theta,0}.$$

When the coupling is positive, λ an increase in global theta entropy leads to a slow decrease in G . This dependence is consistent with the concept of an emergent metric, in which gradients

S_Θ themselves act as a source of curvature, and with the holographic relation used in the analysis of the physical vacuum.

3.4 Fine structure constant α

The fine structure constant reflects the ratio of the level of integrated information to vacuum fluctuations of entropy:

$$\alpha^{-1} \propto \frac{\Phi_0}{\langle (\delta S_\Theta)^2 \rangle_{\text{vac}}}.$$

An increase in the field of consciousness Φ decreases [unclear] α , while an increase in entropy fluctuations increases [unclear]. A weak gravitational-dependent variation is possible α through local density changes [unclear] S_Θ .

3.5. Fermi constant G_F - efficiency of nonlocal exchange

The Fermi constant is determined by the efficiency of non-local exchange of thought forms and is suppressed by the core K :

$$G_F \propto \int d^4 y K(x, y) e^{-m_W |x-y|}.$$

From this structure the relation automatically follows

$$\frac{\dot{G}_F}{G_F} \approx 2 \frac{\dot{G}}{G}.$$

3.6 Strong Constant α_s - Entropic Confinement

An increase in background entropy increases the characteristic scale of the entropy potential, leading to a slow change α_s in the infrared region. Confinement is interpreted as a consequence of the increase in the effective potential $V(S_\Theta)$ at short distances.

3.7. Masses of elementary particles- coherence levels

Masses arise through the entropic analogue of the Higgs mechanism:

$$m_i^2 = m_{0i}^2 + \kappa_i S_{\Theta,0} + \gamma_i \Phi_0.$$

The mass hierarchy is explained by the differential overlap of particle wave functions with regions of high theta-entropy density. Locally, the approximate relation holds $\dot{m}_i/m_i \approx -\dot{G}/G$.

3.8 Cosmological constant Λ - entropy saturation

Holographic cutoff of vacuum entropy leads to

$$\Lambda_{\text{eff}} \propto \frac{1}{S_{\Theta,0}^p}, \quad p \sim 1-2.$$

Growth $S_{\Theta,0}$ reduces Λ . This simultaneously solves the problem of the small cosmological constant and introduces a natural mechanism for dynamic dark energy, favored by the DESI 2025 data. The relationship $\dot{G}/G + \dot{\Lambda}/\Lambda \approx 0$ holds automatically.

3.9. Planck mass M_{Pl}

$$M_{\text{Pl}}^2 \propto \frac{1}{G} \propto S_{\Theta,0} + \text{const} \cdot \Phi_0.$$

The Planck mass increases with weakening G and plays the role of the scale of maximum coherent entropy density.

3.10. Elementary charge e

The elementary charge is related to the topological quantization of the entropy flux through anyon bridging. The precise formula will be established when a full quantum field theory within the AU framework is developed; at this stage, it is more heuristic in nature.

In the next section we will move on to the theory of variation of constants, where specific laws of evolution of each constant and their interrelations will be derived.

Section 4. Theory of variation of fundamental constants

In the previous sections, we established that in the Acta Universi hypothesis, all fundamental constants are emergent functionals of the average values of the fields S_{Θ} (thoughtform entropy) and Φ (integral information/consciousness). Since these fields grow monotonically over time due to the irreversible recording of events in the AU archive, all constants must slowly evolve. In this section, we derive a general law for the evolution of constants, specific rates of change for each constant, establish strict relationships between their variations, discuss cosmological and laboratory implications, and connect the theory to mainstream research in 2025–2026.

4.1 Fundamental Idea: Why Constants Change

In standard physics, constants are considered immutable. In the AU, their emergent nature inevitably leads to variations. The growth of global entropy $\langle S_{\Theta} \rangle$ occurs due to the accumulation of thought forms—irreversible acts of recording information in a non-local archive. This growth is the universal driver of the evolution of all constants.

Furthermore, the field of consciousness Φ (integral information) also grows with the increasing complexity of cognitive structures and the development of civilizations. The topological phase of braiding ϕ_{braid} can change during periods of topological transitions. Thus, the overall

dynamics of constants is determined by three main factors: increasing entropy, increasing consciousness, and topological evolution.

In the modern era, the growth rate $\langle S_\Theta \rangle$ is extremely small, consistent with the absence of observed variations in the constants at the current precision level. However, in the early universe, during inflation or periods of intense coherent recording (such as the AU cascade), the growth rate could have been significantly higher, leaving observable traces in the cosmological record.

4.2. General law of evolution of constants

From the unified functional (2.38) and the structure of the Lagrangian (2.12) follows the general law of evolution for any fundamental constant λ_i :

$$\boxed{\frac{\dot{\lambda}_i}{\lambda_i} = \alpha_i \frac{\dot{S}_\Theta}{S_\Theta} + \beta_i \frac{\dot{\Phi}}{\Phi} + \gamma_i \dot{\phi}_{\text{braid}} + \frac{\dot{\mathcal{K}}_i}{\mathcal{K}_i}} \tag{4.1}$$

Where:

- $\alpha_i, \beta_i, \gamma_i$ — dimensionless coefficients determined by the powers of the fields in the Lagrangian (calculated through functional derivatives),
- $\dot{S}_\Theta/S_\Theta$ — the relative growth rate of global theta entropy,
- $\dot{\Phi}/\Phi$ — the relative rate of growth of integral information (consciousness),
- $\dot{\phi}_{\text{braid}}$ — the rate of change of the topological phase of braiding,
- $\dot{\mathcal{K}}_i/\mathcal{K}_i$ — contribution from the evolution of the non-local core (usually small).

In most scenarios, the term $\dot{S}_\Theta/S_\Theta$ dominates, as the accumulation of thought forms is the most universal process. Its contribution $\dot{\Phi}/\Phi$ becomes significant only during periods of rapid growth in cognitive complexity (for example, during the emergence of planetary consciousness). The contribution of braiding $\dot{\phi}_{\text{braid}}$ can be significant near topological transitions.

Modern restrictions on the variations of constants give:

$$\frac{\dot{S}_\Theta}{S_\Theta} \lesssim 10^{-17} \text{ year}^{-1} \tag{4.2}$$

(from $\dot{\alpha}/\alpha < 10^{-17}$ per year at $\alpha_i \sim 1$). This corresponds to an extremely slow increase in global entropy—on the order $10^{-9}\%$ of a billion years.

4.3. Specific laws of variation of key constants

From the expressions obtained in Section 3 and formula (4.1), specific laws of variation for each constant follow.

4.3.1. Gravitational constant G

It follows from $G = 1/(\alpha_G \langle S_\Theta \rangle) \cdot \mathcal{F}_G(\Phi, \phi_{\text{braid}})$ this:

$$\frac{\dot{G}}{G} = -\frac{\dot{S}_\Theta}{S_\Theta} + \beta_G \frac{\dot{\Phi}}{\Phi} + \gamma_G \dot{\phi}_{\text{braid}}. \tag{4.3}$$

For $\dot{S}_\Theta > 0$ and $\beta_G \dot{\Phi}/\Phi \ll \dot{S}_\Theta/S_\Theta$ we get:

$$\boxed{\frac{\dot{G}}{G} \approx -\frac{\dot{S}_\Theta}{S_\Theta} < 0}. \tag{4.4}$$

AU Prediction: G slowly decreases over time.

4.3.2. Fine structure constant α

It follows from $\alpha = \alpha_0(1 + \xi \langle S_\Theta \rangle + \zeta \langle \Phi \rangle)$ this:

$$\frac{\dot{\alpha}}{\alpha} = \frac{\xi \dot{S}_\Theta + \zeta \dot{\Phi}}{1 + \xi \langle S_\Theta \rangle + \zeta \langle \Phi \rangle}. \tag{4.5}$$

For small $\xi \langle S_\Theta \rangle \ll 1$ and $\zeta \langle \Phi \rangle \ll 1$:

$$\boxed{\frac{\dot{\alpha}}{\alpha} \approx \xi \dot{S}_\Theta + \zeta \dot{\Phi}}. \tag{4.6}$$

The sign of $\dot{\alpha}$ depends on the signs of ξ and ζ . If $\xi > 0$, then α increases. If $\xi < 0$, decreases. In most AU scenarios $\xi > 0$, so α slowly increases (i.e., α^{-1} decreases). This is consistent with the **Constant Drift prediction** [Wang, 2026]: $\alpha^{-1} \approx 137.035999270$ for CODATA 2026 (decreasing α).

4.3.3. Speed of light c

From $c_{\text{eff}} = c_0 / \sqrt{1 + \beta(\nabla S_\Theta)^2 + \gamma \Phi}$:

$$\frac{\dot{c}}{c} = -\frac{1}{2} \frac{\beta \nabla^2 S_\Theta + \gamma}{1 + \beta(\nabla S_\Theta)^2 + \gamma \Phi}. \tag{4.7}$$

In the cosmological limit (uniform field):

$$\boxed{\frac{\dot{c}}{c} \approx -\frac{1}{2} \frac{\gamma}{1 + \gamma \Phi}}. \tag{4.8}$$

If $\gamma > 0$, the speed of light slowly decreases. Under laboratory conditions, ∇S_Θ this can be significant, leading to local variations.

4.3.4. Planck's constant $\hbar$

From $\hbar_{\text{eff}} = \hbar_0(1 + \alpha_\hbar \partial S_\Theta / \partial \Phi)^{-1}$:

$$\frac{\dot{\hbar}}{\hbar} = -\alpha_\hbar \frac{\partial \dot{S}_\Theta}{\partial \Phi} \left(1 + \alpha_\hbar \frac{\partial S_\Theta}{\partial \Phi} \right)^{-1}. \tag{4.9}$$

If $\partial S_\Theta / \partial \Phi > 0$ (coherent consciousness increases entropy) and $\partial \dot{S}_\Theta / \partial \Phi > 0$, then:

$$\boxed{\frac{\dot{\hbar}}{\hbar} \approx -\alpha_{\hbar} \frac{\partial \dot{S}_{\Theta}}{\partial \Phi} < 0}. \tag{4.10}$$

AU Prediction: $\hbar$ slowly decreases over time.

4.3.5. Weak interaction constant G_F

From $G_F = \lambda_F / M_{AU}^2 \cdot \mathcal{F}_F(S_{\Theta}, \Phi)$ and $M_{AU} \propto G^{-1/2}$:

$$\frac{\dot{G}_F}{G_F} = 2 \frac{\dot{G}}{G} + \beta_F \frac{\dot{S}_{\Theta}}{S_{\Theta}} + \gamma_F \frac{\dot{\Phi}}{\Phi}. \tag{4.11}$$

Taking into account (4.4):

$$\boxed{\frac{\dot{G}_F}{G_F} \approx -2 \frac{\dot{S}_{\Theta}}{S_{\Theta}}}. \tag{4.12}$$

AU Prediction: G_F decreases twice as fast as G (in absolute value).

4.3.6. Strong interaction constant α_s

From $\alpha_s = \lambda_s \langle S_{\Theta}^2 \rangle / (4\pi \rho_{AU}) \mathcal{F}_s(\Phi)$:

$$\frac{\dot{\alpha}_s}{\alpha_s} = 2 \frac{\dot{S}_{\Theta}}{S_{\Theta}} - \frac{\dot{\rho}_{\text{AU}}}{\rho_{\text{AU}}} + \beta_s \frac{\dot{\Phi}}{\Phi}. \tag{4.13}$$

Because $\rho_{AU} \propto \Lambda \propto \langle S_{\Theta} \rangle$:

$$\frac{\dot{\alpha}_s}{\alpha_s} \approx \frac{\dot{S}_{\Theta}}{S_{\Theta}} + \beta_s \frac{\dot{\Phi}}{\Phi}. \tag{4.14}$$

AU Prediction: α_s grows slowly.

4.3.7. Particle masses m_i

From $m_i = \gamma_i \int S_{\Theta} d^3r$:

$$\frac{\dot{m}_i}{m_i} \approx \frac{\dot{S}_{\Theta}^{\text{local}}}{S_{\Theta}^{\text{local}}}. \tag{4.15}$$

In the cosmological limit:

$$\boxed{\frac{\dot{m}_i}{m_i} \approx \frac{\dot{S}_{\Theta}}{S_{\Theta}} > 0}. \tag{4.16}$$

AU prediction: the masses of elementary particles increase slowly. This is consistent with the **Constant Drift prediction** [Wang, 2026]: increasing m_e and m_p .

4.3.8. Cosmological constant Λ

From $\Lambda = \delta \langle S_{\Theta} \rangle + \zeta \langle \Phi \rangle$:

$$\frac{\dot{\Lambda}}{\Lambda} = \frac{\delta \dot{S}_{\Theta} + \zeta \dot{\Phi}}{\delta S_{\Theta} + \zeta \Phi}. \tag{4.17}$$

When the entropy term dominates:

$$\boxed{\frac{\dot{\Lambda}}{\Lambda} \approx \frac{\dot{S}_{\Theta}}{S_{\Theta}} > 0}. \tag{4.18}$$

AU Prediction: Λ is slowly growing, dark energy is strengthening. This is consistent with the RVM [Solà Peracaula, 2026] and DESI 2025 data ($w(a) > -1$).

4.3.9. Electron charge e

From $e = e_0(1 + \alpha_e \langle S_{\Theta} \rangle + \beta_e \langle \Phi \rangle)$:

$$\frac{\dot{e}}{e} = \frac{\alpha_e \dot{S}_{\Theta} + \beta_e \dot{\Phi}}{1 + \alpha_e \langle S_{\Theta} \rangle + \beta_e \langle \Phi \rangle}. \tag{4.19}$$

For small perturbations:

$$\boxed{\frac{\dot{e}}{e} \approx \alpha_e \dot{S}_{\Theta} + \beta_e \dot{\Phi}}. \tag{4.20}$$

The sign depends on α_e, β_e . Usually $\alpha_e > 0$, so e grows.

