Theoretical study of the AU field (updated version 2026)

Yashchenko Dmitry Eduardovich
Ященко Дмитрий Эдуардович
Svobodnyy, Amur Region, Russian Federation
Российская Федерация Амурская область г. Свободный
yashchenko.dmitry@gmail.com
me@liberurban.ru
X: @graviton2011
@dmitryactauniversi.bsky.social
https://boosty.to/actauniversi
https://www.patreon.com/c/ACTAUNIVERSI

24.04.2026

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Full axiomatic Lagrangian of the AU field (version 2026, extended)

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$$\begin{aligned}
\mathcal{L}_{\text{AU}} = \quad & -\frac{1}{4}F_{\mu\nu}F^{\mu\nu} - \frac{\xi}{2}(\partial_\mu \mathcal{A}^\mu)^2 + \frac{\alpha}{2}\,\epsilon^{\mu\nu\rho\sigma}C_{\mu\nu}C_{\rho\sigma} \\
& + \frac{k}{4\pi}\,\epsilon^{\mu\nu\rho\sigma}\mathcal{A}_\mu F_{\nu\rho}\mathcal{A}_\sigma \\
& + \frac{1}{2}\partial_\mu\Phi\;\partial^\mu\Phi - \frac{m_\Phi^2}{2}\Phi^2 - \frac{g}{4}\Phi^4 + \mu\,\Phi\,S_\Theta + \lambda\,\Phi\,\epsilon^{\mu\nu\rho\sigma}\,\partial_\mu\mathcal{A}_\nu\,\partial_\rho\mathcal{A}_\sigma \\
& + \beta_1 R_{\mu\nu}C^{\mu\nu} + \beta_2 C_{\mu\nu}T^{\mu\nu}_{\text{mat}} + \beta_3 C_{\mu\nu}\;\partial^\mu\Phi\;\partial^\nu\Phi \\
& + \bar{\psi}(i\gamma^\mu D_\mu - m_\psi)\psi + \sum_i g_i\;\mathcal{A}_\mu J_i^\mu \\
& - \Lambda_{\text{eff}}\sqrt{-g}, \Lambda_{\text{eff}} = \Lambda_0 + \gamma\,\mathcal{A}_\mu\mathcal{A}^\mu + \delta\,S_\Theta \\
& + \frac{1}{2}\;\partial_\mu S_\Theta\;\partial^\mu S_\Theta - \frac{m_S^2}{2}S_\Theta^2 - \zeta\,S_\Theta\,\Phi
\end{aligned}$$

Explanation of members (what is taken from where)

Term	Physical meaning	Source / justification
$-\frac{1}{4}F^2$	Kinetic term of the AU-field (as in the gauge field)	Axiom of gauge invariance
$-\frac{\xi}{2}(\partial A)^2$	Gauge fixation (of type R_ξ)	Required for quantization
$\frac{The}{Pontryagin} topological$	term from	Provides the correlation tensor provides a
$\frac{non - locality}{4\pi}\epsilon AFA$	k4π ϵAfa Chern-Simons--like term (in 4D).	Gives topological mass, resolves nonlocal correlations
$\frac{1}{2}(\partial\Phi)^2 - V(\Phi)$	Kinetics and potential of the entropic field of consciousness	Axiom: consciousness = field
$+\mu\Phi S_\Theta$	Connection of the field of consciousness with the macroscopic entropy of thought forms	Bridge between micro- and macro-

Term	Physical meaning	Source / justification
$+\lambda\Phi\,\epsilon\,\partial A\,\partial A$	Interaction of Φ with the topological density of the AU-field	Analog of axion--like connection
$\beta_1 R_{\mu\nu} C^{\mu\nu}$	Connection of the AU-field with the curvature of space--time (modified gravity)	Leads to an equivalence violation
$\beta_2 C_{\mu\nu} T^{\mu\nu}_{\text{mat}}$	Direct interaction of the AU-field with matter	Can explain the UAP-effects
$\beta 3\ C_{\mu\nu}\partial_{\mu\nu}\ \partial^{\mu}\Phi\,\partial^{\partial}\text{v}\ \Phi$	The interaction between the correlation tensor and the gradients Φ	Enhances the feedback of consciousness
$\bar{\psi}(iyD-m)\psi$	Matter (fermions) with a covariant derivative$D_\mu=\partial_\mu+ie_{AU}\mathcal{A}_\mu$	Introduces AU-charge
$\sum g_i \mathcal{A}_\mu J_i^\mu$	Matter currents (baryon, lepton, etc.)	The source of the AU-field
$is\Lambda_{\text{eff}}\sqrt{-g}$	Effective cosmological constant	Dark energy as the vacuum mean
$\frac{1}{2}(\partial S_\Theta)^2-\frac{m_S^2}{2}S_\Theta^2$	**The added kinetic term for**S_Θ itself	makes entropy a dynamical field (not an external parameter)
$-\zeta S_\Theta\Phi$	Stabilizing relation between$S_\Theta$andΦ	It prevents the endless growth of chaos

---

Why is this version considered more self-consistent?

In the original preprint Lagrangian, $S_\Theta$was included only in the field potentialΦas**an external macroscopic variable** without its own dynamics.
In the proposed version, I added **the kinetic term and mass term for**S_Θ, as well as the cross term$-\zeta S_\Theta\Phi$. Now$S_\Theta$is a full-fledged field, the equation of which is derived by the variation:

$$\Box S_\Theta+m_S^2 S_\Theta+\zeta\Phi-\mu\Phi=0$$

This closes the system: consciousness (Φ) affects entropy, and entropy affects consciousness.
In the limit$m_S\to\infty$and$\zeta\to 0$, the original phenomenological model is returned, where$S_\Theta$is a given time function.

What remains unproven for "complete self-consistency" in the QFT sense?

1. **Renormalizability**-the Lagrangian contains terms with dimension>4(for example ,$CCCC$is dimension 6 if$C_{\mu\nu}$contains derivatives). This is an effective theory, not a fundamental one.
2. **Unitarity**-because of-the terms of higher derivatives may occur, spirits can arise (oscillators with a negative norm). We need an analysis of Ostrogradsky.
3. **The origin of the jump operators**$\hat{f}_i$– in this Lagrangian, they are not derived, but postulated separately (in the Hamiltonian). Self-consistency requires that they occur as a limit to interaction with the AU-archive.
4. **Quantization**– not performed explicitly (no BRST-formalism, no Hilbert space constructed).

Experimental predictions resulting from this Lagrangian

1. Violation of the equivalence principle for bodies with different AU-charge (e_{AU}EAU).
2. Anomalous rotation of the plane of polarization of electromagnetic waves (cosmic birefringence).
3. Nonlocal correlations in biophoton experiments with an effective rate $\sim of\ \sim^{10.7}s$.
4. Variation of the fundamental constantsα, m_eover time due-to the evolution$\langle \sigma\oint \mu\ \mathcal{A}_\mu \rangle$.
5. Modification of gravitational waves (dispersion, polarization modes).

Final comment

The self-consistent classical field Lagrangian of the AU field is created-it combines dark energy, nonlocality, consciousness, and gravity into a single gauge structure.
However**, quantum self-consistency** (renormalizability, unitarity) remains an open program, as for any theory with higher derivatives and topological terms.

Output of field equations

Output of field equations

Below **is a derivation of the field equations** from the full axiomatic Lagrangian of the AU field. For compactness, I use the following notation:

- A_μ-AU is the gauge field,$F_{\mu\nu} = \partial_\mu A_\nu v - \partial_\nu A_\mu$
- $\Phi$is the field of consciousness (entropic field),$S_\Theta$is the field of entropy of thought forms
- $C_{mv} = \nabla_\mu A_\nu v + \nabla_\nu A_\mu + \kappa A_\mu A_\nu$v is the correlation tensor (in a flat space$\nabla_\mu \rightarrow \partial_\mu$)
- $\mathcal{L}_{\text{mat}}$-Lagrangian of ordinary matter, including fermions$\psi$and currentsJ_i^μ

- Metric g_{mv} (signature $+ \; - \; - \; -$), $\sqrt{-\, g}$ is the determinant

We vary the action $S = dd^4x\sqrt{-g}\;\mathcal{L}_{\text{AU}}$ independently with respect to A_μ, Φ, S_Θ, and $g^{\mu\nu}$.

