

Electromagnetic radiation in the context of the Acta Universi hypothesis

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Introduction

1.1 The problem of the ontology of electromagnetic radiation

Electromagnetic radiation occupies a central place in modern physics. Maxwell's equations, special relativity, and quantum electrodynamics (QED) provide an extremely accurate description of the propagation of light, the interaction of radiation with matter, and the quantum properties of photons. However, the ontological status of the electromagnetic field and the photon remains an open question.

In classical electrodynamics, the electromagnetic field is an independent physical entity, governed by linear equations. In quantum field theory, the photon is represented as a quantum of this field—an elementary excitation possessing energy $\hbar\omega$, momentum $\hbar k$, and spin 1. Wave-particle duality is described formally, but does not receive a satisfactory ontological resolution: it is unclear what exactly "exists" between the acts of emission and absorption, what is the status of the photon's wave function, and why electromagnetic interaction allows such a precise gauge-invariant description.

These questions have become particularly pressing in 2025—the International Year of Quantum Science and Technology, when the centenary of quantum mechanics coincides with a new round of discussions about the nature of light, the first quantization of the photon, and possible nonlinear generalizations of Maxwell's equations. It is becoming increasingly clear that a purely phenomenological description, no matter how accurate, leaves a deep ontological void unfilled.

1.2. Objective of the work

This paper proposes a rethinking of electromagnetic radiation within the framework of the Acta Universi (AU) hypothesis. In this hypothesis, the primary entity is the entropy field of thought forms S_Θ —an information-entropy field whose dynamics generate space-time, matter, and fundamental interactions as emergent structures.

The aim of the study is to show that:

- the electromagnetic field arises as a certain class of field excitations S_Θ ;
- the photon can be consistently interpreted as a coherent mode of this field;
- Maxwell's equations (and their quantum version) are the low-energy effective limit of the more general AU dynamics;
- Emission and absorption represent irreversible acts of recording information into the non-local AU archive.

Thus, the work does not seek to replace QED, but to integrate it into a broader information-ontological context, preserving all verified predictions and indicating possible small deviations accessible to experimental verification.

1.3. The place of AU among existing approaches

The proposed approach occupies an intermediate position between standard quantum electrodynamics and a number of alternative programs.

Unlike QED, where the photon is postulated as a fundamental particle, in AU it is an emergent excitation. Unlike purely geometric or discretized models of electromagnetism, AU preserves a continuous field description, supplementing it with a nonlocal core $K(x, y)$ and a connection to entropic dynamics. Unlike nonlinear generalizations of Maxwell's equations introduced phenomenologically, nonlinearity and nonlocality in AU are derived from the structure of the original informational Lagrangian.

A key advantage of the AU approach is its intrinsic connection with other areas of the hypothesis: the origin of spacetime, dark energy, variations in fundamental constants, and even biological and cognitive processes. Electromagnetic radiation turns out not to be an isolated phenomenon, but rather one manifestation of a unified information-entropic dynamic.

1.4. Structure of the article

The article is structured as follows. The first section formulates the ontological foundations and derives a modified AU electrodynamics. The second section examines quantum aspects (coherence, statistics, entanglement) and formulates testable predictions. The third section provides a comparison with standard QED and nonlinear theories, discusses the limitations of the approach, and discusses future research directions.

The primary focus is on the rigor of the conclusions and the feasibility of experimental verification. Historical and overview sections are kept to the bare minimum.

Part I. Ontological and Mathematical Foundations

Chapter 1. Electromagnetic field in AU-ontology

1.1. Field S_Θ as a primary entity

In the Acta Universi hypothesis, the fundamental reality is the entropy field of thought forms S_Θ —a scalar (in its simplest form) information-entropy field defined on an abstract event space. All observable physical structures—space-time, matter, gauge fields—arise as emergent configurations and excitations of this field.

The dynamics S_Θ are given by an action including a kinetic term, a potential $V(S_\Theta)$, an interaction with the integral information field Φ , and a nonlocal contribution determined by the kernel $K(x, y)$:

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

The nonlocal core provides long-range correlations between recording events (thought forms) and simultaneously regularizes ultraviolet divergences. The electromagnetic field in this picture is not primary. It appears as a certain class of collective excitations above the background $S_{\Theta,0}$.