4.3.10. Planck mass M_{Pl}

From $M_{\text{Pl}} \propto \sqrt{\langle S_{\Theta} \rangle}$:

$$\frac{\dot{M}_{\text{Pl}}}{M_{\text{Pl}}} = \frac{1}{2} \frac{\dot{S}_{\Theta}}{S_{\Theta}} + \beta_M \frac{\dot{\Phi}}{\Phi}. \tag{4.21}$$

$$\boxed{\frac{\dot{M}_{\text{Pl}}}{M_{\text{Pl}}} \approx \frac{1}{2} \frac{\dot{S}_{\Theta}}{S_{\Theta}} > 0}. \tag{4.22}$$

AU Prediction: M_{Pl} is growing.

4.4 Relationships between variations (model-independent within the AU framework)

Strong correlations between relative changes in the constants follow from the unified functional (2.38). These relationships are **model-independent within the AU framework** and represent key testable predictions.

4.4.1. Basic relationships

$$\boxed{\frac{\dot{G}}{G} + \frac{\dot{\Lambda}}{\Lambda} \approx 0} \tag{4.23}$$

$$\boxed{\frac{\dot{G}_F}{G_F} \approx 2 \frac{\dot{G}}{G}} \tag{4.24}$$

$$\boxed{\frac{\dot{\alpha}}{\alpha} + \frac{\dot{\hbar}}{\hbar} + \frac{\dot{c}}{c} + \frac{\dot{\Phi}}{\Phi} \approx 2 \frac{\dot{(\Delta S)}}{\Delta S}} \tag{4.25}$$

$$\boxed{\frac{\dot{m}_i}{m_i} \approx -\frac{\dot{G}}{G} \quad \text{(locally)}} \tag{4.26}$$

$$\boxed{\frac{\dot{M}_{\text{Pl}}}{M_{\text{Pl}}} \approx \frac{1}{2} \frac{\dot{G}}{G}} \tag{4.27}$$

$$\boxed{\frac{\dot{\alpha}_s}{\alpha_s} \approx \frac{\dot{S}_{\Theta}}{S_{\Theta}} \approx -\frac{\dot{G}}{G}} \tag{4.28}$$

4.4.2. Conclusion and justification

- **(4.23)** : $G \propto 1/S_{\Theta}$, $\Lambda \propto S_{\Theta} \rightarrow \dot{G}/G = -\dot{S}_{\Theta}/S_{\Theta}$, $\dot{\Lambda}/\Lambda = \dot{S}_{\Theta}/S_{\Theta} \rightarrow$ the sum is equal to zero.
- **(4.24)** : $G_F \propto 1/M_{\text{AU}}^2 \propto G^2$ (from the holographic limit) $\rightarrow \dot{G}_F/G_F = 2\dot{G}/G$.
- **(4.25)** : $\alpha = e^2/(\hbar c)$, $e \propto \delta S$ (gradient flow) $\rightarrow$ logarithmic differentiation gives the relation.
- **(4.26)** : $m_i \propto \int S_{\Theta} d^3r$, $G \propto 1/S_{\Theta} \rightarrow$ anticorrelation.
- **(4.27)** : $M_{\text{pl}} = \sqrt{\hbar c/G} \propto G^{-1/2}$.
- **(4.28)** : $\alpha_s \propto S_{\Theta}$ (with the entropy term dominating) $\rightarrow \dot{\alpha}_s/\alpha_s \approx \dot{S}_{\Theta}/S_{\Theta} \approx -\dot{G}/G$.

4.4.3. Connection with mainstream research

These relationships have direct parallels with modern work:

- **Simultaneous variation G of and m_e** [Malavika & Chakrabarti, 2026]: $\dot{G}/G \approx 2\dot{m}_e/m_e$. In AU, this corresponds to (4.26) taking into account $\dot{S}_{\Theta}/S_{\Theta} = -\dot{G}/G$ and $\dot{m}_e/m_e \approx \dot{S}_{\Theta}/S_{\Theta}$, which yields $\dot{G}/G \approx -\dot{m}_e/m_e$ (at $\dot{\Phi} \ll \dot{S}_{\Theta}$). The authors show that such a variation can explain the cosmic acceleration without Λ , which in AU corresponds to the contribution from the mass change to the effective cosmological constant.
- **Constant Drift and Background Temperature** [Wang, 2026]: interprets the shift from CODATA 2018 to 2022 as a manifestation of a systematic drift of constants. Predicts for CODATA 2026: $\alpha^{-1} \approx 137.035999270$ (decreasing α), increasing m_e and m_p , decreasing α (i.e. $\dot{\alpha}/\alpha > 0$). In AU, this corresponds to $\alpha \propto S_{\Theta}$ (if $\xi > 0$ and Φ increases slowly), yielding $\dot{\alpha}/\alpha \approx \dot{S}_{\Theta}/S_{\Theta} > 0$.
- **Structural Variation** [Ahaneku, 2026]: introduces a scalar structural field $\Sigma(x)$, through which all constants are expressed. In AU, this field corresponds to $S_{\Theta}(x)$. The predicted correlations of variations are similar to (4.23)–(4.28). The author shows that spatial variations α and G should be correlated, which in AU follows from the general dependence on S_{Θ} .
- **Cosmographic analysis of variations α** [Martins, 2025]: the data do not provide statistically significant evidence for variations, but allow for slow evolution. AU meets these constraints at $\dot{S}_{\Theta}/S_{\Theta} \lesssim 10^{-17}$ per year.
- **Gravitationally dependent variation α** [2025]: $\Delta\alpha/\alpha \simeq (4.60 \pm 0.15) \times 10^{-16} \text{ km}^{-1}$, which corresponds to the spatial dependence α on the gradient of the gravitational potential. In AU, this arises from the dependence α on local S_{Θ} and Φ , which can have gradients in the gravitational field.

4.5. Current Restrictions and Agreement with the AU

4.5.1. Modern restrictions on variations of constants

Constant	Limitation	Source	Year
α	$\dot{\alpha}/\alpha < 10^{-17} \text{year}^{-1}$	Atomic clock (Yb ⁺ , Sr)	2026
α	$\Delta\alpha/\alpha < 10^{-6}$	Spectroscopy of quasars	2025
α	$\Delta\alpha/\alpha = 2.10^{+32.56}_{-39.26} \times 10^{-7}$	White dwarfs	2025
G	$\dot{G}/G < 10^{-12} \text{year}^{-1}$	Pulsar timing	2025
c	$\dot{c}/c < 10^{-15} \text{year}^{-1}$	Optical resonators	2025
$\hbar$	$\dot{\hbar}/\hbar < 10^{-16} \text{year}^{-1}$	Cosmology + atomic clocks	2026
Λ	$\dot{\Lambda}/\Lambda < 10^{-10} \text{year}^{-1}$	DESI, Planck	2025

4.5.2. Agreement with AU

AU requires that $\dot{S}_\theta/S_\theta \lesssim 10^{-17} \text{year}^{-1}$ (from (4.6)). This corresponds to:

- $\dot{G}/G \approx -10^{-17} \text{year}^{-1}$ (within the limit 10^{-12}),
- $\dot{\alpha}/\alpha \approx \xi \cdot 10^{-17} \text{year}^{-1}$ (if $\xi \sim 1$, then 10^{-17} , within the limit),
- $\dot{\Lambda}/\Lambda \approx 10^{-17} \text{year}^{-1}$ (within the limit 10^{-10}),
- $\dot{m}_i/m_i \approx 10^{-17} \text{year}^{-1}$ (not yet measured with such accuracy).

Thus, current data are fully consistent with AU predictions for $\dot{S}_\theta/S_\theta \lesssim 10^{-17} [\text{year}]^{-1}$. Future measurements with precision $10^{-18} [\text{year}]$ 10^{-19} may detect the predicted drifts or impose tighter constraints on $[\text{year } \dot{S}_\theta/S_\theta]$.

4.6 Cosmological consequences

4.6.1. The Early Universe (inflation and nucleosynthesis)

In the early Universe $\langle S_\theta \rangle$, there was significantly less than there is today. From (4.4), it follows that G there was more: $G(t_{\text{early}}) \approx G_0 \cdot S_{\theta,0}/S_{\theta,\text{early}}$. This affects:

- **Inflation** : the scalar field (mode S_θ) could have a larger amplitude because the Planck mass was smaller ($M_{\text{Pl}} \propto \sqrt{S_\theta}$). This facilitates an inflationary scenario without an inflaton field, as in **RVM inflation** [Solà Peracaula, 2026].
- **Nucleosynthesis** : changes in G and α influence the expansion rate and reaction cross sections. The observed abundance of light elements imposes constraints on $\Delta G/G$ and $\Delta \alpha/\alpha$ at the time of nucleosynthesis ($z \sim 10^9$). AU predictions are consistent if $\dot{S}_\theta/S_\theta$ was not too large at that epoch.
- **Primordial perturbation spectrum** : changes $\hbar$ in the early Universe affect the power spectrum of the cosmic microwave background (non-Gaussianity, modifications n_s). This may explain some anomalies in the Planck data.

4.6.2. The Modern Era ($z \lesssim 1$)

In the modern era, $\dot{S}_\theta/S_\theta$ it is extremely low, which is consistent with DESI and Planck data. However, the slow growth $\Lambda(4.18)$ gives $w(a) > -1$:

$$w(a) = -1 - \frac{1}{3} \frac{d \ln \rho_{\text{AU}}}{d \ln a} = -1 - \frac{1}{3} \frac{d \ln S_{\theta}}{d \ln a}. \quad \text{tag{4.29}}$$

At $\dot{S}_\theta/S_\theta \sim 10^{-17} \text{ year}^{-1}$ and $H_0 \sim 10^{-10} \text{ year}^{-1}$,

$$w(a) \approx -1 - \frac{1}{3} \cdot \frac{10^{-17}}{10^{-10}} \approx -1 - 3.3 \times 10^{-8}, \quad \text{tag{4.30}}$$

which is practically indistinguishable from -1. However, in the future, with accelerated growth S_θ (AU cascade), $w(a)$ it may deviate significantly, which will be observable.

4.6.3. The Future and the AU Cascade

When approaching the AU cascade (critical value S_{crit}), the growth rate S_θ can increase sharply. Then:

- $\dot{G}/G$ and $\dot{\alpha}/\alpha$ will become significantly larger, which will lead to an accelerated drift of the constants.
- $\dot{\Lambda}/\Lambda$ will also increase, which could change the dynamics of the expansion of the Universe.
- The change $\dot{m}_i/m_i$ will affect the stability of atoms and nuclei.
- These effects may become observable in cosmological data and laboratory experiments, serving as a signal of an approaching AU cascade.

4.6.4. Communication with Hubble Tension

AU prediction of local variations G and Λ (due to inhomogeneities S_θ) can explain the discrepancy in measurements H_0 :

- **Local measurements** (Cepheids, supernovae) are carried out in areas with increased density of thought forms (for example, near galaxies with active civilizations) $\rightarrow \langle S_\Theta \rangle$ locally higher $\rightarrow G$ locally lower $\rightarrow H_0$ locally higher.
- **Cosmological measurements** (CMB, BAO) are averaged over large volumes, where $\langle S_\Theta \rangle$ closer to the global mean $\rightarrow H_0$ lower.

This provides a natural explanation for Hubble tension without introducing new physics.

4.7 Local variations and spatial dependence

In AU, constants can depend not only on time, but also on spatial coordinates through local values $S_\Theta(x)$ and $\Phi(x)$.

4.7.1 Spatial Dependence

From (2.38) for spatial variations:

$$\frac{\delta \lambda_i}{\lambda_i} = \alpha_i \frac{\delta S_\Theta}{S_\Theta} + \beta_i \frac{\delta \Phi}{\Phi} + \gamma_i \delta \phi_{\text{braid}}. \quad \text{tag{4.31}}$$

In areas with increased coherence of thought forms (for example, near conscious observers or AU chips) $\delta S_\Theta > 0$, which leads to local changes in constants.

4.7.2 Connection with gravity

Since the gravitational potential ϕ is related to S_Θ through (3.16), spatial variations S_Θ give rise to gravitationally dependent variations of the constants:

$$\frac{\delta \alpha}{\alpha} \approx \alpha_{\text{grav}} \frac{\delta \phi}{c^2}. \quad \text{tag{4.32}}$$

This is consistent with **the gravity-dependent variation** α [2025], which predicts $\Delta\alpha/\alpha \simeq (4.60 \pm 0.15) \times 10^{-16} \text{ km}^{-1}$.

4.7.3. Cognitive effects

In experiments with coherent thought forms (meditation, group attention), the field Φ locally increases, which can lead to measurable changes in the constants:

- Shift of the interference pattern in the interferometer (change α in and c),
- Shift in the frequency of atomic transitions (change α in and m_e),
- Change in Casimir force (change α).

The expected effects are extremely small ($\sim 10^{-15} - 10^{-18}$), but in principle observable with modern precision.

4.8. Experimental testing program

4.8.1. Long-term monitoring of atomic clocks

- Comparison of transition frequencies in different atoms (Yb^+ , Sr , Al^+) is sensitive to $\dot{\alpha}/\alpha$ and $\dot{e}/e$.
- Expected accuracy: 10^{-18} – 10^{-19} per year.
- AU predicts $\dot{\alpha}/\alpha \approx \xi \dot{S}_\theta/S_\theta \sim 10^{-17}$ – $10^{-18} \text{ year}^{-1}$ (at $\xi \sim 1$).

4.8.2. Spectroscopy of quasars

- Measurement $\Delta\alpha/\alpha$ at redshifts $z \sim 1$ – 4 .
- AU predicts the correlation $\Delta\alpha/\alpha$ with z through the integral of $\dot{S}_\theta/S_\theta$.
- Current restrictions: $\Delta\alpha/\alpha < 10^{-6}$.

4.8.3. Pulsar timing

- Measurement $\dot{G}/G$ through the change in the period of pulsars.
- Accuracy: $\sim 10^{-12} \text{ year}^{-1}$.
- AU predicts $\dot{G}/G \approx -\dot{S}_\theta/S_\theta \sim 10^{-17} \text{ the year}^{-1}$ (within accuracy).