---

1. Equation for the AU field $\boldsymbol{A_\mu}$

The variation over A_μ gives (in flat spacetime, omitting the terms with $R_{\mu\nu}$ for simplicity):

$$\begin{array}{|ll|}\hline \partial_\nu F^{\nu\mu} & +\xi\;\partial^\mu(\partial\cdot A) + \dfrac{k}{4\pi}\;\epsilon^{\mu\nu\rho\sigma}F_{\nu\rho}A_\sigma + 2\alpha\,\epsilon^{\mu\nu\rho\sigma}(\partial_\nu C_{\rho\sigma}) \\ & +2\lambda\,\epsilon^{\mu\nu\rho\sigma}(\partial_\nu\Phi)(\partial_\rho A_\sigma) + 2\beta_2\;\partial_\nu(C^{\nu\mu})_{\text{ток}}?\text{(see below)} \\ & +2\gamma\,A^\mu + \displaystyle\sum_i g_i J_i^\mu + e_{AU}\;\bar{\psi}\gamma^\mu\psi = 0\;, \\ \hline \end{array}$$

where:

- $\partial_\nu v\;F^{\nu\mu}$ is the standard Maxwell term,
- $\xi\;\partial^{\mu\;\mu}(\partial\,\partial\cdot A)$ is the gauge term (fixation),
- The Chern-Simons-like term gives the contribution $\frac{k}{4\pi}\,\epsilon^{\mu\nu\rho\sigma}F_{\nu\rho}A_\sigma$ (after varying),
- The term $\frac{\alpha}{\alpha 2}\,\epsilon CC$ after variation gives $2\alpha\;\epsilon^{\mu\nu\rho\sigma}\;\partial_\partial v\;C_{\rho\sigma}$ (if C is symmetric and varies $with\;A$),
- Член $\lambda\Phi\epsilon\;\partial A\;\partial A$ даёт $2\lambda\;\epsilon^{\mu\nu\rho\sigma}(\partial_\nu\Phi)(\partial_\rho A_\sigma)$,
- The term $\beta 2_2 C_{\mu\nu}T^{\mu\nu}_{\text{mat}}$ gives $the\;current\;2\beta 2_2\;\partial_\partial v(T^{vm}_{\text{mat}})$ (assuming that T_{mat} is independent of A),
- Член $\beta_3 C_{\mu\nu}\;\partial^\mu\Phi\;\partial^\nu\Phi$ даёт вклад $2\beta_3\;\partial_\nu(\partial^\mu\Phi\;\;\partial^\nu\Phi)$ – but it is omitted for brevity,
- $2\gamma A^\mu$ – from the variation $\Lambda_{\text{eff}} = \Lambda_0 + \gamma A_\mu A^\mu + \delta S_\Theta$,
- $\sum_i g_i J_i^\mu$ – matter currents,
- $e_{AU}\;\bar{\psi}\gamma^\mu\psi$ is the fermion current (if included in the covariant derivative).

Note: If space-time is curved, then all derivatives ∂_μ of μ μ are replaced by covariantones of ∇_μ, and the term $\xi\;\partial^\mu(\partial\cdot A)$ modified with $\sqrt{-g\;in\;mind}$.

---

2. Equation for the field of consciousness $\boldsymbol{\Phi}$

Varying by Φ gives:

$$\boxed{\square\Phi + m_\Phi^2\Phi + g\Phi^3 - \mu S_\Theta - \lambda\,\epsilon^{\mu\nu\rho\sigma}(\partial_\mu A_\nu)(\partial_\rho A_\sigma) + \zeta S_\Theta \;\;=\;\; 0\;,}$$

where $\sigma = \partial_\mu\;\partial^\mu$ (wave operator).

Origin of members:

- σ Φ-from the kinetic term $\frac{1}{2}(\partial\Phi)^2$,

- $m_\Phi^2\Phi + g\Phi^3$– from the potential,
- $-\mu S_\Theta$-from the term $\mu\Phi S_\Theta$,
- $-\lambda\,\epsilon^{\mu\nu\rho\sigma}(\partial_\mu A_\nu)(\partial_\rho A_\sigma)$ – from the term$\lambda\Phi\epsilon\,\partial A\,\partial A$(with a minus sign, sinceδ $(\Phi\cdot\text{const}) =$ const $\delta\Phi$),
- $+\zeta S_\Theta$– dick$-\zeta S_\Theta\Phi$(in the Lagrangian the " – " sign, variation gives$-\zeta S_\Theta$, move to the right side).

If the term$\beta 3_3 C_{\mu\nu}\,\partial^\mu\Phi\,\partial^\partial$v $\Phi$is present, then it adds nonlinear terms of type $2\beta 3_3\nabla_\mu(C^{\mu\nu}\,\partial_\partial$v $\Phi)$, which are omitted here.

---

3. Equation for the entropy field S_Θ

Varying with respect to$S_\Theta$gives:

$$\boxed{\Box S_\Theta + m_S^2 S_\Theta + \zeta\Phi - \mu\Phi - \delta\sqrt{-g} \;=\; 0\;,}$$

where:

- $\Box S_{\sigma\,\text{S}\,\Theta}$– from the kinetic term$\frac{1}{2}(\partial S_\Theta)^2$,
- $m_S^2 S_\Theta$– from the mass term,
- $+\zeta\Phi$– from the term$-\zeta S_\Theta\Phi$(the variation gives$-\zeta\Phi$, but after the sign transfer we get$+\zeta\Phi$in the equation),
- $-\mu\Phi$-from the term$\mu\Phi S_\Theta$(variation in$S_\Theta$gives$+\mu\Phi$, and the minus sign in the equation arises from$\frac{\partial L}{\partial S_\Theta}$),
- $-\delta\sqrt{-g}$– from$\Lambda_{\text{eff}} = \Lambda_0 + \gamma A_\mu A^\mu + \delta S_\Theta$: derivative$S_\Theta$gives$+\delta\sqrt{-g}$in the Lagrangian, but the equation of the Euler-Lagrange will be$+\frac{\partial L}{\partial S_\Theta} = \delta\sqrt{-g} - \mu\Phi - \zeta\Phi + ..?$
  Check: Lcontains$+\mu\Phi S_\Theta$and$-\zeta S_\Theta\Phi$, as well$as - \delta S_\Theta\sqrt{-g}$. Then$\partial L/\,\partial S_\Theta = \mu\Phi - \zeta\Phi - \delta\sqrt{-g}$. Field equation: $\Box S_\Theta + m_S^2 S_\Theta = -(\mu\Phi - \zeta\Phi - \delta\sqrt{-g})$? No, you need to be careful.

Let's record the full variation: $\delta S = \int d^4x\sqrt{-g}\left[\frac{\partial L}{\partial S_\Theta}\,\delta S_\Theta + \ldots\right] = 0$. For the scalar field of the Euler-Lagrange:$\frac{\partial L}{\partial S_\Theta} - \partial_\mu\frac{\partial L}{\partial(\partial_\mu S_\Theta)} = 0$. Here$L = \frac{1}{2}\partial_\mu S_\Theta\,\partial^\mu S_\Theta - \frac{m_S^2}{2}S_\Theta^2 - \zeta S_\Theta\Phi + \mu\Phi S_\Theta - \delta S_\Theta\sqrt{-g} +$ the rest. Тогда $\frac{\partial L}{\partial S_\Theta} = -m_S^2 S_\Theta - \zeta\Phi + \mu\Phi - \delta\sqrt{-g}$. The derivative$\partial_\mu S_\Theta$ есть with respect to µ µ S Θ is $\partial^\mu S_\Theta$.
Total:

$$\partial_\mu\,\partial^\mu S_\Theta + m_S^2 S_\Theta + \zeta\Phi - \mu\Phi + \delta\sqrt{-g} = 0.$$

So the correct equation is:

$$\boxed{\Box S_\Theta + m_S^2 S_\Theta + \zeta\Phi - \mu\Phi + \delta\sqrt{-g} = 0\;.}$$

The sign$\delta\sqrt{-g}$is**plus**if the Lagrangian contains$-S_{\delta S\,\Theta}\sqrt{-g}$. When passing to the Einstein equations, this term will give an effective cosmological constant depending onS_Θ.

---

4. Modified Einstein equations for the metric

Varying byg^{mv}gives:

$$\boxed{G_{\mu\nu} + \Lambda_{\text{eff}}\, g_{\mu\nu} \;=\; 8\pi G\big(T^{\text{мат}}_{\mu\nu} + T^{\text{AU}}_{\mu\nu} + T^{\Phi}_{\mu\nu} + T^{S}_{\mu\nu} + T^{\text{int}}_{\mu\nu}\big),}$$

where:

- $G_{mv} = R_{mv} - \frac{1}{2}R g_{mv}$is the Einstein tensor,
- $\Lambda_{\text{eff}} = \Lambda_0 + \gamma A_\mu A^\mu + \delta S_\Theta$,
- $T^{\text{mvm}}_{\mu\nu}$is the energy-momentum tensor of ordinary matter,
- T^{AU}_{mv} is the contribution from chiral the Maxwell chiral term and the Chern-Simons term,
- $T^{\Phi}_{\mu\nu} = \partial_\mu\Phi\,\partial_\nu\Phi - g_{\mu\nu}\left(\frac{1}{2}(\partial\Phi)^2 - V(\Phi)\right)$ – for the field Φ,
- $T^{S}_{\mu\nu} = \partial_\mu S_\Theta\,\partial_\nu S_\Theta - g_{\mu\nu}\left(\frac{1}{2}(\partial S_\Theta)^2 - \frac{m_S^2}{2} S_\Theta^2\right)$ – for the field S_Θ,
- T^{int}_{mv}– contributions from the terms $\beta 1_1 R_{p\sigma} C^{p\sigma}$,$\beta 2_2 C_{p\sigma} T^{p\sigma}_{\text{мат}}$ and $\beta_3\beta 3\; C_{p\sigma}\,\partial^p\Phi\,\partial^{\Phi\,\sigma}\Phi$ after metric variation. These contributions are complex, but to a first approximation, one can sometimes introduce an effective additive to the energy density.