1.2 Photon as a coherent excitation of a field S_{Θ}

Let us consider small perturbations of the field around the vacuum value:

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

Linearization of the equations of motion leads to a dispersion relation of the form

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

where $\tilde{K}(k)$ is the Fourier transform of the nonlocal kernel. In the long-wavelength limit and under certain conditions on the kernel, massless (or nearly massless) modes with a linear dispersion law arise.

These modes are interpreted as photons. Their fundamental properties are interpreted as follows:

- energy and momentum are related to the amplitude and gradient of coherent excitation δS_{Θ} ;
- two physical states of polarization correspond to two independent geometric (or topological) degrees of freedom of perturbation;
- boson statistics follows from the commutation properties of field operators S_{Θ} ;
- Gauge invariance arises as a consequence of the conservation of a certain current in the effective theory obtained after integration over heavy modes S_{Θ} .

Thus, a photon in AU is not a fundamental particle, but a stable coherent mode of the information field.

1.3. Electromagnetic waves as propagation of entropic disturbances

A classical electromagnetic wave corresponds to a semiclassical coherent state of a large number of photon modes. In field terms, S_{Θ} it is an extended, phase-consistent perturbation propagating in accordance with the effective wave equation following from the linearized dynamics of the AU.

Wave polarization is determined by the geometry of the perturbation δS_{Θ} . Interference and diffraction are direct consequences of the linearity (to the lowest order) of the equations for small perturbations. Nonlinear effects (harmonics, self-focusing, etc.) arise when higher-order terms are taken into account in the potential $V(S_{\Theta})$ and in the expansion of the nonlocal kernel.

An important difference from the standard picture is that even a “classical” wave carries entropic content: it represents an ordered excitation of the information field and, when interacting with matter, can leave an irreversible trace in the AU archive.

1.4. The speed of light as the maximum speed of propagation of coherent information

In the AU, the speed of light c is not postulated, but arises as the limiting propagation velocity of coherent long-wave field perturbations S_Θ . It is determined by the structure of the kinetic term and the low-energy limit of the core $K(x, y)$:

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

In the modern era, c_{eff} is virtually constant and coincides with the observed value. However, in the early universe or in regions with significantly different background entropy values, $S_{\Theta,0}$, small deviations are possible. It is this possibility that connects electromagnetism with the previously discussed dynamics of fundamental constants.

From an information perspective, c represents the maximum speed at which coherent (low-entropy) information can propagate without disrupting phase relationships. Any attempt to transmit information faster requires the excitation of high-entropy modes and leads to a loss of coherence, which is consistent with relativistic causality.

Chapter 1 establishes the ontological framework: the electromagnetic field and the photon are not primary entities, but arise as collective excitations of the entropy field of thought forms. The next chapter is devoted to deriving the effective equations of electrodynamics from the AU Lagrangian.

Chapter 2. Modified Electrodynamics AU

2.1. Lagrangian of the electromagnetic field with entropy and nonlocal terms

In the Acta Universi hypothesis, the electromagnetic field is not introduced as an independent, primary entity. It emerges as an effective description of a specific sector of excitations of the thought-form entropy field S_Θ . Therefore, the full Lagrangian of the theory contains both the standard Maxwellian term and additional contributions reflecting the connection with information-entropy dynamics.

The effective Lagrangian of the electromagnetic sector has the form

$$\mathcal{L}_{\text{EM+AU}} = -\frac{1}{4} F_{\mu\nu} F^{\mu\nu} + \mathcal{L}_{\text{int}}(A_\mu, S_\Theta, \Phi) + \mathcal{L}_{\text{nonlocal}}^{\text{EM}}.$$

Here $F_{\mu\nu} = \partial_\mu A_\nu - \partial_\nu A_\mu$ is the usual stress tensor. The interaction term in the leading order can be written as

$$\mathcal{L}_{\text{int}} = \xi_1 S_\Theta F_{\mu\nu} F^{\mu\nu} + \xi_2 \Phi F_{\mu\nu} F^{\mu\nu} + \xi_3 (\partial_\mu S_\Theta) (\partial^\mu S_\Theta) A_\nu A^\nu + \dots$$

(the specific set of structures is fixed by the requirements of gauge invariance and parity).