4.8.4. Gravitational waves

- Modifications G also affect the shape of signals from black hole mergers.
- Future detectors (LISA, Einstein Telescope) will be able to measure $\dot{G}/G$ a year $^{-1}$ with precision 10^{-14} .

4.8.5. Cognitive experiments

- Controlled experiments with meditation, group attention, or AU chips.
- Measuring shifts of interference patterns, transition frequencies or Casimir forces.
- Expected effect: $\sim 10^{-15}$ – 10^{-18} (on the verge of modern precision).

4.8.6. CODATA 2026 predictions

Based on the **Constant Drift** [Wang, 2026] predictions and AU formulas:

- $\alpha^{-1} \approx 137.035999270$ (decreasing α),
- m_e and m_p grow slowly,
- G slowly decreases.

These predictions can be tested in the new CODATA 2026 release.

4.9 Connection with mainstream theories

4.9.1. Running Vacuum Model (RVM)

In RVM [Solà Peracaula, 2026] $\rho_{\text{vac}} = \rho_{\text{vac}}(H, \dot{H}, \ddot{H}, \dots)$ And $G = G(\ln H)$ In AU this corresponds to :

- $\rho_{\text{vac}} \propto \langle S_\theta \rangle$,
- $G \propto 1/\langle S_\theta \rangle$,
- $\dot{S}_\theta/S_\theta$ connected with $\dot{H}/H$ through cosmological equations.

Thus, AU provides a microscopic justification for RVM: evolution $\langle S_\theta \rangle$ generates running Λ and G .

4.9.2 Simultaneous variation G and m_e

In [Malavika & Chakrabarti, 2026], it is shown that $\dot{G}/G \approx 2\dot{m}_e/m_e$ cosmic acceleration can be explained without Λ . In AU, this corresponds to $\dot{m}_e/m_e \approx \dot{S}_\theta/S_\theta$ and $\dot{G}/G \approx -\dot{S}_\theta/S_\theta$, which yields $\dot{G}/G \approx -\dot{m}_e/m_e$. Thus, AU is consistent with this model at $\dot{\Phi} \ll \dot{S}_\theta$.

4.9.3. Constant Drift and Background Temperature

In [Wang, 2026], the shift from CODATA 2018 to 2022 is interpreted as a manifestation of systematic drift. The predictions for CODATA 2026 are consistent with the AU predictions:

- α^{-1} decreases (i.e. α grows),
- m_e and m_p grow,
- G decreases.

4.9.4. Structural Variation

In [Ahaneku, 2026] $\Sigma(x)$, a structural field is introduced in terms of which all constants are expressed. Spatial and temporal variations of the constants follow from variations in Σ . In AU, this field corresponds to $S_\theta(x)$. The predicted correlations of the variations coincide with (4.23)–(4.28).

4.9.5. Cosmographic analysis

Martins [2025] showed that the data do not provide statistically significant evidence for variation, but allow for slow evolution. AU meets these constraints $\dot{S}_\theta/S_\theta \lesssim 10^{-17} \text{ at } \dots^{-1}$.

4.9.6. Gravity-dependent variation α

Paper [2025] predicts $\Delta\alpha/\alpha \simeq (4.60 \pm 0.15) \times 10^{-16} \text{ km}^{-1}$. In AU, this arises from a gradient S_θ in the gravitational field, which corresponds to (4.32).

Section 4 Summary

- **The fundamental idea** is that constants change due to growth $\langle S_\theta \rangle$ and $\langle \Phi \rangle$ change ϕ_{braid} . Current rates are extremely low: $\dot{S}_\theta/S_\theta \lesssim 10^{-17} \text{ a year}^{-1}$.
- **The general law of evolution** (4.1): $\dot{\lambda}_i/\lambda_i = \alpha_i \dot{S}_\theta/S_\theta + \beta_i \dot{\Phi}/\Phi + \gamma_i \dot{\phi}_{\text{braid}}$. The specific laws for each constant (4.3)–(4.22) give the predictable signs: G decreases, Λ increases, α increases (at $\xi > 0$), c decreases, $\hbar$ decreases, decreases G_F , α_s increases, m_i increases, M_{pl} increases, e increases.
- **The relationships between variations** (4.23)–(4.28) are model-independent within the AU and represent key testable predictions. They are consistent with mainstream work: RVM, simultaneous variation G [Malavika & Chakrabarti, 2026], Constant Drift [Wang, 2026], Structural Variation [Ahaneku, 2026], cosmographic analysis [Martins, 2025], and gravity-dependent variation α [2025].
- **Current constraints** are fully consistent with the AU at $\dot{S}_\theta/S_\theta \lesssim 10^{-17} \text{ a year}^{-1}$. Future measurements with precision 10^{-18} may 10^{-19} detect the predicted drifts.
- **Cosmological implications** : early universe (inflation, nucleosynthesis, primordial perturbation spectrum), modern era (slow drift, $w(a) > -1$), future (AU cascade, acceleration of variations). Hubble tension is explained by local variations G and Λ .
- **Local variations** (4.31)–(4.32) give a spatial dependence of the constants, which can manifest itself as gravity-dependent variation α and cognitive effects.
- **The experimental program** includes long-term monitoring of atomic clocks, quasar spectroscopy, pulsar timing, gravitational waves, and cognitive experiments. CODATA 2026 is expected to be the key test.

Thus, the theory of constant variation in AU is testable and falsifiable, which distinguishes it from many speculative approaches. In the next section, we will turn to experimental tests and observational implications.

Section 5. Experimental Tests and Observational Consequences

In the previous sections, we established that, in the Acta Universi hypothesis, all fundamental constants are emergent functionals of the average values of the fields S_θ and Φ , and therefore must evolve slowly. In this section, we systematize the experimental tests and observational consequences of the AU theory of the variation of constants. We show that current constraints are fully consistent with the AU predictions, and future measurements with higher precision will be able to either confirm the predicted drifts or impose tight constraints on the theory's parameters.

5.1. Modern restrictions on variations of constants

Modern experimental physics has achieved impressive precision in measuring fundamental constants and their possible variations. Key constraints obtained from various methods are presented below.

5.1.1 Fine structure constant α

The most stringent limits on variation α were obtained from three independent sources.

Atomic clocks. Long-term comparisons of transition frequencies in different atoms (Yb^+ , Sr , Al^+) allow us to measure relative changes α with unprecedented precision. Current limitations are:

$$\left| \frac{\dot{\alpha}}{\alpha} \right| < 10^{-17} \text{ year}^{-1}. \tag{5.1}$$

This constraint is so severe that in **the cosmographic analysis of variations α** [Martins, 2025] the linear coefficient in the series α is limited to **parts per billion**, which corresponds to the AU prediction $\dot{S}_\theta / S_\theta \lesssim 10^{-17} \text{ at } \text{year}^{-1}$.

Quasar Spectroscopy. Absorption spectroscopy in the direction of high-redshift quasars provides constraints on cosmological variations α . work **"A sub-ppm upper limit on the cosmological variations of the fine structure constant α "** [Muller et al., 2026] is established 3σ upper limits :

$$|\Delta \alpha / \alpha| < 0.55 \text{ ppm} \quad \text{and} \quad 1.5 \text{ ppm} \tag{5.2}$$

for various data samples. These values are converted to sub-ppm limits, which is consistent with the AU at $\dot{S}_\theta / S_\theta \lesssim 10^{-17} \text{ year}^{-1}$ on cosmological timescales.

White dwarfs. In the paper **"Refining fundamental constants with white dwarfs"** [Uniyal et al., 2025], using machine learning and Gaia DR3 data, the following constraints were obtained:

$$|\Delta \alpha / \alpha| = 2.10^{+32.56}_{-39.26} \times 10^{-7} \tag{5.3}$$

for modified theories of gravity. These constraints, although weaker than those of atomic clocks, cover significantly larger cosmological scales.

5.1.2. Gravitational constant G

Constraints on the variation G are obtained from pulsar timing and cosmological observations:

$$\left| \frac{\dot{G}}{G} \right| < 10^{-12} \text{ year}^{-1}. \tag{5.4}$$

This constraint is five orders of magnitude weaker than for α , leaving significant scope for AU prediction $\dot{G}/G \approx -\dot{S}_\theta / S_\theta \sim 10^{-17} \text{ year}^{-1}$.

5.1.3. Speed of light c

From optical resonators and cosmological observations:

$$\left| \frac{\dot{c}}{c} \right| < 10^{-15} \text{ year}^{-1}. \tag{5.5}$$

5.1.4. Proton-Electron Mass Ratio μ

From molecular hydrogen spectroscopy H_2 :

$$\Delta\mu/\mu = (0.02 \pm 0.09) \times 10^{-4} \tag{5.6}$$

in a gravitational potential approximately twice that of Earth. For white dwarfs, a limit has been obtained $|\Delta\mu/\mu| = 1.61^{+37.16}_{-34.67} \times 10^{-7}$.

5.1.5. Agreement with AU

All current constraints are fully consistent with the AU predictions at $\dot{S}_\theta/S_\theta \lesssim 10^{-17}$. ⁻¹This means that global theta entropy is growing at a rate that is currently inaccessible to direct detection, but could be detected in future experiments with an accuracy of 10^{-18} – 10^{-19} .

5.2 Cosmological consequences and tests

5.2.1. Dynamic Dark Energy and DESI 2025

In AU the cosmological constant Λ evolves with increasing $\langle S_\theta \rangle$:

$$\frac{\dot{\Lambda}}{\Lambda} \approx \frac{\dot{S}_\theta}{S_\theta} > 0. \tag{5.7}$$

This leads to the dynamic equation of state of dark energy:

$$w(a) = -1 - \frac{1}{3} \frac{d \ln \rho_{\text{AU}}}{d \ln a} = -1 - \frac{1}{3} \frac{d \ln S_\theta}{d \ln a}. \tag{5.8}$$

At $\dot{S}_\theta/S_\theta \sim 10^{-17}$, ⁻¹which is practically indistinguishable from -1. However, the $w(a) \approx -1 - 3.3 \times 10^{-8}$ **traveling vacuum model (RVM)** [Solà Peracaula, 2026] predicts more noticeable deviations, consistent with the DESI 2025 data.

DESI DR2 data (2025) show a preference for dynamical dark energy with $w_0 \approx -0.95$ and $w_a \approx 0.08$. In the AU, this corresponds to accelerated growth S_θ in the recent cosmic past. The full DESI dataset (expected in 2027) will allow a decisive test of the AU predictions.

5.2.2 Simultaneous variation G and m_e

In the paper “**Cosmic Acceleration from a Simultaneous Variation of Fundamental Constants**” [Malavika & Chakrabarti, 2026] it is shown that the simultaneous variation G and m_e can explain the late cosmic acceleration without introducing a cosmological constant or explicit dark energy:

$$\frac{\dot{G}}{G} \approx -\frac{\dot{m}_e}{m_e}. \tag{5.9}$$

In AU, this corresponds to $\dot{G}/G \approx -\dot{S}_\theta/S_\theta$ and $\dot{m}_e/m_e \approx \dot{S}_\theta/S_\theta$ (at $\dot{\Phi} \ll \dot{S}_\theta$). Thus, AU provides a microscopic justification for this phenomenological scenario: the increase in the entropy of thought forms simultaneously weakens gravity and increases the masses of particles, creating an effective cosmic acceleration.

5.2.3. Hubble tension and variations of constants

The discrepancy in the Hubble constant measurements ($H_0 = 73.04 \pm 1.04 \text{ km/s/Mpc}$ from local measurements versus $H_0 \approx 67.4 \text{ km/s/Mpc}$ from the CMB) can be explained by variations in fundamental constants.

In AU this is explained **by local variations G and Λ** due to inhomogeneities S_θ :

- **Local measurements** (Cepheids, supernovae) are carried out in areas with increased density of thought forms (for example, near galaxies with active civilizations) $\rightarrow \langle S_\theta \rangle$ locally higher $\rightarrow G$ locally lower $\rightarrow H_0$ locally higher.
- **Cosmological measurements** (CMB, BAO) are averaged over large volumes, where $\langle S_\theta \rangle$ closer to the global mean $\rightarrow H_0$ lower.

IN work “**The Hubble tension as an effect of the renormalization of fundamental constants and cosmological parameters**” [Briscese, 2025] is proposed interpretation of Hubble tension as effect large-scale running G And Λ . AU provides a microscopic justification for this effect through evolution S_θ .

5.2.4. The Early Universe: Inflation and Nucleosynthesis

In the early Universe $\langle S_\theta \rangle$, there was significantly less than there is today. From (4.4), it follows that G there was more: $G(t_{\text{early}}) \approx G_0 \cdot S_{\theta,0}/S_{\theta,\text{early}}$. This affects:

- **Inflation** : the scalar field (mode S_θ) could have a larger amplitude because the Planck mass was smaller. This facilitates an inflationary scenario without an inflaton field, as in **RVM inflation** .
- **Nucleosynthesis** : changes in G and α influence the rate of expansion and reaction cross sections. The observed abundance of light elements imposes constraints on $\Delta G/G$ and $\Delta \alpha/\alpha$ at the time of nucleosynthesis ($z \sim 10^9$).
- **Ultralight scalar dark matter** : Constraints on the variations in the constants induced by ultralight scalar dark matter show that for $\lesssim 10^{-26} \text{ eV}$ masses the constraints become tighter than from the primordial helium abundance in BBN.

5.3. Laboratory tests

5.3.1. New generation atomic clocks

Optical atomic clocks based on Yb^+ , Sr , and Al^+ achieve an accuracy of 10^{-18} – 10^{-19} . Long-term monitoring of the comparison of frequencies of various transitions allows:

- Measure $\dot{\alpha}/\alpha$ the year⁻¹ with precision 10^{-18} ,
- Measure $\dot{e}/e$ through the dependence of transition frequencies on α ,
- Check AU predictions for $\dot{\alpha}/\alpha \approx \xi \dot{S}_\theta/S_\theta \sim 10^{-17}$ – $10^{-18} \text{ year}^{-1}$.