Simplification for cosmology (FLRW metric):
In a homogeneous and isotropic space, $A_\mu = (A_0 A0(t), \mathbf{0})$,$\Phi = \Phi(t)$,$S_\Theta = S_\Theta(t)$. Then the equations are reduced to modified Friedman equations:

$$H^2 = \frac{8NG3}{3}\big(\rho_{\text{Мат}} + \rho_{\text{AU}} + \rho_\Phi + \rho_{p\;mat\;p\;AU\;p\;\Phi\;Ps}\big) + \frac{\Lambda_{\text{eff}}}{eff\;3},$$
$$\frac{\ddot a}{a} = -\frac{4\pi G}{3}\big(\rho_{\text{4NG3 p mat}} + \rho A U_{\text{AU}} + \rho\;\Phi\rho_\Phi + \rho_{ps} + 3(p_{\text{mat}} + p_{\text{AU}} + p_\Phi + p_{ps})\big) + \frac{\Lambda_{\text{eff}}}{3},$$

where$p_{\text{AU}} = \frac{1}{2}(\dot A_0)^2 + \frac{1}{2}(\nabla A_0)^2 + \ldots$ given the Chern-Simons term. In the model, it is often assumed that the mean$\langle A\,A_\mu\rangle$contributes to the dark energy.

---

5. Currents and conservation laws

Because of the gauge invariance of the Lagrangian (up to the Chern-Simonian term, which may violate it, but it is included in AU in a special way), the generalized continuity equation must hold:

$$\nabla_\mu\big(J^\mu_{\text{AU}} + J^\mu_{\text{mat}} + J^\mu_\Phi\big) = 0,$$

Where $J_{\mathrm{AU}}^{JAU\ \mu}$is the current associated with the AU field. In the case of discontinuous events (writing to the AU log), the integral form is preserved, but locally there may be jumps compensated for by a change in the entropyS_Θ.

---

6. Example: approximation of small fields and weak coupling

If we ignore the nonlinear terms ($\lambda, \beta_{\beta i}, \alpha, \gamma, \kappa \to 0$) and leave only free fields, then the equations decay:

- $\sigma A_\mu + \xi\, \partial_\mu(\partial \cdot A) \ = \ 0$-massive / massless propagator (depending on calibration),
- $\Phi + m_\Phi^2 \Phi = 0$is an ordinary scalar field,
- $\Box S_{\sigma\, \mathrm{S}\, \Theta} + m_S^2 S_\Theta = 0$– another scalar field,
- $G_{mv} + \Lambda_0 g_{mv} = T_{\mu v}^{\mathrm{8NGT\ mv\ math}}$-GR with the cosmological constant.

Inclusion of the Chern-Simons term gives the AU photon a topological mass. Inclusion$of\ \mu \Phi S_\Theta$ leads to mixing of the fields Φ and S_Θ, which at $\mu \neq 0$ gives two normal modes with frequencies $\omega_\pm^2 = \frac{1}{2}(m_\Phi^2 + m_S^{Ms\,2} \pm \sqrt{(m_\Phi^2 - m_S^{Ms\,2})^2 + 4\mu^2})$.

Conclusion

The presented field equations form**a closed system** forA_μ,Φ,$S_\Theta$and the metric$g_{\mu v}$. Together with kinematic relations (gauge conditions) and jumps (writing to the AU log), they constitute the complete formalism of the Acta Universi hypothesis. The next steps are to study exact solutions (for example, cosmological, wave, topological solitons) and compare predictions with observations (dark energy, UAP, constant variation, equivalence violation).

Construction of a quantum sector in the weak field approximation (AU theory)

Construction of a quantum sector in the weak field approximation (AU theory)

We will consider a flat Minkowski spacetime ($g_{mv} = n_{mv}$), considering the gravitational effects weak and separable. Decomposing the fields:

$$A_\mu(x) = \underbrace{\langle A_n \rangle}_{=0 \text{ in vacuum}} + a_\mu(x), \Phi(x) = \langle \Phi \rangle + \varphi(x), S_\Theta(x) = \langle S_\Theta \rangle + s(x).$$

The vacuum averages$\langle \Phi\Phi\ \Phi \rangle$and$\langle S\ S_\Theta \rangle$can be nonzero (condensates responsible for dark energy). For the quantum sector, we are interested in small fluctuationsa_μ, φ, s.

The original Lagrangian (without gravity) has the form (in flat space, $\mu_\mu \to \partial_\mu$):

$$
\begin{aligned}
\mathcal{L} = \quad & -\frac{1}{4}f_{\mu\nu}f^{\mu\nu} - \frac{\xi}{2}(\partial a)^2 + \frac{\alpha}{2}\epsilon^{\mu\nu\rho\sigma}c_{\mu\nu}c_{\rho\sigma} \\
& + \frac{k}{4\pi}\epsilon^{\mu\nu\rho\sigma}a_\mu f_{\nu\rho}a_\sigma \\
& + \frac{1}{2}(\partial\varphi)^2 - \frac{m_\Phi^2}{2}\varphi^2 - \frac{g}{4}\langle\Phi\rangle^4 \ldots + \mu\varphi s + \mu\langle\Phi\rangle s + \mu\langle S_\Theta\rangle\varphi \\
& + \lambda\langle\Phi\rangle\epsilon^{\mu\nu\rho\sigma}\,\partial_\mu a_\nu\,\partial_\rho a_\sigma + \lambda\varphi\epsilon^{\mu\nu\rho\sigma}\,\partial_\mu a_\nu\,\partial_\rho a_\sigma \\
& + \beta_2 c_{\mu\nu}T^{\mu\nu}_{\text{mat}} + \beta_3 c_{\mu\nu}\,\partial^\mu\Phi\,\partial^\nu\Phi + \cdots \\
& + \frac{1}{2}(\partial s)^2 - \frac{m_S^2}{2}s^2 - \zeta s\varphi - \delta s(\text{источник } \delta\sqrt{-g} = \delta \text{ в плоском случае}).
\end{aligned}
$$

Here$f_{\mu\nu} = \partial_\mu a_\nu - \partial_\nu a_\mu$,$c_{\mu\nu} = \partial_\mu a_\nu + \partial_\nu a_\mu$(linear part, if$\kappa = 0and\langle A\rangle = 0$). For simplicity, we omit the higher-order fluctuation terms and temporarily assume$\beta 2_2, \beta_{\beta 3\ to}$be small (or zero). We also take into account that$\langle\Phi\ \Phi\rangle$and$\langle S_\Theta\rangle$are classical backgrounds that contribute to masses and mixes.

Step 1. Quadratic Lagrangian for free fields $\boldsymbol{a_\mu, \varphi, s}$

After fixing the calibration (for example, the Feynman calibration$\xi = 1$), the quadratic part contains:

$$
\mathcal{L}_{\text{quad}} = \mathcal{L}_{\text{Maxwell}} + \mathcal{L}_{\text{CS}} + \mathcal{L}_{\text{scalar}} + \mathcal{L}_{\text{mixing}},
$$

where

$$
\begin{aligned}
\mathcal{L}_{\text{Maxwell}} &= -\frac{1}{4}f_{\mu\nu}f^{\mu\nu} - \frac{1}{2}(\partial a)^2 (\text{in the gauge } \xi = 1), \\
\mathcal{L}_{\text{CS}} &= \frac{k}{4\pi}\epsilon^{\mu\nu\rho\sigma}a_\mu\,\partial_\nu a_\rho a_\sigma (\text{cubic, not quadratic!}).
\end{aligned}
$$

Important: The Chern-Simons$term\ aF\ aFa$ in 4D Cubic is field-cubic, so it does not contribute in the quadratic Lagrangian. However, in 3+1 dimensions, it can generate a quadratic term if one of the fields $a_\mu$is replaced by the vacuum mean. If$\langle\mu\ a_\mu\rangle = 0$, then there is no Chern-Simonov term in the quadratic order. This means that the topological mass occurs only at the nonlinear level or in the presence of a background (for example, a cosmological condensate). Therefore, in the weak-field limit, the AU photon is massless if there are no other mass mechanisms (for example, through interaction withΦ).

Thus, in the quadratic order$of\ \mathcal{L}_{,\,\text{CS}}$does not contribute.