Nonlocal contribution

$$\mathcal{L}_{\text{nonlocal}}^{\text{EM}} \sim \int d^4 y A_\mu(x) K^{\mu\nu}(x, y, S_\Theta) A_\nu(y)$$

arises after integration over heavy field modes S_Θ and contains the same kernel K that already appeared in the equations for theta entropy.

Thus, the electromagnetic field “feels” both the local value S_Θ and Φ the non-local correlations of the archive.

2.2. Derivation of modified Maxwell's equations

Varying the action with respect to the four-potential A_μ leads to the generalized Maxwell equations. In differential form, they look like this:

$$\begin{aligned} \nabla \cdot E &= \frac{\rho}{\varepsilon_0} + \rho_{\text{ent}}, \\ \nabla \times B - \mu_0 \varepsilon_0 \frac{\partial E}{\partial t} &= \mu_0 J + J_{\text{ent}} + J_{\text{nl}}, \end{aligned}$$

where ρ_{ent} and J_{ent} are entropy sources (and currents) proportional to the gradients and time derivatives of S_Θ and Φ , and J_{nl} is the nonlocal contribution determined by the kernel $K^{\mu\nu}$.

In the absence of strong gradients S_Θ and at , $K \rightarrow \delta^{(4)}(x - y)$ the additional terms disappear, and the usual Maxwell equations are restored. In regions with noticeable inhomogeneity of the information field or when long-range correlations are taken into account, small corrections appear that, in principle, could be accessible to precision measurements.

The wave equation for the potential (in the Lorentz gauge) takes the form

$$\square A^\mu = \mu_0 J_{\text{tot}}^\mu + \int \mathcal{K}^\mu{}_\nu(x, y) A^\nu(y) d^4 y + \dots,$$

where the operator $\mathcal{K}$ contains both local entropy contributions and a non-local kernel.

2.3. The role of the nonlocal core $K(x, y)$

The non-local core performs two functions.

First, it provides ultraviolet regularization: high-frequency modes of the electromagnetic field are suppressed, which eliminates some of the divergences that usually require renormalization in standard QED.

Secondly, the core generates long-range correlations. Even in the absence of direct causal contact, two spatially separated regions can exchange information through an event archive. In the electromagnetic sector, this manifests itself as small instantaneous (in kairos time) corrections to the photon propagator and as a possible contribution to the observed entanglement.

It is important that causality at the level of observed signals is not violated: any influence propagating through the core is accompanied by an increase in theta entropy and is therefore consistent with the thermodynamic arrow of time defined through the kairos parameter τ .

2.4. Recovery limit of standard QED

Standard quantum electrodynamics is reproduced in the following limit:

- background values $S_{\theta,0}$ are both Φ_0 constant and small compared to characteristic atomic scales;
- gradients ∇S_{θ} and $\partial_t S_{\theta}$ are negligible;
- the nonlocal kernel contracts to δ the δ -function on scales significantly smaller than the Compton wavelength of the electron;
- nonlinear terms in the potential $V(S_{\theta})$ are not excited.

Under these conditions, the additional sources ρ_{ent} , J_{ent} and J_{nl} vanish, the wave equation becomes ordinary, and quantization leads to the standard commutation relations and Feynman rules of QED.

Deviations from this limit are small and controllable. They form the basis of the theory's testable predictions (level shifts, possible anomalies in photon statistics, weak violations of locality on very large scales).

Chapter 2 establishes the mathematical connection between the AU field and electromagnetism. The next chapter is devoted to the interpretation of emission and absorption processes as entropic recording events.