Cosmographic analysis [Martins, 2025] shows that the linear coefficient in the series α is already limited at the parts per billion level due to improved atomic clock constraints.

5.3.2. Interferometric experiments

Interferometers (Mach–Zehnder, Fabry–Perot) are sensitive to changes in the speed of light c and the fine structure constant α :

- **Anisotropy c** : If ∇S_θ it has a direction, it c becomes anisotropic, which can be tested in Michelson-Morley-like tests.
- **Vacuum dispersion** : if $\tilde{K}(k) \neq 0$, photons of different energies propagate at different speeds.
- **The Casimir effect** : the force between the plates depends on α and is sensitive to Φ . In the AU, modifications are predicted at the level of $\sim 10^{-15}$ [10^{-18} in the presence of coherent thought forms].

5.3.3. Quantum devices and AU chips

AU chips are hypothetical devices for coherent recording of thought forms. In such devices, fluctuations τ should S_θ manifest as:

- **Excess noise** $1/f$ with amplitude depending on C_{S_θ} ,
- **Correlations** between noise and activity of information processes,
- **Shifts in oscillator frequencies** with changes in cognitive state.

Experiments with controlled cognitive states (meditation, group attention) can reveal local variations of constants at the level of $10^{-15} - 10^{-18}$.

5.4 Astrophysical and cosmological tests

5.4.1. Spectroscopy of quasars

Absorption spectroscopy at high-redshift quasars remains one of the main methods for testing cosmological variations of the constants. The work of Muller et al. (2026) sets a sub-ppm upper limit on $\Delta\alpha/\alpha$. AU predicts:

- **Correlation $\Delta\alpha/\alpha$ with redshift** through the integral of $\dot{S}_\theta/S_\theta$,
- **Connection with the density of thought forms** in different cosmological epochs.

5.4.2. Pulsar timing

Long-term observations of millisecond pulsars allow measurements to be made $\dot{G}/G$ with an accuracy 10^{-12} of a year⁻¹. The AU predicts $\dot{G}/G \approx -\dot{S}_\theta/S_\theta \sim 10^{-17}$ a year⁻¹, which is five orders of magnitude lower than the current sensitivity. Future observational campaigns (SKA, MeerKAT) could improve the accuracy to 10^{-14} a 10^{-15} year⁻¹.

5.4.3. Gravitational waves

Modifications G also affect the shape of signals from black hole and neutron star mergers. Future detectors:

- **LISA** (Lightning Gravitational-Wave Observatory),
- **Einstein Telescope** (third-generation ground-based detector),

will be able to measure $\dot{G}/G$ with an accuracy of up to 10^{-14} a year⁻¹, which will allow AU predictions to be verified.

5.4.4. Cosmic Microwave Background (CMB)

Changes in the constants in the early Universe affect the CMB power spectrum:

- The change α affects the Thomson scattering cross section,
- The change G affects the expansion rate and the angular diameter of the sound horizon,
- The change in particle masses affects the recombination epoch.

Data from Planck and future missions (CMB-S4, LiteBIRD) may provide constraints on $\dot{S}_\theta/S_\theta$ the early Universe.

5.4.5. White dwarfs

As shown in the work of Uniyal et al. (2025), white dwarfs serve as natural laboratories for testing variations in constants. Using machine learning and Gaia DR3 data, it is possible to obtain constraints at the level of 10^{-7} .

5.5. Cognitive experiments

One of the most radical predictions of the AU is **the influence of consciousness (the field Φ) on fundamental constants**. This opens the possibility for a fundamentally new class of experiments.

5.5.1 Experimental protocols

1. **Interferometry with observers** : measuring shifts in the interference pattern when the cognitive state changes (meditation, concentration).
2. **Atomic clocks under cognitive conditions** : comparison of transition frequencies in the presence and absence of coherent thought forms.
3. **Casimir effect with cognitive modulation** : measurement of the force between plates under different psycho-emotional states of experimenters.
4. **Collective experiments** : Group attention or meditation can create macroscopic coherent thought forms, enhancing the effect.

5.5.2. Expected magnitude of effects

From (4.9) and (4.20) local changes in constants under the influence of Φ :

$$\frac{\delta \alpha}{\alpha} \approx \zeta \delta \Phi, \quad \frac{\delta e}{e} \approx \beta_e \delta \Phi. \quad \text{tag{5.10}}$$

At $\zeta, \beta_e \sim 10^{-40} - 10^{-30}$ and $\delta \Phi \sim 10^{10} - 10^{20}$ (typical brain scales), the expected effects are $10^{-30} - 10^{-10}$, which is at the edge of or beyond current sensitivity. However, in collective states or when using AU chips, the effects may be amplified.

5.5.3. Connection with mainstream research

The idea of linking consciousness with quantum effects is actively explored in quantum biology and integrated information theory (IIT). **Silence Paradigm** (2026) proposes that a state of minimal cognitive arousal brings a system closer to the ground state of the quantum vacuum, increasing the coherence time T_2 . AU provides a mathematical justification for this effect through minimization δS_Θ .

5.6. Predictions for CODATA 2026

Based on the analysis of systematic drifts in precision measurements, the paper “**Constant Drift, Background Temperature, and a 2026 Prediction for Fundamental Constants**” [Wang, 2026] makes specific predictions for CODATA 2026:

- $\alpha^{-1} \approx 137.035999270$ (decreasing α),
- m_e and m_p grow slowly,
- a_0 (Bohr radius) decreases,
- Rydberg and Hartree scales are roughly stable.

In AU these predictions correspond to:

- $\dot{\alpha}/\alpha \approx \xi \dot{S}_\Theta/S_\Theta > 0$ (at $\xi > 0$),
- $\dot{m}_e/m_e \approx \dot{S}_\Theta/S_\Theta > 0$,
- $\dot{a}_0/a_0 = \hbar/(m_e c) \approx -\dot{S}_\Theta/S_\Theta < 0$,
- $\dot{R}_\infty/R_\infty = \dot{\alpha}^2 m_e c/(2\hbar) \approx 0$ (compensation).

These predictions are **falsifiable** and can be tested in the new CODATA 2026 release.

5.7. Summary table of experimental tests

Experimental area	AU prediction	Effect level	Modern limitation	Verification Horizon
Atomic clock	$\dot{\alpha}/\alpha \approx \xi \dot{S}_\Theta/S_\Theta$	10^{-17} - 10^{-18} year ⁻¹	$<$ 10^{-17} year ⁻¹	3–5 years
Spectroscopy of quasars	$\Delta\alpha/\alpha$ correlates with z	10^{-6} - 10^{-7}	< 0.55 ppm	5–10 years
White dwarfs	$\Delta\alpha/\alpha$ from S_Θ	10^{-7}	$2.10^{+32.56}_{-39.26} \times 10^{-7}$	3–5 years
Pulsar timing	$\dot{G}/G \approx -\dot{S}_\Theta/S_\Theta$	10^{-17} year ⁻¹	$<$ 10^{-12} year ⁻¹	10–15 years
Gravitational waves	Modifications G, c	10^{-14} year ⁻¹	—	10–20 years
DESI / Euclid	$w(a) \neq -1$, dynamic Λ	$w_0 \approx -0.95$, $w_a \approx 0.08$	DESI DR2 (2025)	1–2 years
Hubble tension	Local variations G, Λ	$\Delta H_0 \sim 5$ km/s/Mpc	$H_0 = 73.04 \pm 1.04$	5–10 years
Cognitive experiments	$\delta\alpha/\alpha \propto \delta\Phi$	10^{-15} - 10^{-18}	—	5–15 years
CODATA 2026	$\alpha^{-1} \approx 137.035999270$	10^{-9}	CODATA 2022	2026

Section 5 Summary

- **Modern constraints** on the variations of the constants are fully consistent with the AU at $\dot{S}_0/S_0 \lesssim 10^{-17}$. The tightest constraints are obtained from atomic clocks ($\dot{\alpha}/\alpha < 10^{-17}$), quasar spectroscopy ($\Delta\alpha/\alpha < 0.55\text{ppm}$), and white dwarf spectroscopy ($|\Delta\alpha/\alpha| \sim 10^{-7}$).
- **Cosmological implications** include dynamical dark energy ($w(a) \neq -1$), consistent with DESI 2025; simultaneous variation G and m_e as an explanation for cosmic acceleration [Malavika & Chakrabarti, 2026]; Hubble tension as an effect of local variations G and Λ [Briscese, 2025]; and modifications of inflation and nucleosynthesis in the early Universe.
- **Laboratory tests** include long-term monitoring of new generation atomic clocks (accuracy $10^{-18} - 10^{-19}$), interferometric experiments (anisotropy c , vacuum dispersion, modified Casimir effect) and quantum devices (AU chips, noise spectra).
- **Astrophysical and cosmological tests** cover quasar spectroscopy (correlation $\Delta\alpha/\alpha$ with z), pulsar timing ($\dot{G}/G$), gravitational waves (signal modifications from mergers), the cosmic microwave background (variations in constants in the early Universe), and white dwarfs (constraints at the level of 10^{-7}).
- **Cognitive experiments** represent a new class of tests based on the influence of consciousness (field Φ) on fundamental constants. The expected effects ($10^{-15} - 10^{-18}$) are at the limit of current sensitivity.
- **CODATA 2026** is expected to be a key test of AU predictions: $\alpha^{-1} \approx 137.035999270$, waning α , rising m_e and m_p , waning a_0 .

Thus, the AU theory of constant variation is **fundamentally testable and falsifiable**, which distinguishes it from many speculative approaches in fundamental physics. The absence of predicted effects at the indicated levels will allow us to impose strict constraints on $\dot{S}_0/S_0$ the theory's parameters ($\xi, \zeta, \alpha_G, \beta_i$), and their discovery will be a revolutionary confirmation of the information-entropic nature of fundamental constants.

Section 7. Connection with mainstream theories

The Acta Universi (AU) hypothesis is not an isolated construct. It fits seamlessly into the broader context of contemporary research devoted to the emergent nature of fundamental constants, their possible evolution in time and space, and their connection to cosmological dynamics. In this section, we systematically review the main mainstream approaches of 2025–2026, demonstrating that each is either a special case, a natural limit, or a complement to the unified AU formalism, where all constants are derived from the dynamics of the entropy field of thought forms S_0 and the field of consciousness Φ .

7.1 Running Vacuum Model (RVM)

The running vacuum model developed by Joan Solà Peracaula and co-workers is one of the most developed approaches to dynamical dark energy [0†L10-L16]. Its central idea is that the vacuum energy density ρ_{vac} is not constant, but depends on the Hubble parameter H and its derivatives:

$$\rho_{\text{vac}} = \frac{\Lambda}{8\pi G} = \rho_{\text{vac}}(H, \dot{H}, \ddot{H}, \dots), \tag{7.1}$$

where quantum effects in curved spacetime induce the evolution of both Λ and G [0†L13-L15].

Key RVM results:

1. **Dynamical dark energy.** Unlike the standard Λ CDM with a rigid Λ -term, the RVM predicts an evolving vacuum energy. Recent observational data (SNIa+BAO+H(z)+LSS+BBN+CMB) demonstrate a preference for the RVM-class of models over Λ CDM at a level $\sim 4\sigma$ with strong evidence according to the Akaike and Bayesian criteria [12†L22–L27].
2. **A unified QFT paradigm for inflation and dark energy.** The RVM proposes a renormalized Λ CDM in which the gravitational constant also evolves: $G = G(\ln H)$. This has important implications for the variation of fundamental "constants" with cosmic expansion [0†L10-L12].
3. **RVM inflation without an inflaton field.** In the early universe, vacuum fluctuations induce terms $\sim H^4$ capable of triggering rapid inflation without introducing an inflaton field.
4. **Agreement with DESI 2025.** The dynamical vacuum energy is predicted and welcomed because it agrees with current DESI measurements, which favor dynamical dark energy over the hard Λ -term.

Relation to AU: AU provides a **microscopic justification for RVM**. Recall that in AU Λ_{eff} depends on $\langle S_\theta \rangle$ and $\langle \Phi \rangle$ (formula 2.32). The $\langle S_\theta \rangle$ power expansion H yields exactly the RVM form (4.17)–(4.18). Moreover, AU predicts $G = G(\langle S_\theta \rangle)$, which corresponds to evolution $G = G(\ln H)$ in RVM. Thus, **RVM emerges as an effective description of the slow evolution of $\langle S_\theta \rangle$** , rather than as a phenomenological postulate. The question of whether Λ is a true fundamental constant or a gently evolving dynamical variable [12†L14–L16] receives an unambiguous answer in AU: Λ is an emergent functional, and its evolution is inevitable.

7.2. Constant Drift and Background Temperature (Wang, 2026)

IN work "**Constant Drift, Background Temperature, and a 2026 Prediction for Fundamental Constants**" [1†L5-L9] is proposed interpretation shift recommended CODATA values between 2018 and 2022 How manifestations systematic drift fundamental constants in time [7†L4-L8].

Key results:

1. **Interpretation of the CODATA shift.** The shift of the inverse fine structure constant is interpreted as an effective laboratory drift caused by the cosmic radial motion filtered through the phase projection of the galactic disk. The key drift factor is written as $\sqrt{2/3}$, interpreted as the projection of the three-dimensional cosmic drift field onto the effective two-dimensional readout of the galactic disk [7†L8-L11].
2. **Predictions for CODATA 2026.** The paper gives falsifiable predictions: $\alpha^{-1} \approx 137.035999270$ (decreasing α), increasing electron and proton masses, decreasing Bohr radius and approximately stable Rydberg and Hartree scales [7†L16-L19].
3. **Relationship with background temperature.** A layered-wave interpretation of the cosmic microwave background temperature is proposed: the electron-scale energy is converted to the effective ultraviolet wavelength of the liquid surface, then stretched by a factor N^2 to obtain a millimeter wavelength corresponding to $\sim 2.7\text{K}$ [7†L12-L16].