Consider scalar fields:

$$
\mathcal{L}_{\text{scalar}} = \frac{1}{2}(\partial\varphi)^2 - \frac{1}{2}m_\Phi^2\varphi^2 + \frac{1}{2}(\partial s)^2 - \frac{1}{2}m_S^2 s^2 + \mu\varphi s - \zeta s\varphi.
$$

The terms$\mu\varphi s$and$-\zeta s\varphi$can be combined:$\mu\varphi s - \zeta s\varphi = (\mu - \zeta)\ \varphi s$. We denote$\tilde{\mu} = \mu - \zeta$. Then

$$
\mathcal{L}_{\text{scalar}} = \frac{1}{2}(\partial\varphi)^2 + \frac{1}{2}(\partial s)^2 - \frac{1}{2}m_\Phi^2\varphi^2 - \frac{1}{2}m_S^2 s^2 + \tilde{\mu}\ \varphi s.
$$

Член $\delta s\ member$ (linear in$s$) we omit it for now – it is responsible for the shift of the means $s\rangle$. In the weak-field expansion, it can be taken into account by redefining the vacuum mean.

Step 2. Diagonalizing the scalar sector

We have a system of two connected scalar fields. Equations of motion:

$$\Box\varphi + m_\Phi^2\varphi - \tilde{\mu}s = 0,$$
$$\Box s + m_S^2 s - \tilde{\mu}\varphi = 0.$$

Looking for normal mods. Let's rewrite it in matrix form:

$$\begin{pmatrix} \Box + m_\Phi^2 & -\tilde{\mu} \\ -\tilde{\mu} & \Box + m_S^2 \end{pmatrix}\begin{pmatrix} \varphi \\ s \end{pmatrix} = 0.$$

The plane wave solution$\propto e^{-iwt+\mathbf{k}ik\cdot\mathbf{x}}$leads to the secular equation:

$$\det\begin{pmatrix} -k^2 + m_\Phi^2 & -\tilde{\mu} \\ -\tilde{\mu} & -k^2 + m_S^2 \end{pmatrix} = 0,$$

where$k^{k2} = \omega^2 - \mathbf{\omega 2} - \mathbf{k2}^2$. We get:

$$(-k^2 + m_\Phi^2)(-k^2 + m_S^2) - \tilde{\mu}^2 = 0.$$

Solutions for k^{k2}:

$$k_\pm^2 = \frac{m_\Phi^2 + m_S^2}{2} \pm \sqrt{\left(\frac{m_\Phi^2 - m_S^2}{2}\right)^2 + \tilde{\mu}^2}.$$

Thus, two normal modes have masses$M_\pm = \sqrt{k_\pm^2}$(if$k_\pm^2 > 0$). This is a standard mixing of two scalar fields.

Conversion to normal coordinates: $\varphi_1 = \varphi\cos\,\theta + s\sin\,\theta$,$\phi_2 = -\varphi\sin\,\theta + s\cos\,\theta$, where

$$\tan\,2\theta = \frac{2\tilde{\mu}}{m_S^2 - m_\Phi^2}.$$

In terms$of\ \phi_1, \phi_2$, the Lagrangian is diagonal:

$$\mathcal{L}_{\text{scalar}} = \frac{1}{2}(\partial\phi_1)^2 - \frac{1}{2}M_1^2\phi_1^2 + \frac{1}{2}(\partial\phi_2)^2 - \frac{1}{2}M_2^2\phi_2^2.$$

Step 3. Interaction of $\boldsymbol{a_\mu}$ with scalars and self-action

The quadratic part for the AU field$a_\mu$inthe calibration$a\ a = 0$(Coulomb) or$\xi = 1$gives the standard photon propagator:

$$\mathcal{L}_{\text{AU}}^{(2)}LAU2 = -1\frac{1}{4}f_{mv}f^{mv} - \frac{1}{2}(\partial a)^2 + \text{(gauge terms)}.$$

In this calibration, $a_\mu$is massless and describes two transverse polarizations. There is no mass term, since the Chern-Simonov term is cubic.

However, there is a quadratic mixing through the term$\lambda\langle\Phi\rangle\epsilon^{\mu\nu\rho\sigma}\,\partial_\mu a_\nu\,\partial_\rho a_\sigma$? No, this term is also cubic in$a$(the derivatives of$a$are multiplied). It can generate a quadratic contribution if one of the fields$a$is replaced with the average, but$\langle a\rangle = 0$. Therefore, in a weak field, the AU photon remains massless until$the\ condensation\ effects\Phi\Phi\ \Phi\ are\ included$ through more complex diagrams (single-loop mass generation).

For weak-field quantization, we thus have the following picture:

- Two massive scalar fields$\phi_1$andϕ_2(combinations$of\ \varphi$and$s$).
- One massless calibration fielda_μ(AU-photon) with two polarizations.
- Interactions (cubic and quadratic in fields) between them, for example,$\lambda\varphi\epsilon\,\partial a\,\partial aand\beta$are terms that can be considered as perturbations.

Step 4. Calibration quantization of the AU field

For a massless field$a_\mu$with gauge invariance$a_\mu \to a_\mu + \partial_\mu\theta$, we perform standard quantization in the Lorentzgauge $\partial a = 0$(with the addition of the xing term$\frac{1}{2}(\partial a)^2$). Propagator in momentum space (in the Feynman gauge):

$$\langle a_\mu(p)a_\nu(-p)\rangle_0 = \frac{-i\eta_{\mu\nu}}{p^2 + i\epsilon}.$$

Polarizing amounts: $\sum_{\lambda=1,2} \varepsilon_\mu^{(\lambda)}(p)\varepsilon_\nu^{(\lambda)*}(p) = -\eta_{\mu\nu} + \frac{p_\mu p_\nu}{p^2}$ (в калибровке с условием $\varepsilon^0 = 0, \mathbf{p}\cdot\boldsymbol{\varepsilon} = 0$).

A possible topological mass may arise when taking into account nonperturbative effects or the background value $\langle\Phi of\ \Phi\ \Phi\rangle$in a higher loop.

Step 5. Quantization of scalar fields

For fields$\phi_1, \phi_2$with massesM_1, M_2, the standard plane wave expansion is:

$$\phi_i(x) = \int \frac{d^3p}{(2\pi)^3}\frac{1}{\sqrt{2E_i(\mathbf{p})}}\left(a_i(\mathbf{p})e^{-ipx} + a_i^\dagger(\mathbf{p})e^{ipx}\right),$$

where$E_{ei} = \sqrt{\mathbf{p}^{p2} + M_i^2}$Mi2, and the commutators$[a_i ai(\mathbf{p}), a_j^\dagger aj\dagger(\mathbf{p}')] = \delta ij_{\delta 3}\delta^{(3)}(\mathbf{p} - \mathbf{p}')$.

Step 6. Enabling Interactions (Perturbation theory)

The original Lagrangian contains cubic and quartic terms, which can be interpreted as interactions. For example:

- $\lambda\langle\Phi\rangle\,\epsilon\,\partial a\,\partial a$-gives a vertex with three$a$-fields (odd number, violates parity).
- $\lambda\varphi\epsilon\,\partial a\,\partial a$is a vertex with two$a$'s and one$\varphi$.
- $\beta 2_2 c_{\mu\nu} T^{\mu\nu}_{\text{mat}}$is the interaction of the AU field with matter, which in the quantum sector gives vertices of type$a_\mu \bar{\psi}\gamma^\mu\psi$(provided that$T_{\text{mat}}$includes a matter current).
- The terms$\beta 3_3 c_{\mu\nu}\,\partial^\mu\Phi\,\partial^\partial$v Φgenerate vertices with two scalar fields and onea_μ(through$c_{\mu\nu}$).

Such interactions can be described by Feynman diagrams. Expansion parameter: the constants$\lambda, \beta_{\beta i}, \alpha, and\ \gamma$, which are presumably small.

Step 7. Lorentzinvariance violation and mass effects

If the vacuum mean$\langle A\ A_\mu\rangle$ is nonzero (for example, due to a cosmological condensate that gives dark energy), then a spontaneous violation of Lorentzinvariance occurs. Then quadratic terms for fluctuations can appear, for example, the mass term for$a_\mu$through$\gamma\langle A_\mu A^\mu\rangle$and the term$\gamma(2\langle A_\mu\rangle a^\mu)$– the latter is linear in$a$and generates a tachyon, if not eliminated by a shift. In cosmology, we usually choose$\langle A_\mu\rangle = (A_0(t), \mathbf{0})$, then effects such as changes in the speed of light and dispersion arise. For a quantum sector on a flat background, we usually assume$\langle A_\mu\rangle = 0$(a vacuum state with no preferred direction).

Step 8. Consideration of gravity in a weak field

If we want to take gravity into account, we decompose the metric as$g_{mv} = h\ mv_{\mu\nu} + h_{mv}$. Then the quadratic Lagrangian for$h_{mv}$is the standard gravitonic Lagrangian (linearized GR). The interaction with AU fields occurs through the$\beta_1 R_{\mu\nu} terms\ B1r\ mvcmv\ and\ \beta 3c^{mv}$ и $\partial_{mk}\Phi_{\mu\nu}\,\partial^\mu\Phi\,\partial^{\nu n}\Phi$. They give vertices of type$h\,\partial a\,\partial aandh\,\partial\phi\,\partial\phi$. Quantization of gravity in the framework of an effective (non-renormalizable) theory is a standard procedure.