Chapter 3. Radiation as an Entropic Process

3.1. Spontaneous emission as an act of recording a thought-form

In standard quantum electrodynamics, spontaneous emission is described as the transition of an atom from an excited state to the ground state with the emission of a photon. The transition matrix element is calculated using the rules of quantum electrodynamics, and the probability is

determined by Fermi's golden rule. The emission itself is considered reversible within the unitary evolution of the extended "atom + field" system.

In the Acta Universi hypothesis, this process acquires additional ontological content. Each act of spontaneous emission is **an irreversible recording** of an event in a non-local AU archive. The excited state of an atom corresponds to a specific coherent configuration of the field S_θ (and the associated field Φ). During the transition, this configuration relaxes, and the released information is recorded as a new thought-form.

Mathematically, this is expressed by the appearance of a contribution to the source J_{event} of the equation for S_θ :

$$J_{\text{event}}(x) \supset \sum_i \Gamma_i |\psi_i(x)|^2 \delta(t - t_i),$$

where Γ_i is the level width, and t_i is the recording instant (in coordinate time). In kairos time, each such event increases τ by an amount proportional to the entropy gain:

$$\Delta\tau \propto \delta S_\theta^{\text{rad}}.$$

It is precisely the irreversibility of the recording that explains why spontaneous emission has a preferred direction and why the reversal of the process (absorption) requires the fulfillment of additional phase matching conditions.

3.2 Thermal radiation and mode distribution S_θ

Thermal radiation of an absolutely black body in the AU approach is interpreted as an equilibrium distribution of entropy modes of the field S_θ .

In standard statistical physics, Planck's formula arises from the quantization of the energy of harmonic oscillators of the field. In AU, the same oscillators are normal modes of the linearized field S_θ on a given background. The average occupation number of a mode with frequency ω still has the Planck form.

$$\langle n(\omega) \rangle = \frac{1}{e^{\hbar\omega/k_B T} - 1},$$

However, the temperature T receives an informational interpretation: it is associated with the intensity of theta-entropy fluctuations in the volume under consideration.

The Stefan–Boltzmann law is preserved as a consequence of the fact that the energy carried away by radiation is proportional to the fourth power of the fluctuation temperature. Part of the energy is converted into an irreversible increase in the global temperature S_θ , which ensures consistency with the second law of thermodynamics in kairos time.

Thus, thermal radiation is a special case of a more general process - the release of excess entropy of the information field in the form of coherent (photonic) excitations.

3.3 Connection with Kairos Time and Irreversibility

The key difference between the AU description of radiation and the standard one is the explicit presence of the arrow of time associated with the kairos parameter τ .

Kairos time is defined by the monotonic growth of theta entropy:

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

Each emission increases S_Θ and, therefore, advances the system τ . The reverse process (absorption) is possible, but requires reconciliation with existing records in the archive and is therefore statistically suppressed.

This circumstance naturally explains:

- irreversibility of spontaneous emission;
- the appearance of a finite width of spectral lines even in ideal insulation;
- the relationship between the excited state lifetime and the local growth rate S_Θ .

In the limit where the change S_Θ is negligible (low intensities, small volumes, short times), the AU description continuously transitions to ordinary unitary QED. Deviations become noticeable only with the accumulation of a large number of recordings or in systems with a high density of coherent thought forms.

Chapter 3 concludes the first part of the article. Electromagnetic radiation is presented as an entropic process, and emission and absorption events are represented as irreversible events of recording in the AU archive. The next section is devoted to quantum aspects and the formulation of testable predictions.

Part II. Quantum and Observational Implications

Chapter 4. Coherence, Statistics, and Entanglement

4.1 Coherent States as Coherent Modes S_Θ

In quantum optics, coherent states $|\alpha\rangle$ occupy a special place: they are eigenstates of the annihilation operator, minimize uncertainty, and, in the classical limit, reproduce the behavior of a classical electromagnetic wave. Laser radiation is precisely described by such states with high accuracy.

In the Acta Universi hypothesis, a coherent state is interpreted as a **macroscopically excited, phase-consistent mode** of the thought-form entropy field S_θ . If linearized perturbations δS_θ are quantized and reduced to a set of oscillators, then a coherent state corresponds to a displacement of the vacuum of one (or more) of these oscillators by a complex amplitude α .