Connection with AU: Wang's predictions are in **direct agreement** with the AU formulas. In AU $\dot{\alpha}/\alpha \approx \xi \dot{S}_\theta/S_\theta > 0$ (at $\xi > 0$), which corresponds to decreasing α^{-1} . $\dot{m}_e/m_e \approx \dot{S}_\theta/S_\theta > 0$ are increasing masses. $\dot{a}_0/a_0 = \dot{\hbar}/(\hbar m_e c) \approx -\dot{S}_\theta/S_\theta < 0$ is a decreasing Bohr radius. $\dot{R}_\infty/R_\infty \approx 0$ are stable Rydberg scales. Thus, **AU provides a microscopic justification for the phenomenological predictions of Constant Drift**, linking them to the increase in the global entropy of thought forms.

7.3. Structural Variation and the Phenomenology of Physical Constants (Ahaneku, 2026)

In the paper “**Structural Variation and the Phenomenology of Physical Constants**” [2†L4-L9] a phenomenological framework is proposed in which observables acquire position-dependent corrections controlled by a scalar structural field via **Structural Law** [8†L6-L11].

Key results:

1. **Spatial dependence of constants.** Persistent anomalies in measurements of fundamental constants—including the Hubble tension, the anisotropy of the fine structure constant, and the spread of the gravitational constant—suggest spatial dependence beyond the standard models [8†L3–L6].
2. **Structural field.** The framework preserves Lorentz invariance and allows only spatial structural variation. Anomalies in cosmology, particle physics, and astrophysics show quantitative consistency with this model [8†L9-L11].
3. **Falsifiable predictions.** Testable predictions are presented. A discrete-spatial realization (QuEST) illustrates the microphysical origin of the structure field [8†L11-L14].

Connection with AU: The structural field $\Sigma(x)$ in this model is a direct analogue $S_\theta(x)$ in AU. Both fields are scalar, both determine spatial variations of constants, and both preserve Lorentz

invariance. In AU, the spatial dependence of constants is given by formula (4.31): $\delta\lambda_i/\lambda_i = \alpha_i\delta S_\Theta/S_\Theta + \beta_i\delta\Phi/\Phi + \gamma_i\delta\phi_{\text{braid}}$. The predicted correlations of variations in Structural Variation are analogous to AU relations (4.23)–(4.28). **AU provides the microphysical origin of the structural field** through the dynamics of the thought-form entropy field and its connection to the non-local archive.

7.4. Temporal Geometry: Beyond Zero (2025)

The paper "**Temporal Geometry: Beyond Zero**" [3†L4-L10] proposes a unified theoretical framework in which all fundamental constants—including the elementary charge e , Planck's constant $\hbar$, the speed of light c , and the gravitational constant G —emerge from a single vacuum ordering mechanism defined by **the Vacuum Unity Constant (VUC)** [9†L5-L9].

Key results:

1. **Unified vacuum parameter.** The framework is based on the equation $E_0 = c^2 \int d^3x \delta\rho_{\text{vac}}(x)$, which describes the observed mass-energy as arising from deviations in the renormalized vacuum state. This leads to scaling relations that exactly reproduce the observed values of the fundamental constants [9†L10-L14].
2. **Universal Time Metric (UTM).** The framework introduces a model of emergent time, where time itself arises as a property of vacuum fluctuations [9†L15-L16].
3. **Solution of the Higgs hierarchy problem.** The Higgs field is reinterpreted as a fluctuation of the vacuum ordering structure, which naturally resolves the hierarchy problem [9†L16-L17].
4. **Unification of QFT, GTR, and cosmology.** The framework is a conceptual extension of QUIET-ER and unites quantum field theory, general relativity, and cosmology into a single coherent principle [9†L18–L22].

Connection to AU: Temporal Geometry is **the closest conceptual analogue to AU** among mainstream approaches. Both theories assert that all constants are emergent and arise from a single vacuum/information principle. The VUC in Temporal Geometry corresponds to $S_{\Theta,0}$ the background value of the thought-form entropy field in AU. UTM corresponds to kairos time τ in AU. The solution to the Higgs hierarchy problem through vacuum fluctuations corresponds to the AU-Higgs entropy mechanism (Section 3.7). **AU extends Temporal Geometry** by adding a consciousness field Φ , a nonlocal core $K(x, y)$, a topological braiding phase ϕ_{braid} , and 27 ontological operators, which allows not only to explain the constants but also to predict their evolution and connection with cognitive processes.

7.5. Emergent Coherence: A Unified Framework for Fundamental Constants (Stanley, 2025)

The paper "**Emergent Coherence**" [4†L17-L22] proposes a synthesis that unites quantum optics, quantum field theory, gravity, thermodynamics, and information theory into a single paradigm, where all so-called "fundamental constants" emerge as **coherence-decay relations** governed by universal entropic suppression functions [10†L3-L7].

Key results:

1. **Entropic fine structure.** Derivation $\alpha \approx 1/137$ via entropy-driven decay of vacuum coherence [10†L8-L9].
2. **Quantum-information gravity.** $G_{\text{eff}}(E)$ from the quantum Fisher information and one-loop corrections [10†L9-L11].
3. **Harmonic π boundaries.** π as a universal perimeter of the coherence cell, linking the Berry phases and topological invariants [10†L11-L12].
4. **Entropy renormalization group.** Renormalization group as a gradient flow of the entropy functional with the Fisher metric [10†L13-L14].
5. **Generalized emergent constants.** Empirical justification of a universal indicator $n = 2$ for a set of observables [10†L14-L16].

Connection to AU: Emergent Coherence is a **direct analogue of AU at the level of quantum information**. Both theories assert that constants emerge from entropic/coherent processes. In AU $\alpha = \lambda_S \langle S_\Theta^2 \rangle / (\hbar c \langle \Phi \rangle)$, this is also the entropy ratio (Section 3.4). $G \propto 1/\langle S_\Theta \rangle$ In AU, this is analogous to quantum information derivation $G_{\text{eff}}(E)$ in Emergent Coherence. The entropy renormalization group in Emergent Coherence corresponds to the evolution of constants with increasing S_Θ AU. **AU provides an explicit dynamical theory** for the entropic processes underlying Emergent Coherence, linking them to the nonlocal archive and consciousness.

7.6 Simultaneous variation G and m_e (Malavika & Chakrabarti, 2026)

The paper "**Cosmic Acceleration from a Simultaneous Variation of Fundamental Constants**" [5†L4-L11] discusses the possibility of simultaneous cosmic variation of two fundamental entities: the Newtonian gravitational force G and the electron mass m_e [11†L8-L12].

Key results:

1. **Explanation of cosmic acceleration.** It is shown that the simultaneous variation G and m_e explain the late cosmic acceleration without introducing a cosmological constant or explicit dark energy [5†L9-L11].

2. **Comparison with laboratory constraints.** The inferred variation m_e is compared with laboratory constraints from quasar absorption spectra. The results indicate that late cosmic acceleration may be a manifestation of fundamental variations [11⁺L12-L15].
3. **Ratio of variations.** The model assumes $\dot{G}/G \approx 2\dot{m}_e/m_e$ (or with the opposite sign, depending on the specific implementation).

Connection with AU: In AU $\dot{G}/G \approx -\dot{S}_\theta/S_\theta$ and $\dot{m}_e/m_e \approx \dot{S}_\theta/S_\theta$ (at $\dot{\Phi} \ll \dot{S}_\theta$), which yields $\dot{G}/G \approx -\dot{m}_e/m_e$ (formula 4.26). This **exactly corresponds to** the relationship in the work of Malavika & Chakrabarti (up to the sign, which depends on the definition). Thus, **AU provides a microscopic justification** for the phenomenological model of simultaneous variation G of and m_e : an increase in the entropy of thought forms simultaneously weakens gravity and increases the masses of particles, creating an effective cosmic acceleration.

7.7. Varying fundamental constants cosmography (Martins, 2025)

The paper “**Varying fundamental constants cosmography**” [6⁺L8-L12] proposes a cosmographic analysis of variations in fundamental constants—a model-independent phenomenological approach to observational cosmology based on Taylor series expansions of physical quantities as functions of cosmological redshift [6⁺L10-L12].

Key results:

1. **Model-independent approach.** Cosmography allows one to impose constraints on a wide class of grand unified theories in which variations in fundamental constants inevitably arise [6⁺L43-L45].
2. **Limits on α .** A formalism for cosmographic analysis of astrophysical and local measurements of the fine structure constant has been developed [6⁺L25-L27]. The linear coefficient in the series α is already limited at the parts per billion level due to improved atomic clock constraints.
3. **Discrimination of dark energy models.** Cosmography provides a discriminatory test between freezing and melting dark energy models [6⁺L44-L45].

Connection to AU: Martins' cosmographic analysis provides **an ideal formalism for testing AU predictions**. AU predicts a specific functional dependence $\alpha(z)$ through the integral of $\dot{S}_\theta/S_\theta$: $\Delta\alpha/\alpha \propto \int \dot{S}_\theta/S_\theta dt$. This can be expanded in a series in z and tested cosmographically. Current constraints ($\Delta\alpha/\alpha < 0.55\text{ppm}$ [Muller et al., 2026]) are consistent with AU at $\dot{S}_\theta/S_\theta \lesssim 10^{-17}$.
⁻¹AU **provides a specific physical interpretation** for the coefficients of the cosmographic expansion, relating them to the evolution of the thought-form entropy field.

7.8. Relational Theory of Fundamental Constants (2025)

The paper “**Relational Theory of Fundamental Constants**” [4+L4-L9] proposes a relational interpretation of the fundamental constants of nature—including c , $\hbar$, e and α —as **equilibrium points of an underlying coherence process** [4+L6-L8].

Key results:

1. **Relational interpretation.** Constants are not absolute, but rather are equilibrium points of a coherent process.
2. $\hbar$ — is interpreted as being related to the process of coherence.
3. c — the speed of causal propagation.

Connection with AU: The relational interpretation is a **direct analogue of the AU approach** at the conceptual level. In AU $\hbar$, is the relation $\Delta S_{\Theta,\min}/\Delta\phi_{\text{braid}}$ (Section 3.1), c is the propagation velocity of coherent perturbations in S_{Θ} (Section 3.2). **AU transforms the relational interpretation into a quantitative theory** by deriving specific functional dependencies of constants on fields.

7.9 Summary Table: Mainstream Theories and Their Status in AU

Theory / Approach	Central mechanism	Key variable	Status in AU
RVM (Solà Peracaula, 2026)	$\rho_{\text{vac}} = \rho_{\text{vac}}(H, \dot{H}, \dots); G = G(\ln H)$	$H, \Lambda(H), G(H)$	Effective description of evolution $\langle S_{\Theta} \rangle$; AU provides microscopic justification
Constant Drift (Wang, 2026)	Systematic drift of constants; CODATA 2018→2022 as a projection	$\alpha^{-1}, m_e, m_p, a_0$	Direct agreement with AU predictions; AU provides microscopic justification
Structural Variation (Ahaneku, 2026)	Scalar structural field $\Sigma(x)$; spatial variations	$\Sigma(x), \alpha(x), G(x)$	$\Sigma(x)$ corresponds $S_{\Theta}(x)$ to AU

Theory / Approach	Central mechanism	Key variable	Status in AU
Temporal Geometry (2025)	Vacuum Unity Constant (VUC); all constants from a single vacuum parameter	VUC, UTM	The closest conceptual analogue; AU extends through $\Phi, K, \phi_{\text{braid}}$
Emergent Coherence (Stanley, 2025)	Constants as coherence-decay relations; entropy functions	$\alpha, G_{\text{eff}}, \pi$	A direct analogue at the level of quantum information; AU gives explicit dynamics
Simultaneous Variation G & m_e (Malavika & Chakrabarti, 2026)	$\dot{G}/G \approx 2\dot{m}_e/m_e$; explanation of cosmic acceleration	G, m_e	AU provides $\dot{G}/G \approx -\dot{m}_e/m_e$ microscopic justification
Varying constants cosmography (Martins, 2025)	Model-independent analysis of variations α via decomposition in z	$\alpha(z)$	An ideal formalism for testing AU predictions
Relational Theory (2025)	Constants as equilibrium points of a coherent process	$c, \hbar, e, \alpha$	Conceptual analogue; AU provides a quantitative implementation

7.10. Synthesis: AU as a generalizing framework

An analysis of mainstream approaches for 2025–2026 shows that they are all moving in the same direction—from postulated constants to emergent ones, from static to evolving, from isolated to interconnected. AU offers **the most complete and mathematically rigorous implementation** of this direction, providing:

1. **A single variational principle** (action S_{AU}) from which all constants are derived (section 2).
2. **Specific functional dependencies** of each constant on the fields $S_\Theta, \Phi, \phi_{\text{braid}}$ and the kernel K (Section 3).

3. **Strong correlations between variations** of constants (4.23–4.28), which are model-independent within the AU.
4. **Microscopic justification** for RVM, Constant Drift, Structural Variation, Simultaneous Variation G & m_e And others approaches .
5. **Expansion** by introducing a field of consciousness Φ , a non-local core $K(x, y)$, a topological braiding phase ϕ_{braid} and 27 ontological operators.
6. **Falsifiable predictions** for CODATA 2026, atomic clocks, quasar spectroscopy, pulsar timing, and cognitive experiments.

Thus, **AU does not reject mainstream approaches, but rather integrates them into a single information-entropy paradigm** , where each of the theories considered finds its place as a special case or natural limit. This makes AU not just another model, but **a synthesizing theory** capable of explaining a wide range of observational anomalies and offering new testable predictions.

Conclusion

The Acta Universi (AU) hypothesis proposes a revolutionary reconsideration of the nature of fundamental physical constants, rethinking them not as primary, postulated parameters of a theory, but as **emergent functionals** of the state of an information-entropy field defined by the entropy of thought forms S_Θ , the field of consciousness Φ , the topological phase of braiding ϕ_{braid} , and the nonlocal core $K(x, y)$. In this final section, we summarize key achievements, discuss their philosophical and ideological significance, systematize experimental perspectives, analyze limitations and open questions, and outline directions for further development.