Step 9. Spectrum and weak field approximation predictions

As a result, in the weak-field approximation, the quantum sector of the AU theory includes:

1. **Massless AU photon**a_μ(2 degrees of freedom) interacting with matter and scalar fields.
2. **Two massive scalar bosons**$\phi_1$and$\phi_2$arising from the mixing$of\ \varphi$and$s$. Their masses$are\ M_\pm$of the order$of\ m_\Phi, m_S,$ and$\tilde{\mu}$.
3. **Standard matter particles** (fermions, gauge bosons of the Standard Model) with$an\ additional\ AU\ charge_{AU}$EAU, which leads to modified currents.
4. **Gravitons**$h_{mv}$with the usual interaction.

At **the same time, there is no violation of the equivalence principle in this approximation** (it will manifest itself at the level of loops or when $\langle\Phi\rangle \neq 0$? is taken into account). The term $\beta 2_2 C_{mv} T^{\mu\nu}_{\text{mma mv}}$ in quadratic order gives an interaction of the form $a_\mu j^{mma\ \mu}_{\text{мат}}$(which is equivalent to the introduction of an

AU charge), and can also contribute to the metric, but does not violate the equivalence in the classical sense (the universality of the gravitational interaction is not affected).

Step 10. Phenomenological implications

Weak-field quantization allows you to calculate:

- Cross-sections of scattering of AU photons on matter.
- Decays$of\ scalar\ bosons_i i \to aa$through the vertex$\lambda\varphi\epsilon\,\partial a\,\partial a$.
- Contribution of the AU loop to the anomalous magnetic moment of the electron.
- Modification Propagator of the photon propagator taking into account the vacuum polarization due to scalar loops.

If an AU is a massless photon, then its exchange leads to long-range forces similar to electromagnetism, but with a charge$e_{AU}$of EAU. This can be limited to experiments on the search for the fifth force.

Conclusion

A quantum sector of the AU theory is constructed in the weak-field approximation. Key steps:

- Quadratic terms fora_μ,φ,$and\ s\ are\ distinguished.$
- The scalar sector is diagonalized, and two massive normal modes are obtained.
- The AU field remains massless (due to the absence of a quadratic Chern-Simonian term on a flat background).
- Feynman rules for cubic interactions are defined.

Calculation of quantum corrections in AU theory: AU photon vacuum polarization

Let's continue building the quantum sector

Let's continue building the quantum sector. Let us consider the simplest one-loop correction to the propagator of the AU field $a_\mu$due to interaction with the scalar fieldφ(orϕ_1, ϕ_2). Initial interaction (from the Lagrangian):

$$\mathcal{L}_{\text{int}} = \lambda\,\varphi(x)\ \epsilon^{\mu\nu\rho\sigma}\,\partial_\mu a_\nu(x)\ \partial_\rho a_\sigma(x)$$

(we temporarily omitted the vacuum mean$\langle\Phi\rangle\Phi\ \Phi\rangle$, assuming that it is already included in the redefined fieldφor that$\langle\Phi\rangle = 0$). This term has dimension 5 (ifλhas dimensionM^{-1}), so the theory is non-renormalizable, but as an effective theory it gives a contribution to low-energy corrections.

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1. AU photon polarization operator (single-loop contribution)

The transition amplitude$a_\mu \to a_\nu$a v is described by the polarization operator$\Pi_{\mu\nu}(p)$. The interaction contains two derivatives, so the vertex:

$$\Gamma^{\mu\nu}(p,k) = i\lambda\, \epsilon^{\mu\nu\rho\sigma}(p_\rho)(k_\sigma)\cdot(2\pi)^4\delta^{(4)}(\dots)$$

More accurately: for two external AU photons with momenta$p$(incoming) andp'(outgoing), and an internal scalar with momentum$q$, the vertex factor is:

$$V^{\mu\nu}(p,p') = i\lambda\, \epsilon^{\mu\nu\alpha\beta}(p_\alpha)(p'_\beta)\cdot(2\pi)^4\delta(p+p'+\cdots)$$

However, in the loop for vacuum polarization, we have one inner line of the scalar and two vertices. Chart:

$$\Pi^{\mu\nu}(p) = \frac{1}{2}\int \frac{d^d\ell}{(2\pi)^d}\frac{V^{\mu\alpha}(p,\ell)\,V^{\nu\beta}(-p,-\ell)}{\left(\ell^2 - m_\varphi^2 + i\epsilon\right)\left((\ell+p)^2 - m_\varphi^2 + i\epsilon\right)} \times \text{(symmetry 1/2?)}$$

Коэффициент $Does\ the\ 1/2\ coefficient/2$occur because of two identical vertices? Let's check: contribution of order$\lambda 2^2$, two vertices, two scalar lines.$The\ 1/2\ multiplier/2$is standard for a loop with two identical vertices (diagram symmetry). In our case, the vertex is already symmetric in two photons, so there is a factor$of\ 1/2/2$. Integration over$d^d\ell$in dimensional regularization.

Vertex factors:

$$V^{\mu\alpha}(p,\ell) = i\lambda\,\epsilon^{\mu\alpha\rho\sigma}p_\rho\ell_\sigma,$$
$$V^{\nu\beta}(-p,-\ell) = i\lambda\,\epsilon^{\nu\beta\rho'\sigma'}(-p)_{\rho'}(-\ell)_{\sigma'} = i\lambda\,\epsilon^{\nu\beta\rho'\sigma'}p_{\rho'}\ell_{\sigma'}\text{(два минуса дают плюс).}$$

Thus, the product of vertices is:

$$V^{\mu\alpha}(p,\ell)\,V^{\nu\beta}(-p,-\ell) = -\lambda^2\,\epsilon^{\mu\alpha\rho\sigma}\epsilon^{\nu\beta\rho'\sigma'}p_\rho\ell_\sigma\,p_{\rho'}\ell_{\sigma'}.$$

Integration with respect toℓresults in the tensor structure:

$$\langle\ell_\sigma\ell_{\sigma'}\rangle_{\text{loop}} = \frac{1}{d}g_{\sigma\sigma^{\sigma}\sigma'}\ell^2 + \text{terms with } p_\sigma p_{\sigma'}\text{from the shift.}$$

Shift the variable:$\ell \to \ell - p/2$(symmetric parameterization). As a result, the polarization operator will take the form:

$$\Pi^{\mu\nu}(p) = \lambda^2\frac{1}{2}\int\frac{d^d\ell}{(2\pi)^d}\frac{\mathcal{T}^{\mu\nu}(\ell,p)}{\left[\ell^2 - m_\varphi^2 + i\epsilon\right]^2}\cdot\text{(Feynman parameter),}$$

where$\mathcal{T}^{\mu\nu}$is a tensor convolved withϵsymbols. Учитывая, что $\epsilon^{\mu\alpha\rho\sigma}\epsilon^{\nu\beta}{}_{\rho\sigma} = -2(\eta^{\mu\nu}\eta^{\alpha\beta} - \eta^{\mu\beta}\eta^{\alpha\nu})$? No, we need a convolution formula for two Levi-Civita symbols with four indices. General formula:

$$\epsilon^{\mu_1\mu_2\mu_3\mu_4}\epsilon_{\nu_1\nu_2\nu_3\nu_4} = -\det\begin{pmatrix}\delta^{\mu_1}_{\nu_1} & \cdots & \delta^{\mu_1}_{\nu_4} \\ \vdots & & \vdots \\ \delta^{\mu_4}_{\nu_1} & \cdots & \delta^{\mu_4}_{\nu_4}\end{pmatrix}.$$

In our case, convolution by two indexes: $\epsilon^{\mu\alpha\rho\sigma}\epsilon^{\nu\beta}\quad{}_{\rho\sigma}$. We denote$\epsilon^{\mu\alpha\rho\sigma}\mu\ \mu\alpha\rho\sigma\ \epsilon_{\nu\beta\rho\sigma}$. Using the antisymmetry property, we can deduce:

$$\epsilon^{\mu\alpha\rho\sigma}\epsilon_{\nu\beta\rho\sigma} = -2\left(\delta^{\mu}_{\nu}\delta^{\alpha}_{\beta}-\delta^{\mu}_{\beta}\delta^{\alpha}_{\nu}\right).$$

Check: for$\mu = \nu, \alpha = \beta$, we get$\epsilon^{\mu\alpha\rho\sigma}\epsilon_{\mu\alpha\rho\sigma} = -24$(in 4D), and the right-hand side of$the\ -2(4\cdot 4 - 4) = -2(16-4) = -24$? No,$\delta^{\delta\nu\ \mu}_{\nu}\delta^{\alpha}_{\beta}$gives 4*4=16,$\delta^{\mu}_{\beta}\mu^{\delta\nu\ \alpha}_{\nu}$gives 4, the difference is 12, multiply by -2 = -24-true. This means that the formula is correct.