Phase coherence in the conventional sense is a manifestation of information field coherence: gradients and phases δS_θ are maintained consistent over macroscopic distances due to the structure of the kinetic term and the low-frequency behavior of the nonlocal core $K(x, y)$. In this picture, laser generation is the process of amplifying a selected coherent mode through the irreversible recording of pump energy in the AU archive.

4.2 Photon statistics and field fluctuations

Photon statistics (Poisson, super-Poisson, sub-Poisson) in standard quantum optics are determined by the properties of the corresponding quantum field state. In AU, these properties are directly related to the nature of the field fluctuations S_θ .

- Thermal (chaotic) radiation corresponds to high-entropy, weakly correlated fluctuations S_θ . The number of photons follows a geometric distribution.
- Coherent radiation corresponds to low-entropy, phase-ordered excitation. The statistics are close to Poissonian.
- Squeezed and other non-classical states arise from special correlations between modes, which can be created by nonlinear terms of the potential $V(S_\theta)$ or a non-local kernel.

Fluctuations in the photon number thus reflect fluctuations in theta entropy. This opens the possibility of searching for small deviations from standard QED predictions in highly statistical experiments that accumulate a large number of recordings.

4.3 Entanglement as a manifestation of a non-local core

Quantum entanglement of photons (in particular, the violation of Bell's inequalities in experiments like Aspect) is usually considered one of the most striking manifestations of the nonlocality of quantum mechanics. In the AU approach, this nonlocality has a specific carrier—the nonlocal kernel $K(x, y)$.

When two photon excitations are created in a common recording event (for example, during parametric scattering or a cascade transition), they are correlated through the kernel. This correlation is preserved even when separated spatially because both excitations remain associated with the same entry in the AU archive.

Mathematically, the propagator of a two-photon state contains the contribution

$$\langle \delta S_\theta(x_1) \delta S_\theta(x_2) \rangle \supset K(x_1, x_2) + \dots$$

It is this contribution that is responsible for the preservation of polarization and momentum correlations over arbitrary distances. Causality is not violated: any attempt to use correlation to

transmit information is accompanied by additional growth S_θ and is therefore consistent with the arrow of kairos time.

Thus, the entanglement of photons in AU is not a “mysterious” action at a distance, but is a manifestation of the already existing non-local structure of the information archive.

Chapter 4 shows how the fundamental concepts of quantum optics—coherence, statistics, and entanglement—are unified in terms of field dynamics S_θ and a nonlocal core. The next chapter is devoted to specific testable predictions of the theory.

Chapter 5. Testable Predictions

5.1 Entropic corrections to atomic levels and the Lamb shift

The most direct way to test AU electrodynamics is to look for small systematic shifts of atomic levels associated with entropy terms in the effective potential.

In the presence of background $S_{\theta,0}$ and possible weak gradients, the modified Schrödinger equation (or Dirac equation) acquires additional terms of the form

$$V_{\text{ent}}(r) \propto \xi_1 S_{\theta,0} + \xi_2 (\nabla S_\theta)^2 + \dots$$

These terms lead to level shifts that are formally similar to corrections to the Lamb shift, but have a different dependence on the principal and orbital quantum numbers. In particular, for s-states (having a non-zero probability density near the nucleus), the effect should be significantly stronger than for p- and d-states.

The expected order of magnitude of the corrections is extremely small and is determined by the ratio of the characteristic atomic energy to the scale determined by the background theta entropy. Currently, this order of magnitude is at the limit of, or beyond, the precision of ordinary spectroscopy, but may be achievable in next-generation precision hydrogen and helium spectroscopy experiments (including projects like PreSCHAROC and new Lamb shift measurements).

An important distinguishing feature is that AU corrections must correlate with local conditions that can influence S_θ (matter density, coherent electromagnetic fields, possibly collective quantum states), whereas purely quantum radiative corrections do not depend on such conditions.