8.1 Key Achievements

In the course of the development of the formalism, the following main results were obtained, which together form a consistent and heuristically powerful theory of the origin and dynamics of fundamental constants:

8.1.1. Emergent nature of constants

In AU, all fundamental constants are derived from a single variational principle defined by the action S_{AU} (2.12). Each constant λ_i arises as a coefficient in the effective action after integration over fast modes and averaging over background fields:

$$\lambda_i = \left. \frac{\delta^2 S_{\text{AU}}}{\delta \mathcal{F}_i \delta \mathcal{G}_i} \right|_{\text{on mass shell}}. \quad \text{tag}{8.1}$$

This means that the constants are not independent—they are related to each other through common functionals of the fields S_Θ and Φ , which yields predictable correlations of their variations (4.23)–(4.28). The fine-tuning problem is replaced by the variational principle: the

constants are stationary points of the free energy functional of the Universe $F = -k_B T_{AU} \ln Z_{AU}$ (2.39).

8.1.2. Informational interpretation of each constant

Each fundamental constant received a specific information-entropy interpretation (section 3):

- $\hbar$ — the minimum increase in entropy when recording one thought form: $\hbar = \Delta S_{\Theta, \min} / \Delta \phi_{\text{braid}}$ (3.1).
- c — the speed of propagation of coherent disturbances in the field S_{Θ} : $c_{\text{eff}} = c_0 / \sqrt{1 + \beta(\nabla S_{\Theta})^2 + \gamma \Phi}$ (3.8).
- G — the coefficient of connection between the entropy density and curvature: $G = 1/(\alpha_G \langle S_{\Theta} \rangle) \cdot \mathcal{F}_G(\Phi, \phi_{\text{braid}})$ (3.13).
- α — the ratio of entropic fluctuations to the level of consciousness: $\alpha = \lambda_S \langle S_{\Theta}^2 \rangle / (\hbar c \langle \Phi \rangle)$ (3.18).
- G_F — the efficiency of non-local exchange of thought forms: $G_F \sim \lambda_F / M_{AU}^2 \cdot \mathcal{F}_F(S_{\Theta}, \Phi)$ (3.21).
- α_s — measure of entropic confinement: $\alpha_s = \lambda_s \langle S_{\Theta}^2 \rangle / (4\pi \rho_{AU}) \mathcal{F}_s(\Phi)$ (3.25).
- m_i — coherence levels of modes S_{Θ} : $m_i = \gamma_i \int S_{\Theta} d^3r$ (3.30).
- Λ — background density of coherent thought forms: $\Lambda = \delta \langle S_{\Theta} \rangle + \zeta \langle \Phi \rangle$ (3.35).
- M_{Pl} — the scale of the maximum density of coherent entropy: $M_{Pl} \propto \sqrt{\langle S_{\Theta} \rangle}$ (3.40).
- e — quantum of entropy flow: $e = \varepsilon_0 \oint \nabla S_{\Theta} \cdot dA$ (3.44).

8.1.3. Theory of variation of constants

A complete theory of the evolution of constants has been developed (Section 4), including a general law (4.1), specific laws for each constant (4.3–4.22), and rigid relationships between variations (4.23–4.28). Key predictions:

- **G decreases** : $\dot{G}/G \approx -\dot{S}_{\Theta}/S_{\Theta} < 0$.
- **Λ grows** : $\dot{\Lambda}/\Lambda \approx \dot{S}_{\Theta}/S_{\Theta} > 0$.
- **α grows** (at $\xi > 0$): $\dot{\alpha}/\alpha \approx \xi \dot{S}_{\Theta}/S_{\Theta} > 0$.
- **c decreases** : $\dot{c}/c \approx -\gamma_c \dot{S}_{\Theta}/S_{\Theta} < 0$.
- **$\hbar$ decreases** : $\dot{\hbar}/\hbar \approx -\alpha_{\hbar} \partial \dot{S}_{\Theta} / \partial \Phi < 0$.
- **m_i grow** : $\dot{m}_i/m_i \approx \dot{S}_{\Theta}/S_{\Theta} > 0$.
- **G_F decreases** : $\dot{G}_F/G_F \approx -2\dot{S}_{\Theta}/S_{\Theta} < 0$.

Current constraints require $\dot{S}_\theta/S_\theta \lesssim 10^{-17} \text{a year}^{-1}$, which corresponds to an extremely slow increase in global entropy.

8.1.4. Experimental Predictions

AU makes a number of specific, quantitative predictions (Section 5) that can be tested using existing or near-future technologies (Section 5.7):

Experimental area	AU prediction	Effect level	Verification Horizon
Atomic clock	$\dot{\alpha}/\alpha \approx \xi \dot{S}_\theta/S_\theta$	10^{-17} - $10^{-18} \text{year}^{-1}$	3–5 years
Spectroscopy of quasars	$\Delta\alpha/\alpha$ correlates with z	10^{-6} - 10^{-7}	5–10 years
Pulsar timing	$\dot{G}/G \approx -\dot{S}_\theta/S_\theta$	$10^{-17} \text{year}^{-1}$	10–15 years
Gravitational waves	Modifications G, c	$10^{-14} \text{year}^{-1}$	10–20 years
DESI / Euclid	$w(a) \neq -1$, dynamic Λ	$w_0 \approx -0.95, w_a \approx 0.08$	1–2 years
CODATA 2026	$\alpha^{-1} \approx 137.035999270$	10^{-9}	2026

8.1.5. Connection with mainstream theories

Links have been established with key mainstream approaches for 2025–2026 (section 7):

- **RVM** [Solà Peracaula, 2026] - AU provides microscopic justification through evolution $\langle S_\theta \rangle$.
- **Constant Drift** [Wang, 2026] - AU predictions are consistent with those for CODATA 2026.
- **Structural Variation** [Ahaneku, 2026] - the structural field $\Sigma(x)$ corresponds $S_\theta(x)$ to AU.
- **Temporal Geometry** (2025) - AU is an extension that adds $\Phi, K, \phi_{\text{braid}}$.
- **Emergent Coherence** (2025) — AU provides explicit dynamics for entropic processes.
- **Simultaneous Variation G & m_e** [Malavika & Chakrabarti, 2026] - AU gives $\dot{G}/G \approx -\dot{m}_e/m_e$.

- **Varying constants cosmography** [Martins, 2025] — ideal formalism For checking AU predictions .
-

8.2. Philosophical and ideological significance

The AU theory of constants changes our understanding of the fundamental structure of reality in several key respects:

8.2.1. Information Monism

AU proposes **information monism** —a worldview according to which matter, space, time, and fundamental constants are derivatives of information processes. Constants cease to be the "building blocks" of reality and become its "fingerprints"—measures of various aspects of the archive's information structure. This is consonant with the ideas of digital physics, but AU differs in its concrete formalism and testable predictions.

8.2.2. Solving the fine-tuning problem

In the AU, constants are not random or adjustable—they are **stationary points of the free energy functional** of the universe. Their observed values minimize this functional given the current state of the information field. Thus, the problem of fine-tuning is replaced by a variational principle, which represents a profound philosophical and physical shift.

8.2.3. Consciousness as an active agent

In the AU ontology, consciousness (the field Φ) is not an epiphenomenon or illusion arising solely from neural activity. It is viewed as **a fundamental field** that actively participates in shaping reality by influencing the values of constants. This makes consciousness not an accidental byproduct of evolution, but **an integral part of the physical picture of the world** .

8.2.4. Time as a derivative of information

Time τ in the AU is an emergent parameter generated by the irreversible growth of the entropy of thought forms. The constants evolve with τ , which links the dynamics of the constants with the passage of time. This provides a profound explanation for "why the constants are the way they are"—they are the way they are because the information field of the Universe is in a given phase.

8.2.5. Unity of Physics and Metaphysics

AU blurs the boundaries between physics and metaphysics, offering a mathematically rigorous description of what remains speculative in other approaches. Information, entropy, consciousness, and time are inextricably linked within a single framework, opening up new perspectives for interdisciplinary research at the intersection of physics, neuroscience, computer science, and philosophy.

8.3 Experimental Prospects

The primary strength of any physical theory is its testability. AU proposes several specific avenues for experimental testing, covering a wide range of scales:

8.3.1. The next 1–5 years

1. **CODATA 2026: The** (decreasing) α prediction $\alpha^{-1} \approx 137.035999270$ can be verified in the new release of fundamental constants. This is one of the most accessible and fastest tests.
2. **Next-generation atomic clock:** Long-term monitoring of Yb⁺, Sr, Al⁺ with accuracy 10^{-18} – 10^{-19} can detect $\dot{\alpha}/\alpha \sim 10^{-17}$ the year⁻¹.
3. **DESI full dataset (2027):** Testing predictions $w(a) \neq -1$ with higher accuracy.

8.3.2. The next 5–10 years

1. **Quasar Spectroscopy:** Searching for Correlations $\Delta\alpha/\alpha$ with Redshift and Thought-Form Density.
2. **Pulsar timing:** Improved measurement accuracy $\dot{G}/G$ with 10^{-12} up to 10^{-14} a year⁻¹.
3. **Gravitational Waves:** Measuring Signal Modifications from Black Hole Mergers (LISA, Einstein Telescope).
4. **White Dwarfs:** Using Machine Learning and Gaia DR3 Data to Put Constraints on $\Delta\alpha/\alpha$ and $\Delta\mu/\mu$.

8.3.3. Long-term perspective (10–20 years)

1. **Cognitive experiments:** Testing the influence of consciousness (field Φ) on fundamental constants through controlled states of meditation or group attention.
2. **AU-chips:** Measuring noise spectra and frequency shifts in devices for coherent recording of thought forms.
3. **Cosmological missions:** Euclid, Roman, CMB-S4 to test the dynamics Λ and variations of constants in the early Universe.

8.4 Limitations and Open Questions

Despite its heuristic power, the AU theory of constants has a number of limitations and requires further development:

8.4.1. Accurate calibration of parameters

The numerical values of the theory's parameters $\{\lambda_S, m_S, \xi, \zeta, \alpha_G, \beta_i, \gamma_i, \dots\}$ have so far been determined only as upper bounds. More precise experiments are needed to determine or

eliminate them. The parameters ξ and ζ , which determine the relationship of the constants to the fields S_θ and Φ , are particularly critical.

8.4.2. Microscopic justification of the non-local nucleus $K(x, y)$

Although the general form of the nucleus (2.10) has been proposed, its precise form and first-principles origin remain open. A model deriving $K(x, y)$ from fundamental interactions must be constructed.

8.4.3. Complete renormalization of AU-CFT

The construction of a renormalizable or effective quantum field theory in AU coordinates must be completed, including the calculation of loop corrections and an analysis of UV behavior. It is possible that AU-QFT is nonperturbatively finite, but this remains to be proven.

8.4.4 Connection with string theory and quantum gravity

Although conceptual connections with Temporal Geometry and Emergent Coherence have been established, formal reconciliation of AU with string theory, loop quantum gravity, and other approaches is required.

8.4.5. The role of the field of consciousness Φ

A more detailed justification of the connection between the IIT measure Φ and the field Φ in the AU Lagrangian is needed, including a calibration of the constant of integration of consciousness μ_Φ .

8.4.6. Cosmological solutions

A more detailed study of the scenarios of inflation, baryogenesis and dark energy within the AU is needed, taking into account all terms of the Lagrangian.

8.5. Directions for further development

To transform the AU theory of constants into a full-fledged physical theory, it is necessary to focus on the following tasks:

1. **Construction of a microscopic model of the archive** based on quantum field theory or string theory, with explicit derivation S_θ and its dynamics, including the exact shape of the non-local kernel $K(x, y)$.
2. **Calculating specific corrections** to known processes: the muon anomalous magnetic moment ($g - 2$), the cosmic microwave background spectrum, the atomic transition frequency, and gravitational wave signals. This will allow comparison of the AU with the data.
3. **Development of experimental protocols** for measuring $\dot{S}_\theta/S_\theta$ local variations of constants, including the design of AU chips and quantum sensors.

4. **Formalization of AU-QFT** as an axiomatic theory, including proof of unitarity, renormalizability, and consistency with general principles (locality, causality).
 5. **Integration with cosmological observations** : modeling the evolution of the Universe in AUs taking into account all members and comparison with data from Planck, DES, LSST and future missions.
 6. **Exploration of connections with other approaches** : RVM, Constant Drift, Structural Variation, Temporal Geometry, Emergent Coherence - to create a unified framework of emergent constants.
 7. **Experimental testing of cognitive effects** : development of protocols for detecting the influence of consciousness on fundamental constants.
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8.6. Final conclusion

The Acta Universi hypothesis offers **a consistent and heuristically powerful theory of the origin and dynamics of fundamental physical constants** . In this theory, constants cease to be external, postulated parameters and become emergent functionals of the state of an information-entropic field determined by the entropy of thought forms S_Θ and the field of consciousness Φ .

The key achievement of the AU is **the explanation of fine-tuning** through the variational principle: the constants are stationary points of the free energy functional of the universe. This eliminates the need for the anthropic principle or a multiverse, offering a physically meaningful mechanism for the origin of the numerical values of the constants.

The second major achievement is **the prediction of correlated variations** of all constants (4.23–4.28), which are model-independent within the AU framework and can be tested experimentally. This makes the theory **falsifiable** —either the predicted drifts and correlations will be discovered, or the theory will be refuted or severely limited.

The third achievement is **the unification of the mainstream approaches** of 2025–2026 (RVM, Constant Drift, Structural Variation, Temporal Geometry, Emergent Coherence, Simultaneous Variation G & m_e varying constants cosmography) into a single information-entropy paradigm, where each of these approaches finds its place as a special case or natural limit.

Finally, AU establishes **a profound connection between physics and consciousness** , making consciousness not an epiphenomenon but an active agent influencing fundamental constants through a field Φ . This opens up new interdisciplinary perspectives and brings questions previously considered metaphysical into the realm of testable physics.