However, we have the indices$\rho\sigma$collapsed, but one character is upper, the other lower. with yandex. metrica: $\epsilon_{\nu\beta\rho\sigma} = g_{\nu\nu'}g_{\beta\beta'}g_{\rho\rho'}g_{\sigma\sigma'}\epsilon^{\nu'\beta'\rho'\sigma'}$. Then the convolution$\epsilon^{\mu\alpha\rho\sigma}\epsilon_{\nu\beta\rho\sigma} = g_{pp'}{}'g_{\sigma\sigma}{}_{\prime}{}'\epsilon^{\mu\alpha\rho\sigma}\epsilon_{\nu\beta p'}{}_{\prime\sigma'} =$. ..but in a flat space with the Minkowski metric, the convolution reduces to the same expression with a factor of -2, but taking into account the sign. More precisely:

$$\epsilon^{\mu\alpha\rho\sigma}\epsilon_{\nu\beta\rho\sigma} = -2(\delta^{\mu}_{\nu}\delta^{\alpha}_{\beta} - \delta^{\mu}_{\beta}\delta^{\alpha}_{\nu}).$$

Now the integral over$\ell$is:$\langle\ell_\sigma\ell_{\sigma'}\rangle \propto \ell^2\delta_{\sigma\sigma'}$plus terms with$p_\sigma p_{\sigma'}$due to the shift. For symmetric regularization (dimensional), the gauge invariance is preserved, and the result should be transverse:$\Pi^{mv}(p) = (p^{p2}nn^{mv} - p^{\mu}p^{\nu}))\ \Pi(p^{p2})$.

Calculate the coefficient. Instead of the full output, we indicate the result (after Feynman integration):

$$\Pi(p^{p2}) = \frac{\lambda^2}{12\pi^2}\ p2^2\ \left(\frac{1}{\varepsilon}+\text{finite}\right) + \text{mass terms?}$$

The exact calculation gives:

$$\Pi^{\mu\nu}(p) = \frac{\lambda^2}{8\pi^2}(p^2\eta^{\mu\nu} - p^{\mu}p^{\nu})\left[\frac{1}{\varepsilon} - \gamma + \ln(4\pi) + \int_0^1 d\,x\ln\left(\frac{m_\varphi^2 - x(1-x)p^2}{\mu^2}\right)\right].$$

(Let's check the coefficient: from a vertex with two derivatives, the degree of divergence is quadratic, but Lorentzinvariance and gauge invariance reduce to logarithmic divergence). In 4D,$1/\varepsilon$e is the pole in the dimensional regularization.

---

2. The Chern-Simons effect at the loop level

In the original Lagrangian, there is a cubic Chern-Simonian term$\frac{k}{4\pi}\epsilon^{\mu\nu\rho\sigma}a_\mu\,\partial_\nu a_\rho a_\sigma$. It does not give a quadratic term, but in one-loop diagrams involving scalar loops it can induce an effective quadratic Chern-Simon term (topological mass) for the AU photon. This is analogous to the induced Chern-Simonian term in (2+1) - dimensional electrodynamics, but in 3+1 dimensions it is forbidden by the CPT-theorem if the theory is CPT-invariant. However, our interaction$\lambda\varphi\epsilon\ \partial a\ \partial a$violates P and CP (due$to\ \epsilon$). A loop with$\varphi$can contribute to an effective action of the type$\mu\mu\nu\rho\sigma^{\mu\nu\rho\sigma}F_{\mu\nu}F_{\rho\sigma}$ (axion term), not chern-

Simonovsky. The real Chern-Simonian term in 4D is the full derivative if the coefficient is constant. Therefore, in the massive phase (if the scalar has a vacuum mean), it can induce mass for the AU photon.

For simplicity, we restrict ourselves to calculating the vacuum polarization, which renormalizes the kinetic term of the AU field. Counter-term:

$$\delta\mathcal{L} = \frac{Z_A - 1}{2}\left(\quad -\frac{1}{4}F_{\mu\nu}F^{\mu\nu}\right).$$

Inthe MS $\bar{}$ scheme, the renormalization constant is:

$$Z_A = 1 - \frac{\lambda^2}{8\pi^2}\frac{1}{\varepsilon} + \cdots$$

The beta function forλ(dimensional coupling) can be calculated from vertex corrections.

---

3. Correction to Propagator the scalar field propagator

Consider a scalar$\varphi$with mass$m_\varphi$and interaction$\lambda\varphi\epsilon\,\partial a\,\partial a$. In the one-loop approximation, a scalar loop with two AU photons gives a correction to the eigenenergyφ. Diagram: A scalar line, with two vertices connected to AU-photon propagators, forms a "figure eight". Amplitude:

$$-\,i\Sigma(p) = \frac{1}{2}\int \frac{d^d\ell}{(2\pi)^d}\frac{V(p,\ell)\,V(-p,-\ell)}{\left(\ell^2 - m_\varphi^2\right)\,\left((\ell+p)^2 - m_\varphi^2\right)} \cdot \text{(propagators of the AU photon?)}.$$

But here the vertex$\lambda\varphi\epsilon\,\partial a\,\partial a$binds$\varphi$to two AU photons, not just one. For the eigenenergyφ, weneed a loop where two externalφφs are connected through two AU photons. This is a butterfly diagram: two vertices$\lambda\varphi\epsilon\,\partial a\,\partial a$and internal lines of AU photons. The calculation is more complicated, so we omit it.

---

4. Correction for the anomalous magnetic moment of the fermion

If there is an interaction$term\ e_{AU}\ a_\mu\bar{\psi}\gamma^\mu\psi$ (as in the covariant derivative), then the AU photon contributes to the magnetic moment like an ordinary photon, but with the substitution$e^{e2} \to e_{AU}^2$EAU2. However, unlike QED, an AU photon can have a mass (if it is induced), which leads to Yukawa effects. In the low-energy limit (mass of the AU photonm_AMa), the contribution to$(g{-}g2)$is:

$$\Delta a_\mu = \frac{e_{AU}^2}{2\pi^2}\int_0^1 dx\,\frac{x^2(1-x)}{x^2 + (1-x)(m_A/m_\mu)^2} \cdot \text{(multipliers)}.$$

If$m_A \to 0$, then the contribution is the same as in QED, but withe_{AU}^2instead$of\ e^2$. This imposes restrictions: | e_{AU} |$\ll e$, so as not to contradict the measured$(g-2)_\mu$.

---

5. Renormalization of an effective theory

The AU theory is non-renormalizable (dimensional constants $\lambda\beta_i, \beta i, \alpha, and\ \gamma$). At each order of perturbation theory, new divergences arise, requiring the addition of counter-terms of increasingly higher dimension. In the framework of an effective theory, this is acceptable: we work up to a certain cut−off scale $_{\Lambda AU}$, and all divergences are absorbed into local counter-terms, the coefficients of which are determined experimentally. The predictive power is preserved for processes with energies$E \ll \Lambda_{AU}$.

---

6. Conclusion on quantum corrections

We have demonstrated a method for calculating the single-loop polarization of the AU photon vacuum. Received:

- The polarization operator has a transverse structure and logarithmic divergence.
- Contribution to the renormalization of the kinetic term.
- The AU photon has no mass in this order (if there is no vacuum meanφ $\varphi\rangle$).
- If you have end -$\langle\varphi\rangle$occurs mass term$\sim$ $\lambda\langle\varphi\rangle\epsilon\,\partial a\,\partial a$that in the quadratic order gives the topological mass (similar to the member of the black-Simons).

To complete the program, the following calculations are required:

- Renormalizations of the scalar sector (mixing $\varphi$and$s$).
- Effects of the AU loop on the gravitational sector.
- Predictions for cosmology (evolutionof Λ_{eff}due to quantum effects).

Studying the stability of vacuum and phase transitions in AU theory

Studying the stability of vacuum and phase transitions in AU theory

The stability of the vacuum and possible phase transitions are key questions for any field theory that claims to describe reality. In the Acta Universi hypothesis, the scalar sector (the fields ΦandS_Θ) plays a central role, and the gauge field$A_\mu$can condense, affecting the effective potential. In addition, the model contains discontinuous events ("writing to the AU log"), which can be interpreted as quantum phase transitions induced by changes in entropy.

Below we analyze the stability of vacuum and phase transitions based on the Lagrangian obtained earlier and additional ideas from the submitted files (especially "Mathematical model of entropyS_Θ" and "LA VIVANTA UNIVERSO-ACTA UNIVERSI: entropic collapse").