5.2 Possible modulation of excited state lifetimes

The second class of predictions concerns the lifetimes of excited states. Since spontaneous emission in AU is an act of recording, its probability may depend weakly on the current state of the information field.

In particular, with increasing local coherence (increasing Φ or decreasing fluctuations S_θ), the effective density of final states and the transition matrix element can change slightly. This leads to a small modulation of the level width Γ .

The expected relative effect $\delta\Gamma/\Gamma$ is extremely small. However, it differs fundamentally from conventional external influences (collisional broadening, the Stark effect, etc.) in that it should correlate with global or collective coherence indices, and not just with local electromagnetic fields.

The most sensitive systems for searching for such an effect are narrow forbidden transitions and long-lived states in ions used in optical clocks.

5.3 Cosmological aspects (briefly)

On cosmological scales, electromagnetic radiation in AU is related to general entropic dynamics. The cosmic microwave background radiation is interpreted as a "frozen" record of the field state S_θ at the moment of recombination. Small additional contributions to the anisotropy and spectrum may arise from nonlocal correlations, but their magnitude is likely below the sensitivity of current experiments (Planck, ACT, SPT).

More promising is the possible contribution of accumulated theta entropy (including the contribution from radiation) to the effective cosmological constant Λ_{eff} . This contribution has already been discussed in papers on dark energy and the dynamics of constants; the electromagnetic sector merely adds one growth channel S_θ .

5.4 Proposed experimental protocols

Protocol A. Precision spectroscopy.

Comparison of the frequencies of the same transitions in hydrogen (or helium) atoms placed in conditions with obviously different densities of coherent electromagnetic modes or different degrees of isolation from external information noise. The goal is to search for systematic shifts not explained by standard CED and external fields.

Protocol B. Lifetime Measurements

Statistically significant comparison of lifetimes of narrow transitions in optical clocks at different levels of controlled electromagnetic coherence in the laboratory (including the possibility of operation under conditions of a strong laser field of non-resonant frequency).

Protocol B. Photon Statistics:

Search for small deviations from Poisson statistics in highly stable laser sources with the accumulation of very large statistics. Any deviation that correlates with independent estimates of information field fluctuations would be of interest.

In all cases, what is decisive is not the absolute magnitude of the effect, but the presence of correlations predicted by AU and absent in the standard theory.

Chapter 5 formulates those predictions that can, in principle, be tested or constrained by existing and upcoming experiments. The next chapter compares the AU approach with standard quantum electrodynamics and nonlinear theories.

Part III. Comparison and Conclusion

Chapter 6. Comparison with standard QED and nonlinear theories

6.1 Ontological differences

Standard quantum electrodynamics views the electromagnetic field as a fundamental entity, and the photon as its elementary excitation. Gauge invariance, renormalizability, and Feynman rules are postulated within the framework of quantum field theory on a fixed spacetime. The ontological status of the vacuum, virtual photons, and the act of measurement itself remains subject to interpretation.

In the Acta Universi hypothesis, the electromagnetic field and photon are **emergent**. The primary reality is the entropy field of thoughtforms, S_Θ along with a nonlocal core $K(x, y)$. Maxwell's equations and the QED structure are reproduced as a low-energy effective limit. Gauge invariance arises dynamically after integration over heavy modes, and the irreversibility of radiation processes is associated with the growth of theta entropy and advancement along kairos time.

Thus, the difference is fundamentally ontological: QED describes "how" electromagnetic phenomena occur with high precision; AU offers an answer to the question of "what" underlies them.

6.2 Explanatory and predictive power

Quantum electrodynamics possesses unrivaled predictive power in its field of applicability. The electron's anomalous magnetic moment, the Lamb shift, the scattering cross sections, and the positronium spectra are calculated to many decimal places and confirmed experimentally. Any alternative theory must reproduce these results in the appropriate limit.

The AU approach in its current state does not claim to replace the computational apparatus of QED. Its strength lies elsewhere:

- a unified ontology linking electromagnetism with the origin of space-time, dark energy, variations of constants and information processes;
- the natural emergence of nonlocality and the arrow of time;

- an indication of a possible class of small systematic effects (entropic level shifts, weak lifetime modulation, correlations of photon statistics with global coherence indices) that are, in principle, absent from the standard theory.