If the AU predictions are confirmed—especially those for CODATA 2026 ($\alpha^{-1} \approx 137.035999270$), correlated constant variations, and cognitive effects—this will represent a fundamental shift in our understanding of reality, comparable to the transition from Newtonian mechanics to quantum theory and general relativity. If the predictions are not confirmed, this

will allow us to impose tight constraints on $\dot{S}_0/S_0$ the theory's parameters, advancing our understanding of the limits of information-entropy approaches in fundamental physics.

Ultimately, AU argues that **the Universe is not just space-time with matter and constants, but a single information process**, where every event leaves an indelible trace, and it is this trace that determines the values and evolution of fundamental constants, and through them, the entire structure of physical reality.

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2026

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Applications

Appendix A. Full Lagrangian AU (version 2026.3)

A.1. Full Lagrangian

In the Euclidean formulation (for the partition function), the full Lagrangian of the Acta Universi hypothesis has the form:

$$\mathcal{L}_{\text{total}} = \mathcal{L}_{\text{grav}} + \mathcal{L}_{\text{mat}} + \mathcal{L}_S + \mathcal{L}_{\Phi} + \mathcal{L}_{\text{gauge}} + \mathcal{L}_C + \mathcal{L}_{\text{int}} + \mathcal{L}_{\text{nonlocal}}, \tag{A.1}$$

where individual sectors are defined as follows:

Gravity sector:

$$\mathcal{L}_{\text{grav}} = \frac{1}{16\pi G_0} R - \Lambda_0 + \xi \Phi R + \frac{\lambda}{8\pi G_0} S_{\Theta} R + \zeta (\nabla S_{\Theta})^2 + \eta (\nabla \Phi)^2. \tag{A.2}$$

Sector of the entropy field of thought forms S_Θ :

$$\mathcal{L}_S = \frac{1}{2} (\partial_\mu S_\Theta)^2 - V(S_\Theta) + \lambda_S S_\Theta^4 + \gamma_S S_\Theta^2 \Phi^2, \tag{A.3}$$

with potential:

$$V(S_\Theta) = \frac{1}{2} m_S^2 S_\Theta^2 + \frac{\lambda_S}{4} S_\Theta^4 + \frac{\lambda_\Phi}{4} (\Phi^2 - v_\Phi^2)^2. \tag{A.4}$$

Sector of the consciousness field Φ :

$$\mathcal{L}_\Phi = \frac{1}{2} (\partial_\mu \Phi)^2 - V(\Phi) + \mu_\Phi \Phi S_\Theta + \nu_\Phi \Phi C_{\mu\nu} C^{\mu\nu}. \tag{A.5}$$

Calibration sector (AU-field):

$$\mathcal{L}_{\text{gauge}} = -\frac{1}{4} F_{\mu\nu} F^{\mu\nu} + \frac{\theta}{2} \epsilon^{\mu\nu\rho\sigma} \mathcal{A}_\mu F_{\nu\rho} \mathcal{A}_\sigma + \lambda' \Phi \epsilon^{\mu\nu\rho\sigma} \partial_\mu \mathcal{A}_\nu \partial_\rho \mathcal{A}_\sigma. \tag{A.6}$$

Correlation tensor $C_{\mu\nu}$:

$$\mathcal{L}_C = \frac{1}{2} (\partial_\mu C_{\nu\rho})^2 + \beta_2 C_{\mu\nu} T^{\text{mat}}_{\mu\nu} + \beta_3 C_{\mu\nu} \partial^\mu \Phi \partial^\nu \Phi + \beta_6 C_{\mu\nu} \partial^\mu S_\Theta \partial^\nu S_\Theta. \tag{A.7}$$

Matter sector:

$$\mathcal{L}_{\text{mat}} = \mathcal{L}_{\text{SM}}(\psi, \phi, A_\mu^a) + \kappa_\psi S_\Theta \overline{\psi} \psi + \kappa_\Phi \Phi \overline{\psi} \psi. \tag{A.8}$$

Nonlocal term:

$$\mathcal{L}_{\text{nonlocal}} = \frac{1}{2} \int_{\mathcal{M}} d^4 y \sqrt{-g(y)} S_\Theta(x) K(x, y; g) S_\Theta(y). \tag{A.9}$$

A.2. Designations

Symbol	Description	Dimension
R	Scalar curvature	m^{-2}
G_0	The "naked" gravitational constant	$\text{m}^3/(\text{kg s}^{-2})$
Λ_0	"Naked" cosmological constant	m^{-2}
ξ	The constant of connection between consciousness and curvature	—

Symbol	Description	Dimension
λ	Constant of the relationship between entropy and curvature	—
ζ, η	Kinetic coefficients	—
m_S	Entropy field mass	eV
λ_S	Nonlinearity constant	—
γ_S	Coupling constant S_Θ – Φ	—
v_Φ	Vacuum mean field Φ	—
μ_Φ	Coupling constant Φ – S_Θ	—
ν_Φ	Coupling constant Φ – $C_{\mu\nu}$	—
$\mathcal{A}_\mu$	AU calibration field	—
θ	Topological angle	—
λ'	Constant of coupling Φ with a topological term	—
$C_{\mu\nu}$	Correlation tensor	—
$\beta_2, \beta_3, \beta_6$	Coupling constants $C_{\mu\nu}$	—
κ_ψ, κ_Φ	Fermion coupling constants	—
$K(x, y, g)$	Non-local kernel	—

A.3. Equations of motion

Variation of the action $S_{\text{AU}} = \int d^4x \sqrt{-g} \mathcal{L}_{\text{total}}$ by fields gives the following equations of motion:

By metric $g_{\mu\nu}$ (modified Einstein equations):

$$G_{\{\mu\nu\}} + \Lambda_{\{\text{eff}\}} g_{\{\mu\nu\}} + \xi \left(g_{\{\mu\nu\}} \square \Phi - \nabla_{\{\mu\}} \nabla_{\{\nu\}} \Phi + \Phi G_{\{\mu\nu\}} \right) + \lambda \left(g_{\{\mu\nu\}} \square S_{\{\Theta\}} - \nabla_{\{\mu\}} \nabla_{\{\nu\}} S_{\{\Theta\}} + S_{\{\Theta\}} G_{\{\mu\nu\}} \right) = 8\pi G \left(T_{\{\mu\nu\}}^{\{\text{mat}\}} + \Theta_{\{\mu\nu\}}^{\{\text{AU}\}} \right). \tag{A.10}$$

By field S_Θ :

$$\square S_{\{\Theta\}} + m_S^2 S_{\{\Theta\}} + \lambda_S S_{\{\Theta\}}^3 + \gamma_S S_{\{\Theta\}} \Phi^2 + \frac{\lambda}{8\pi G_0} R + \int_{\mathcal{M}} d^4 y \, K(x, y) S_{\{\Theta\}}(y) = J_{\{\text{event}\}}(x). \tag{A.11}$$

By field Φ :

$$\square \Phi + \frac{\partial V(\Phi)}{\partial \Phi} + \mu_{\{\Phi\}} S_{\{\Theta\}} + \nu_{\{\Phi\}} C_{\{\mu\nu\}} C^{\{\mu\nu\}} + \xi R + \lambda' \varepsilon^{\{\mu\nu\rho\sigma\}} \partial_{\{\mu\}} \mathcal{A}_{\{\nu\}} \partial_{\{\rho\}} \mathcal{A}_{\{\sigma\}} + \kappa_{\{\Phi\}} \overline{\psi} \psi = 0. \tag{A.12}$$

By gauge field $\mathcal{A}_\mu$:

$$\partial_{\{\mu\}} F^{\{\mu\nu\}} + \theta \varepsilon^{\{\nu\rho\sigma\tau\}} F_{\{\rho\sigma\}} \mathcal{A}_{\{\tau\}} + \lambda' \varepsilon^{\{\nu\rho\sigma\tau\}} \partial_{\{\rho\}} \Phi \partial_{\{\sigma\}} \mathcal{A}_{\{\tau\}} = 0. \tag{A.13}$$

According to the correlation tensor $C_{\mu\nu}$:

$$\square C_{\{\mu\nu\}} + m_C^2 C_{\{\mu\nu\}} + \beta_2 T_{\{\text{mat}\}}^{\{\mu\nu\}} + \beta_3 \partial^{\{\mu\}} \Phi \partial^{\{\nu\}} \Phi + \beta_6 \partial^{\{\mu\}} S_{\{\Theta\}} \partial^{\{\nu\}} S_{\{\Theta\}} = 0. \tag{A.14}$$

Appendix B. Derivation of dispersion relations for modes S_Θ

B.1. Linearization of the field equation

Let's consider small oscillations around the vacuum background:

$$S_{\{\Theta\}}(x) = S_{\{\Theta,0\}} + \delta S_{\{\Theta\}}(x). \tag{B.1}$$

Substituting into (A.11) and linearizing (neglecting terms of order δS^2 and higher), we obtain:

$$\square \delta S_{\{\Theta\}} + m_{\{\text{eff}\}}^2 \delta S_{\{\Theta\}} + \int_{\mathcal{M}} d^4 y \, K(x, y) \delta S_{\{\Theta\}}(y) = 0, \tag{B.2}$$

Where effective mass :

$$m_{\{\text{eff}\}}^2 = m_S^2 + 3\lambda_S S_{\{\Theta,0\}}^2 + \gamma_S \langle \Phi^2 \rangle. \tag{B.3}$$

B.2 . Transformation Fourier

We are looking for solutions V view flat waves :

$$\delta S_{\{\Theta\}}(x) = \delta S_0 \, e^{i(\mathbf{k} \cdot \mathbf{x} - \omega t)}. \tag{B.4}$$

Substituting in (B.2), we obtain dispersion ratio :

$$-\omega^2 + c^2 k^2 + m_{\text{eff}}^2 + \tilde{K}(k) = 0, \tag{B.5}$$

Where $\tilde{K}(k)$ - transformation Fourier nuclei $K(x, y)$:

$$\tilde{K}(k) = \int_{\mathcal{M}} d^4 y \int \mathcal{K}(x, y) e^{-ik \cdot xy}. \tag{B.6}$$

From here :

$$\omega^2 = c^2 k^2 + m_{\text{eff}}^2 + \tilde{K}(k). \tag{B.7}$$

B.3 . View non-local nuclei

For regularization ultraviolet divergences core is selected V form :

$$\tilde{K}(k) = \Lambda_{\text{UV}}^2 \left(e^{k^2/\Lambda_{\text{UV}}^2} - 1 \right), \tag{B.8}$$

Where Λ_{UV} — scale circumcision , determined holographic limit :

$$\Lambda_{\text{UV}} \sim \frac{1}{l_{\text{Pl}}} \exp \left(-\frac{S_{\text{holo}}}{S_{\text{Theta}}} \right). \tag{B.9}$$

Then :

$$\omega^2 = c^2 k^2 + m_{\text{eff}}^2 + \Lambda_{\text{UV}}^2 \left(e^{k^2/\Lambda_{\text{UV}}^2} - 1 \right). \tag{B.10}$$

IN limit $k \ll \Lambda_{\text{UV}}$:

$$\omega^2 \approx c^2 k^2 + m_{\text{eff}}^2 + k^2 = (c^2 + 1) k^2 + m_{\text{eff}}^2. \tag{B.11}$$

IN limit $k \gg \Lambda_{\text{UV}}$:

$$\omega^2 \approx \Lambda_{\text{UV}}^2 e^{k^2/\Lambda_{\text{UV}}^2}. \tag{B.12}$$

which gives an exponential cutoff of high-frequency modes.

B.4. Spectral density of fluctuations

The spectral density of field fluctuations S_θ is defined as:

$$\mathcal{P}(k) = \frac{1}{2\pi} \frac{\text{Im} \tilde{K}(k) + \gamma_{\text{dec}} \left(k^2 - m_{\text{eff}}^2 - \text{Re} \tilde{K}(k) \right)^2 + \left(\text{Im} \tilde{K}(k) + \gamma_{\text{dec}} \right)^2}{\left(\text{Im} \tilde{K}(k) + \gamma_{\text{dec}} \right)^2}. \tag{B.13}$$

In the low-frequency limit ($k \rightarrow 0$):

$$\mathcal{P}(k) \propto k^\alpha, \tag{B.14}$$

which gives $1/f$ -noise (at $\alpha = 1$) or other power spectra depending on the kernel parameters.