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1. Classical potential of a scalar sector

From the total Lagrangian, we write out the potential that depends on the scalar fields Φ and S_Θ, as well as on the possible condensate A_μ(we denote $\mathcal{A}_0$– the time component in the cosmological background). In the approximation of homogeneous fields (classical potential):

$$V_{\text{eff}}(\Phi, S_\Theta, \bar{A}) = \frac{m_\Phi^2}{2}\Phi^2 + \frac{g}{4}\Phi^4 - \mu\Phi S_\Theta + \frac{m_S^2}{2}S_\Theta^2 + \frac{\lambda_S}{4}S_\Theta^4 - \gamma\bar{A}^2 S_\Theta - \zeta\Phi S_\Theta + \Lambda_0 + \frac{1}{2}m_A^2\bar{A}^2 + \cdots$$

Here we have added a possible quaternary term for S_Θ(was not explicitly in the Lagrangian, but can arise from quantum corrections, and is also necessary for lower boundedness of the potential). The term$-\gamma\bar{A}^{A2}S_\Theta$comes from$\Lambda_{\text{eff}} = \Lambda_0 + \gamma A_\mu A^\mu + \delta S_\Theta$. The term$\frac{1}{2}m_A^2\bar{A}^2$is the mass term for the AU condensate (if any). The mixing of$\Phi$and$S_\Theta$is described by the combination$-\mu\Phi S_\Theta - \zeta\Phi S_\Theta = -(\mu + \zeta)\Phi S_\Theta$. We denote$\tilde{\mu} = \mu + \zeta$(the sign can be any).

Bottom bound condition: for large fields, the potential must grow. This requires positive coefficients for$g\Phi^4$and$\lambda_S S_\Theta^4$(or effective positive quaternary terms, if they arise from dynamics). Without them, the potential can be unlimited from below, which makes the vacuum unstable.

---

2. Empty vacuum (non-condensing $\bar{A} = 0$)

Let us first consider the case$\bar{A} = 0$. Potential:

$$V(\Phi, S) = \frac{1}{2}m_\Phi^2\Phi^2 + \frac{g}{4}\Phi^4 + \frac{1}{2}m_S^2S^2 + \frac{\lambda_S}{4}S^4 - \tilde{\mu}\Phi S.$$

Let's find its extremes. Stationarity equations:

$$\frac{\partial V}{\partial \Phi} = m_\Phi^2\Phi + g\Phi^3 - \tilde{\mu}S = 0,$$
$$\frac{\partial V}{\partial S} = m_S^2 S + \lambda_S S^3 - \tilde{\mu}\Phi = 0.$$

This system allows for three types of solutions:

1. **A trivial vacuum**: $\Phi = 0, S = 0$. Hessian:

$$H = \begin{pmatrix} m_\Phi^2 & -\tilde{\mu} \\ -\tilde{\mu} & m_S^2 \end{pmatrix}.$$

Stability (local minimum) requires both eigenvalues to be positive: $\lambda_\pm = \frac{m_\Phi^2 + m_S^2}{2} \pm \sqrt{\left(\frac{m_\Phi^2 - m_S^2}{2}\right)^2 + \tilde{\mu}^2} > 0$. This holds if$m_\Phi^2\mathit{\Phi}2 > 0, m_S^{S2} > 0$, and$\tilde{\mu}^2 < m_\Phi^2 m_{\Phi 2\, m}^{S2}$(the condition that there is no tachyon in the mixed sector). Otherwise, the trivial vacuum is a saddle or local maximum.

2. **Symmetric vacuum** with nonzero$\Phi$and$S$of the same sign (the fields are proportional). We are looking for a solution in the form$S = \alpha\Phi$. Substitution gives:

$$m_\Phi^2 + g\Phi^2 - \tilde{\mu}\alpha = 0,$$
$$m_S^2\alpha + \lambda_S\alpha^3\Phi^2 - \tilde{\mu} = 0.$$

Исключая Excluding$^2\Phi 2$, we can findα. For$\tilde{\mu}m > 0$and$m_\Phi^2, m_S^2$of different signs, spontaneous symmetry breaking is possible.

3. **A single-component-dominated vacuum**: if$\tilde{\mu}$is small, then a minimum close to$\Phi \approx \pm\sqrt{-m_\Phi^2/g}$is possible (if$m_\Phi^2 < 0$), and$S \approx (\tilde{\mu}/m_S^{S2})\Phi$and vice versa.

Stability criterion: the quadratic form at the minimum must be positively defined. Also, the potential must not have deeper minima with negative energy, otherwise the vacuum can tunnel.

3. Influence of the AU field condensate

If the mean$\bar{A} = \langle A_0 \rangle \neq 0$(for example, in cosmology), an additional term$appears - \gamma \bar{A}^{A2} S$.It shifts the minimum by$S$:

$$\frac{\partial V}{\partial S} = m_S^2 S + \lambda_S S^3 - \tilde{\mu}\Phi - \gamma \bar{A}^2 = 0.$$

For$a\ l\bar{a}rge^{A2}$, the field$S$receives a linear source, which can inducea **phase transition of the first kind**: a jump in the mean$\langle S \rangle$with a change$\iota n^{-} A$.This is similar to the effect of dark energy's reverse reaction to entropy: the larger$\bar{A}$(i.e., the AU field density), the stronger the entropy of thought forms shifts.

---

4. Effective potential at finite temperature and entropy

In the early universe or in the presence of strong entropic fluxes (for example, in the biosphere), the potential is modified by thermal contributions. Standard method: add the contribution$Vt_T = \frac{\pi^2}{90} g_* T^4$(for radiation) and temperature masses$\sim T^2$for scalars. In the AU theory**, the macroscopic entropy**S_Θ(not the microscopic temperature) plays a special role. According to the file "Mathematical Model of entropy s_Θ", it is directly included in the potential as an order parameter. We can interpret$S_\Theta$as the effective temperature of the information field.

Entropy-induced phase transition: increasingS_Θ (chaos, an increase in the number of thought forms) changes the sign of the effective massΦthrough the term$-\mu \Phi S_\Theta$. When$S_\Theta > S_c = m_\Phi^2/\mu$, the field Φ becomes tachyonic, and a **spontaneous symmetry breaking** occurs$-\ condensation$ $\langle\rangle\Phi 00$ occurs. This condensate, in turn, changes the rate of expansion of the Universe (viaΛ_{eff}). This scenario is described in the works "Entropic cascade of the collapse of civilization": the growth of global entropyδleads to instability, which accelerates the collapse.

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5. Types of phase transitions in AU theory

Order parameter	Control parameter	Transition type	Cosmological / physical manifestation
$\langle \Phi\Phi\ \Phi \rangle$	S_Θ(entropy of thought forms)	Second kind (continuous) or first kind (if there are cubic terms)	The emergence of "consciousness" as a condensate, the transition from a lifeless universe to a habitable
$one\langle S_\Theta \rangle$	$\bar{A}^2$(dark energy density)	First kind (jump)	"Awakening" of planetary consciousness, a sharp change in the rate of expansion

Order parameter	Control parameter	Transition type	Cosmological / physical manifestation
$\langle A A_{\mu \rangle} \rangle$	Temperature $/S_\Theta$	Possible transition to the superconducting phase (massive AU photon)	Shielding of AU charges, modification of the interstellar medium

During a first-order phase transition, bubbles of a new phase appear. In cosmology, this could lead to the formation of domains with different values$\Lambda_{\text{of eff}}$, which is observed as a large-scale structure or as variations of the Hubble constant.

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6. Vacuum stability in quantum theory (tunneling)

Even if the classical minimum is locally stable, there may be a deeper minimum separated by a potential barrier. Quantum tunneling through the barrier leads to the decay of the false vacuum. In the AU theory, the decay of a false vacuum can be caused by an increase in the entropyS_Θ(as an external parameter), which is analogous **to a catastrophic phase transition**– "entropic collapse".

Estimating the tunneling probability (in the thin-wall approximation) gives an exponentially small amplitude for barriers well above quantum fluctuations. However, in the presence of non-local correlations (the Chern-Simons term), it is possible to accelerate the decay due to topological effects.

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7. Application to the "Entropic Collapse" hypothesis (LA VIVANTA UNIVERSO)

The 2026 files describe **the AU cascade**, a sequence of phase transitions in the collective consciousness and biosphere leading to civilizational collapse. From the point of view of quantum field theory, this scenario can be interpreted as:

1. **Beginning**: The universe is in a metastable vacuum with small$\langle \Phi\Phi\ \Phi \rangle$(weak consciousness) and smallS_Θ.
2. **The growth of entropy** (via demographic, technological, and environmental factors) increasesS_Θ.
3. When the critical value is reached$The\ S_{\text{crit}}$fieldΦloses stability –**a first-order phase transition occurs**: $\langle \Phi \rangle$increases abruptly, which dramatically increasesΛ_{eff}(dark energy) and accelerates the expansion. At the macro level, this manifests itself as climate and social catastrophes.
4. **The formation of new " arks "**(stable regions) is possible if locally$S_\Theta$remains below the threshold.

Thus, the stability of the vacuum in the AU theory is directly related to global entropy-this makes the theory testable through measurements of cosmological parameters and monitoring of the biosphere.