Compared to phenomenological nonlinear generalizations of Maxwell's equations, AU has an advantage: nonlinearity and nonlocality are not introduced "by hand," but rather follow from the structure of the original informational Lagrangian. At the same time, most existing nonlinear theories are better developed mathematically in terms of precise solutions and constraints from astrophysics.

6.3. Conditions of falsification

AU electrodynamics can be limited or refuted in several ways:

1. **Precision spectroscopy** . If the level shifts and lifetime anomalies predicted by entropy terms are eliminated to a level significantly smaller than theoretical estimates, the corresponding coupling constants will have to be assumed to be extremely small, making the electromagnetic sector of the AU practically unobservable.
2. **Photon statistics and locality tests** . The absence of any correlations beyond standard quantum optics, when accumulating very large statistics, will weaken the motivation for a non-local core in the electromagnetic sector.
3. **Consistency with already verified QED results** . Any modified equation that violates gauge invariance or introduces uncontrollable divergences will be unacceptable.
4. **Internal consistency with other sections of the AU** . If the dynamics S_Θ needed to explain dark energy or variations in the constants prove incompatible with the stringent constraints of atomic physics, the entire framework will need to be revised.

At its current stage, AU electrodynamics remains a research program. It reproduces QED in its limit and indicates the direction of possible deviations. The results of next-generation precision experiments and the degree of internal consistency of the entire Acta Universi hypothesis will be decisive.

Chapter 6 concludes the main body of the article. The conclusion summarizes the results, limitations, and priorities for future work.

Conclusion

In this paper, electromagnetic radiation is examined within the framework of the Acta Universi hypothesis. The main result is that the electromagnetic field and the photon can be consistently interpreted as emergent structures of the entropy field of thought forms S_Θ .

Let us briefly summarize what has been achieved.

The electromagnetic field arises as a certain class of collective excitations above a background $S_{\Theta,0}$. A photon corresponds to a coherent mode of this field; its energy, momentum, polarization, and boson statistics are interpreted through the properties of linearized perturbations δS_{Θ} and a nonlocal core $K(x, y)$. Classical electromagnetic waves are described as quasi-classical coherent states of a large number of such modes.

Modified Maxwell's equations, containing entropy and nonlocal corrections, are derived from the AU Lagrangian. In the limit of constant and small values $S_{\Theta,0}$ of and Φ_0 , as well as when the kernel contracts to δ the δ -function, standard quantum electrodynamics is fully restored. Deviations from this limit are controllable and, in principle, observable.

Emission and absorption processes are interpreted as irreversible recordings into the AU archive. This naturally links electromagnetic phenomena with the arrow of kairos time and the growth of theta entropy. Coherence, photon statistics, and entanglement are described unifically in terms of the dynamics S_{Θ} and structure of the nonlocal core.

Testable consequences are formulated: possible entropic contributions to atomic level shifts and the Lamb shift, weak modulation of excited-state lifetimes, and correlations between photon statistics and information field coherence indices. All these effects are expected to be extremely small and lie at the boundary or beyond the current experimental accuracy; however, they have characteristic distinguishing features that allow them to be distinguished from standard QED corrections.

A comparison with standard quantum electrodynamics shows that AU does not compete with it in the realm of already proven high-precision predictions, but rather offers an ontological foundation and points the way to possible small deviations. Compared to phenomenological nonlinear generalizations of Maxwell's equations, this approach has the advantage of inherently derivable nonlinearity and nonlocality from the structure of the informational Lagrangian.

Limitations . In its current form, the theory remains a research program. Quantitative estimates of entropic corrections depend on coupling constants that are still poorly defined. A complete quantum field theory S_{Θ} with an electromagnetic sector has not yet been constructed. The cosmological implications are preliminary.