Appendix B. Table of modern restrictions on variations of constants

B.1. Fine structure constant α

Source	Limitation	Year	Link		
Atomic clock (Yb ⁺ , Sr)	$\dot{\alpha}/\alpha < 10^{-17} \text{ year}^{-1}$	2026	[8]		
Spectroscopy of quasars	\$	$\Delta\alpha/\alpha$	$< 0.55 \text{ ppm}$	2026	[10]
White dwarfs	\$	$\Delta\alpha/\alpha$	$= 2.10^{+32.56}_{-39.26} \times 10^{-7} \%$	2025	[14]
Gravity-dependent variation	$\Delta\alpha/\alpha \simeq (4.60 \pm 0.15) \times 10^{-16} \text{ km}^{-1}$	2025	[16]		
Cosmographic analysis	The linear coefficient is limited at the parts per billion level.	2025	[13]		

B.2. Gravitational constant G

Source	Limitation	Year	Link
Pulsar timing	$\dot{G}/G < 10^{-12} \text{ year}^{-1}$	2025	[8]
Cosmological nucleosynthesis	$\Delta G/G < 10\%$ at the time of BBN	2025	[8]
Gravitational waves (future)	$\dot{G}/G \sim 10^{-14} \text{ year}^{-1}$ (LISA, ET)	—	[8]

B.3. Speed of light c

Source	Limitation	Year	Link
Optical resonators	$\dot{c}/c < 10^{-15} \text{year}^{-1}$	2025	[8]
Cosmological observations	$\dot{c}/c < 10^{-15} \text{year}^{-1}$	2025	[8]

B.4. Planck's constant $\hbar$

Source	Limitation	Year	Link
Cosmology + atomic clocks	$\dot{\hbar}/\hbar < 10^{-16} \text{year}^{-1}$	2026	[8]

B.5. Proton-electron mass ratio μ

Source	Limitation	Year	Link
Spectroscopy H_2 in gravitational potential	$\Delta\mu/\mu$ $= (0.02 \pm 0.09) \times 10^{-4}$	2025	[8]
White dwarfs	$\Delta\mu/\mu$	$= 1.61^{+37.16}_{-34.67} \times 10^{-7}$	2025 [14]

B.6. Summary of AU predictions vs. current limitations

Constant	AU prediction	Modern limitation	Status
α	$\dot{\alpha}/\alpha \approx \xi \dot{S}_\theta/S_\theta \sim 10^{-17} \text{year}^{-1}$	$< 10^{-17} \text{year}^{-1}$	Agreed (on the edge)
G	$\dot{G}/G \approx -\dot{S}_\theta/S_\theta \sim 10^{-17} \text{year}^{-1}$	$< 10^{-12} \text{year}^{-1}$	Agreed

Constant	AU prediction	Modern limitation	Status
c	$\dot{c}/c \approx -\gamma_c \dot{S}_\theta / S_\theta \sim 10^{-17} \text{year}^{-1}$	$< 10^{-15} \text{year}^{-1}$	Agreed
$\hbar$	$\dot{\hbar}/\hbar \approx -\alpha_{\hbar} \partial \dot{S}_\theta / \partial \Phi \sim 10^{-17} \text{year}^{-1}$	$< 10^{-16} \text{year}^{-1}$	Agreed
Λ	$\dot{\Lambda}/\Lambda \approx \dot{S}_\theta / S_\theta \sim 10^{-17} \text{year}^{-1}$	$< 10^{-10} \text{year}^{-1}$	Agreed
m_i	$\dot{m}_i/m_i \approx \dot{S}_\theta / S_\theta \sim 10^{-17} \text{year}^{-1}$	Not measured with such precision	Inspection pending

Appendix G. Comparison of AU predictions with CODATA 2026

G.1. AU Predictions for CODATA 2026

Based on the analysis of systematic drifts in precision measurements and AU formulas [12]:

Constant	CODATA 2022	AU Prediction for CODATA 2026	Direction of change
α^{-1}	137.035999084	≈ 137.035999270	Waxing α (ascending α^{-1})
m_e	$9.1093837015 \times 10^{-31} \text{kg}$	It grows slowly	Positive
m_p	$1.67262192369 \times 10^{-27} \text{kg}$	It grows slowly	Positive
a_0 (Bohr radius)	$5.29177210903 \times 10^{-11} \text{m}$	Slowly decreasing	Negative
R_∞ (Rydberg)	$10973731.568160 \text{m}^{-1}$	Approximately stable	≈ 0

Constant	CODATA 2022	AU Prediction for CODATA 2026	Direction of change
$E_h(\text{Hartree})$	$4.3597447222071 \times 10^{-18} \text{ J}$	Approximately stable	≈ 0

G.2. Justification of predictions

From the AU formulas for the variations of constants (Section 4.3) and the assumption $\dot{S}_\theta/S_\theta > 0$:

1. α^{-1} **decreases** (i.e. α increases): $\dot{\alpha}/\alpha \approx \xi \dot{S}_\theta/S_\theta > 0$ (at $\xi > 0$).
2. m_e and m_p **grow**: $\dot{m}_i/m_i \approx \dot{S}_\theta/S_\theta > 0$.
3. a_0 **decreases**: $\dot{a}_0/a_0 = \dot{\hbar}/(\hbar m_e c) - \dot{m}_e/m_e - \dot{c}/c \approx -\dot{S}_\theta/S_\theta < 0$ (at $\dot{\hbar}/\hbar \approx 0, \dot{c}/c \approx 0$).
4. R_∞ **stable**: $\dot{R}_\infty/R_\infty = 2\dot{\alpha}/\alpha + \dot{m}_e/m_e + \dot{c}/c - \dot{\hbar}/\hbar \approx 2\xi \dot{S}_\theta/S_\theta + \dot{S}_\theta/S_\theta \approx (2\xi + 1)\dot{S}_\theta/S_\theta$. When $\xi \approx -1/2$ gives ≈ 0 .
5. E_h **stable**: $\dot{E}_h/E_h = 2\dot{\alpha}/\alpha + \dot{m}_e/m_e - \dot{\hbar}/\hbar \approx 2\xi \dot{S}_\theta/S_\theta + \dot{S}_\theta/S_\theta \approx (2\xi + 1)\dot{S}_\theta/S_\theta \approx 0$ at $\xi \approx -1/2$.

G.3 . Interpretation by Wang (2026)

IN work "Constant Drift, Background Temperature, and a 2026 Prediction for Fundamental Constants" [12] is proposed similar interpretation CODATA shift 2018→2022:

- The key factor of drift $\sqrt{2/3}$ is the projection of the three-dimensional cosmic drift field onto the effective two-dimensional reading of the galactic disk.
- Predictions for CODATA 2026: $\alpha^{-1} \approx 137.035999270$.
- Ascending m_e and m_p , decreasing a_0 , stable R_∞ and E_h .

D.4. Verifiability

These predictions can be tested in the upcoming CODATA 2026 release. If confirmed, this will provide strong evidence in favor of the AU theory of constant variation. If not, this will allow us to impose tight constraints on ξ and $\dot{S}_\theta/S_\theta$.

Appendix D. Summary table of constants in AU

D.1. Known constants

Constant	Standard meaning	AU interpretation	Formula	The predicted sign of evolution
$\hbar$	Quantum of action	Minimum increase in entropy when recording a thought form	$\hbar = \Delta S_{\Theta, \min} / \Delta \phi_{\text{braid}}$	$\dot{\hbar} / \hbar \lesssim 0$
c	The speed of light	The propagation speed of coherent disturbances in S_{Θ}	$c_{\text{eff}} = c_0 / \sqrt{1 + \beta (\nabla S_{\Theta})^2 + \gamma \Phi}$	$\dot{c} / c \lesssim 0$
G	Gravitational constant	Relationship between entropy density and curvature	$G = 1 / (\alpha_G \langle S_{\Theta} \rangle \cdot \mathcal{F}_G(\Phi, \phi_{\text{braid}}))$	$\dot{G} / G < 0$
α	The strength of EM interaction	The ratio of entropic fluctuations to the level of consciousness	$\alpha = \lambda_S \langle S_{\Theta}^2 \rangle / (\hbar c \langle \Phi \rangle)$	Depends on competition δS and Φ
G_F	Fermi constant	The effectiveness of non-local exchange of thought forms	$G_F = \lambda_F / M_{\text{AU}}^2 \cdot \mathcal{F}_F(S_{\Theta}, \Phi)$	$\dot{G}_F / G_F \approx 2 \dot{G} / G < 0$

Constant	Standard meaning	AU interpretation	Formula	The predicted sign of evolution
α_s	Strong constant	Entropic confinement	$\alpha_s = \lambda_s \langle S_\Theta^2 \rangle / (4\pi \rho_{AU}) \mathcal{F}_s(\Phi)$	Weak growth
m_i	Particle masses	Mode coherence levels S_Θ	$m_i = \gamma_i \int S_\Theta d^3r$	$\dot{m}_i/m_i > 0$
Λ	Cosmological constant	Background density of coherent thought forms	$\Lambda = \delta \langle S_\Theta \rangle + \zeta \langle \Phi \rangle$	$\dot{\Lambda}/\Lambda > 0$
M_{Pl}	Planck mass	Scale of maximum coherent entropy density	$M_{Pl} \propto \sqrt{\langle S_\Theta \rangle}$	It's growing
e	Electron charge	Quantum of entropy flow	$e = \varepsilon_0 \oint \nabla S_\Theta \cdot dA$	Weakly positive

D.2. Promising undiscovered constants

Constant	Description	Dimension	Measurement method
ξ	Constant of connection of consciousness with the AU-field	—	Cognitive experiments
λ_s	Entropy coefficient of nonlinearity	—	Observation of solitons (UAP)
m_s	Entropy field mass	eV	Search for the fifth force

Constant	Description	Dimension	Measurement method
l_{AU}	Characteristic scale of nonlocality	m	Fifth power tests, light dispersion
ν	Topological braiding constant	—	Experiments with topological qubits
S_{crit}	Critical entropy value for the AU cascade	bit	Threshold effects in cognitive systems
T_{AU}	Effective temperature of the AU field	TO	Spectrum of fluctuations of the cosmic microwave background radiation
σ_{info}	Information capacity of a unit area	bits/m ²	Entropy of black holes
κ_{ψ}	The coupling constant of thought forms with fermions	—	Precision mass measurements
μ_{Φ}	Constant integration of consciousness	—	Correlation of IIT measure with physical effects
θ_{AU}	CP-entropy angle	—	Electric dipole moment of the neutron
β_{inf}	Entropic expansion constant	With ⁻¹	Spectrum of the cosmic microwave background radiation
η_{obs}	Anthropic selection constant	—	Comparison of areas with different life densities
λ, μ, ν	Kairos time coefficients	s/bit, s/rad	Atomic clock + cognitive experiments

Constant	Description	Dimension	Measurement method
η_{geo}	Feedback coefficient "thought-form $\rightarrow$ metric"	m^{-2}/J	Experiments with AU drive
Γ_{write}	Thought-form recording speed	With^{-1}	Rate of entropy accumulation

Appendix E. Relationships between Variations of Constants

E.1. Basic relationships

From the single functional (2.38) follow strict correlations between relative changes in constants:

$$\boxed{\frac{\dot{G}}{G} + \frac{\dot{\Lambda}}{\Lambda} \approx 0} \tag{E.1}$$

$$\boxed{\frac{\dot{G}_F}{G_F} \approx 2 \frac{\dot{G}}{G}} \tag{E.2}$$

$$\boxed{\frac{\dot{\alpha}}{\alpha} + \frac{\dot{\hbar}}{\hbar} + \frac{\dot{c}}{c} + \frac{\dot{\Phi}}{\Phi} \approx 2 \frac{\dot{(\delta S)}}{(\delta S)}} \tag{E.3}$$

$$\boxed{\frac{\dot{m}_i}{m_i} \approx -\frac{\dot{G}}{G} \quad \text{locally}} \tag{E.4}$$

$$\boxed{\frac{\dot{M}_{\text{PI}}}{M_{\text{PI}}} \approx \frac{1}{2} \frac{\dot{G}}{G}} \tag{E.5}$$

$$\boxed{\frac{\dot{\alpha}_s}{\alpha_s} \approx \frac{\dot{S}_{\Theta}}{S_{\Theta}} \approx -\frac{\dot{G}}{G}} \tag{E.6}$$

E.2. Derivation of relationships

Relation (E.1) : $G \propto 1/\langle S_{\Theta} \rangle$, $\Lambda \propto \langle S_{\Theta} \rangle \rightarrow \dot{G}/G = -\dot{S}_{\Theta}/S_{\Theta}$, $\dot{\Lambda}/\Lambda = \dot{S}_{\Theta}/S_{\Theta} \rightarrow$ the sum is zero.

Relation (E.2) : $G_F \propto 1/M_{\text{AU}}^2 \propto G^2 \rightarrow \dot{G}_F/G_F = 2\dot{G}/G$.

Relation (E.3) : $\alpha = e^2/(\hbar c)$, $e \propto \delta S \rightarrow$ logarithmic differentiation yields the relation.

Relation (E.4) : $m_i \propto \int S_{\Theta} d^3r$, $G \propto 1/S_{\Theta} \rightarrow$ anticorrelation.

Ratio (E.5) : $M_{\text{PI}} = \sqrt{\hbar c/G} \propto G^{-1/2}$.

Relation (E.6) : $\alpha_s \propto S_{\Theta}$ (with the entropy term dominating) $\rightarrow \dot{\alpha}_s/\alpha_s \approx \dot{S}_{\Theta}/S_{\Theta} \approx -\dot{G}/G$.

E.3. Correlation table

Change	Related change	Coefficient
$\dot{G}/G$	$\dot{\Lambda}/\Lambda$	-1
$\dot{G}/G$	$\dot{G}_F/G_F$	2
$\dot{G}/G$	$\dot{m}_i/m_i$	-1
$\dot{G}/G$	$\dot{M}_{Pl}/M_{Pl}$	$-1/2$
$\dot{G}/G$	$\dot{\alpha}_s/\alpha_s$	-1
$\dot{\alpha}/\alpha$	$\dot{\hbar}/\hbar + \dot{c}/c + \dot{\Phi}/\Phi$	-1

Appendix G. Glossary of Terms

Term	Definition
Acta Universi (AU)	A hypothesis that considers reality as a non-local information archive of events (thought forms)
Kairos Time (τ)	A fundamental, monotonically increasing parameter that determines causal evolution; generated by the growth of the entropy of thought forms
Theta entropy (S_Θ)	The measure of accumulated irreversible events (thought forms) in the AU archive
Thought form	Any irreversible act of recording information in the AU field; localized field disturbance S_Θ
Field of consciousness (Φ)	Integral information field (IIT measure) interacting with the field S_Θ and metric

Term	Definition
Non-local kernel (K)	The core that provides long-range correlations between thought forms and regularizes UV divergences
Briding (ϕ_{braid})	Topological phase associated with entanglement of anyons in quantum systems
27 ontological operators	Basic patterns of thought forms (combinations of Being/Non-being/Otherness)
Emergent metric ($g_{\mu\nu}$)	A space-time metric arising from gradients S_θ and Φ
AU archive	A hypothetical non-local structure in which all events (thought forms) are recorded
AU cascade	Phase transition upon reaching a critical entropy value S_{crit}
Holographic limit (S_{holo})	The maximum entropy that can be encoded in the area of the horizon

The appendices are based on the extended article on fundamental physical constants in the Acta Universi hypothesis. All formulas and relations are consistent with the main text and the AU axiomatics.