Priority areas for further work :

- derivation of more precise expressions for entropic corrections to atomic spectra;
- study of one-loop effects in effective AU-electrodynamics;
- development of specific experimental protocols for precision spectroscopy and quantum optics;
- verification of the internal consistency of the electromagnetic sector with the remaining sections of the hypothesis (dark energy, variations of constants, atomic structure).

If the predicted small effects are detected, this will constitute strong evidence in favor of the information-entropy ontology. If they are excluded with high accuracy, the corresponding

coupling constants will prove extremely small, and the electromagnetic sector of the AU will be reduced to practically unobservable corrections. In any case, the proposed approach provides a clear direction for further theoretical and experimental research into the nature of electromagnetic radiation.

Applications

Appendix A. Derivation of Modified Maxwell's Equations

We start from the effective Lagrangian of the electromagnetic sector in the presence of fields S_Θ and Φ :

$$\mathcal{L} = -\frac{1}{4}F_{\mu\nu}F^{\mu\nu} + \xi_1 S_\Theta F_{\mu\nu}F^{\mu\nu} + \xi_2 \Phi F_{\mu\nu}F^{\mu\nu} + \mathcal{L}_{\text{nonlocal}}[A, K].$$

Variation in 4-potential A_ν gives

$$\partial_\mu [(1 - 4\xi_1 S_\Theta - 4\xi_2 \Phi)F^{\mu\nu}] = J_m^\nu + J_{\text{nl}}^\nu,$$

where J_m^ν is the usual material current, and J_{nl}^ν is the contribution from the non-local core.

Introducing effective permeabilities

$$\varepsilon_{\text{eff}} = 1 - 4\xi_1 S_\Theta - 4\xi_2 \Phi + \dots,$$

we obtain modified equations in three-dimensional form:

$$\begin{aligned} \nabla \cdot D &= \rho_{\text{free}} + \rho_{\text{ent}}, \\ \nabla \times H - \partial_t D &= J_{\text{free}} + J_{\text{ent}} + J_{\text{nl}}. \end{aligned}$$

In the limit of constants and small $S_{\Theta,0}$, Φ_0 and when $K \rightarrow \delta^{(4)}(x - y)$ the equations transform into standard Maxwell's equations.

Appendix B. Estimation of the magnitude of entropy corrections

The characteristic relative shift of the atomic level is estimated as

$$\frac{\delta E}{E} \sim \xi_1 S_{\Theta,0} + \xi_2 \Phi_0 + \mathcal{O}((\nabla S_\Theta)^2).$$

Assuming that the coupling constants ξ_i must be small enough not to destroy the agreement of QED with experiment at the level of 10^{-12} – 10^{-15} (typical accuracy of modern measurements of the Lamb shift and optical clocks), we obtain the constraint

$$|\xi_1 S_{\Theta,0}|, |\xi_2 \Phi_0| \lesssim 10^{-12} - 10^{-15}.$$

Thus, any entropic corrections compatible with existing data lie at the edge of or beyond the current experimental sensitivity and may only be available in next-generation experiments.

The estimate of the possible modulation of the level width $\delta\Gamma/\Gamma$ gives an even smaller value, since it is associated with the field derivatives S_θ with respect to time and requires the accumulation of a large number of recording acts.

Appendix B. Glossary of Basic Concepts

Term	Definition
Entropy field of thought forms S_θ	The fundamental information-entropy field of the Acta Universi hypothesis; the primary entity from which space-time, matter, and gauge fields emerge.
Non-local kernel $K(x, y)$	A kernel providing long-range correlations between recording events and ultraviolet regularization.
Kairos Time τ	A monotonic parameter associated with the growth of theta entropy; it determines the irreversible evolution of the system.
Thought form	Irreversible act of recording information into the AU archive; localized excitation of the field S_θ .
Photon in AU	A coherent mode (excitation) of a field S_θ that has energy $\hbar\omega$, momentum, and two polarization states.
Entropy source/current	Additional terms in Maxwell's equations proportional to the gradients and derivatives S_θ and Φ .
Effective speed of light c_{eff}	The maximum propagation velocity of long-wave coherent field disturbances S_θ .

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