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8. Conclusion and open questions

What we installed:

- The classical scalar potential of the AU theory can have several vacuums (symmetric, broken, mixed).
- The stability of a trivial vacuum requires$m\ \Phi 2^2_\Phi > 0, m^2_{S2} > 0, \widetilde{\mu\ 2}^2 < m^2_\Phi m^{S2}_{\Phi 2\ m}$.
- The AU-field condensate$\langle A_{A0} \rangle$induces a term linear in$S_\Theta$that can cause a first-order phase transition.
- The growth of the global entropy$S_\Theta$acts as a control parameter; when the threshold$S_c$is exceeded, the fieldΦbecomes tachyonic – a spontaneous symmetry breaking occurs, leading to an acceleration of the expansion of the Universe ("entropic collapse").
- Quantum tunneling between vacuums can be accelerated by nonlocal correlations of the AU field.

What remains for further research:

- Calculation of the effective potential taking into account one-loop corrections (eigenenergy ΦandS_Θ).
- Determination of the parameters$of\ \lambda_S$(the quaternary termS^4_Θ) using renormalization group theory.
- Modeling of the phase transition in an expanding universe (taking into account the Hubble effect).
- Quantitative relationship betweenδ(entropy gain from a social file) and the critical valueS_c.
- Experimental verification: search for anomalies in cosmological data (DESI, Euclid, JWST) indicating a changein Λ_{eff}as a function of redshift.

One-loop effective potential for AU scalars (Coleman-Weinberg method) / Phase diagram in coordinates (m^2_Φ, S) / Estimation of the lifetime of a metastable vacuum

1. Single-loop effective potential for AU scalars (Coleman-Weinberg method)

Consider the action for two scalar fields$\Phi$and$S$(notation$S$instead$of\ S_\Theta$) in Euclidean space:

$$S_E = \int d^4x_E \left[\frac{1}{2}(\partial\Phi)^2 + \frac{1}{2}(\partial S)^2 + V(\Phi, S)\right],$$
$$V(\Phi, S) = \frac{1}{2}m^2_\Phi \Phi^2 + \frac{1}{2}m^2_S S^2 + \frac{g}{4}\Phi^4 + \frac{\lambda_S}{4}S^4 - \tilde{\mu}\,\Phi S,$$

where$\tilde{\mu} = \mu + \zeta$ (taken from the original Lagrangians). For generality, we have added the quarterary term $\frac{\Lambda S4S4_S}{4}S^4$, which is necessary for the potential to be bounded from below.

We calculate the single-loop effective potential in the $\overline{\text{MS}}$ scheme(dimensional regularization,$Mkr\ scale_R$). For a theory with multiple scalar fields, the Coleman-Weinberg formula is:

$$V_{\text{1-loop}}(\Phi, S) = \frac{1}{64\pi^2} \text{Str} \left[\mathcal{M}^4(\Phi, S) \left(\ln \frac{\mathcal{M}^2(\Phi, S)}{\mu_R^2} - \frac{3}{2} \right) \right],$$

where$\mathcal{M}^2$is the matrix of second derivatives of the potential with respect to fields, taken on the background valuesΦ, S.For two fields, this$is\ a\ 2x2$matrix.

Matrix of second derivatives:

$$\frac{\partial^2 V}{\partial \Phi^2} = m_\Phi^2 + 3g\Phi^2, \frac{\partial^2 V}{\partial S^2} = m_S^2 + 3\lambda_S S^2, \frac{\partial^2 V}{\partial \Phi\, \partial S} = -\tilde{\mu}.$$

Therefore,

$$\mathcal{M}^2 = \begin{pmatrix} m_\Phi^2 + 3g\Phi^2 & -\tilde{\mu} \\ -\tilde{\mu} & m_S^2 + 3\lambda_S S^2 \end{pmatrix}.$$

Eigenvalues ($\lambda_\pm$):

$$\lambda_\pm = \frac{1}{2} \left[A + B \pm \sqrt{(A-B)^2 + 4\tilde{\mu}^2} \right],$$

where$A = m_\Phi^2 + 3g\Phi^2, B = m_S^2 + 3\lambda_S S^2$.

Then **the full one-loop effective potential**is:

$$\boxed{V_{\text{eff}}(\Phi, S) = V_{\text{tree}}(\Phi, S) + \frac{1}{64\pi^2} \left[\lambda_+^2 \square \left(\ln \frac{\lambda_+}{\mu_R^2} - \frac{3}{2} \right) + \lambda_-^2 \square \left(\ln \frac{\lambda_-}{\mu_R^2} - \frac{3}{2} \right) \right]}.$$

Note: the formula takes into account the factor$1/2/2$for real scalars (the statistical factor$1/2/2$for a loop with a scalar field). The " – " sign for bosons? Standard contribution: $\frac{1}{64\pi^2} M^4 (\ln\ M^2/\mu_R^{2-3} - 3/2)$for a single scalar. Here are two scalars, and we sum.

---

2. Phase diagram in coordinates$(\boldsymbol{m_\Phi^2}, \boldsymbol{S})$

We construct a tree phase diagram by considering$S$as an external control parameter (macroscopic entropy). Potential for the field$\Phi$for a fixed$S$:

$$V_\Phi(\Phi; S) = \frac{1}{2} m_\Phi^2 \Phi^2 + \frac{g}{4} \Phi^4 - \tilde{\mu} S \Phi + \text{const}(S).$$

The minimum equation:

$$m_\Phi^2 \Phi + g\Phi^3 - \tilde{\mu} S = 0.$$

The phase transition between$\langle \phi аз\ \Phi \rangle = 0and\langle \Phi \rangle \neq 0$occurs when the depth of the minima is compared. Let's consider separate areas.

2.1. Trivial minimum $\mathbf{\Phi = 0}$

It always exists. His energy: $V_{V0} = \frac{1}{2} m_S^2 S^2 + \frac{\lambda_S}{4} S^4$(ignoring the term $\frac{1}{2} m_\Phi^2 \cdot 0$).

2.2. Non-trivial minima

If $m_\Phi^2 > 0$ and S is small, there is one root $\Phi \approx \frac{\tilde{\mu} S}{m_\Phi^2}$. It is not a minimum if the second derivative is positive, but if g is small, then it is just a shift. As $S\ increases$, a second minimum (barrier) may occur. For $m_\Phi^2 < 0$(tachyon), even at $S = 0$, there are two degenerate minima $\Phi = \pm\sqrt{-m_\Phi^2/g}$ and a maximum at $\Phi = 0$. Inclusion of the linear term removes the degeneracy.

The condition **for the co-existence of two phases** (transition of the first kind) is found from the equality of pressures: $V_\Phi(\Phi_{\text{min1}};\ S) = V_\Phi(\Phi_{\text{min2}};\ S)$. For simplicity, consider the case $m_S^2 \gg 1$,λ_S is small, so that S does not fluctuate. We restrict ourselves to the situation when the minimum $\Phi = 0$ and the nonzero minimum have the same energy.

Solving $V(\Phi_{\Phi 0}) = V(0)$ taking into account the minimum condition, we obtain the critical value $of\ S_c$. For $m_\Phi^2 > 0$ and $g\tilde{\mu} > 0$, it can be shown (see the literature on Landau theory with a linear term) that a transition of the first kind occurs when

$$S_c = \frac{2}{3\sqrt{3}} \frac{m_\Phi^3}{g^{1/2}\tilde{\mu}}.$$

For $m_\Phi^2 < 0$, the transition can be of the second kind for small S..

Let's construct a qualitative phase diagram in coordinates $\left(m_\Phi^2, S.\right)$.

- Region I (small S,m_Φ^2 is positive): minimum $\Phi = 0$ is stable, phase is symmetric.
- Region II (large S or negative m_Φ^2): $\langle\Phi\rangle \neq 0$, the symmetry is broken.
- Phase transition line: for $m_\Phi^2 > 0$– curve $S_c(m_\Phi^2)$, for $m_\Phi^2 < 0$-boundary $S = 0$, where a continuous transition occurs.

Sample chart view (description):

text

S

↑

/ II (broken)

| /

| /

| / transition line of the 1st kind

| /   (S_c ~ m_Φ^3)

| /

| /

| / I (symmetric phase)

|/_________________→ m_Φ^2

0 (negative → positive)

---

3. Estimation of the lifetime of a metastable vacuum

Consider a scenario where, for a fixed$S$, there are two minima: a local (false) vacuum and a global (true) vacuum. The transition occurs through the nucleation of true vacuum bubbles. In 4D Euclidean space, the probability of decay per unit volume per unit time is:

$$\Gamma = \frac{1}{R_0^4}\, e^{-B},$$

where$B = S_E[\text{bounce}]$is the action for the instanton (bubble). For a thin-walled bubble (the energy difference$\Delta\varDelta v$is small compared to the barrier height), we have:

$$B = \frac{27\pi^2}{2}\frac{\sigma^4}{\Delta V^3},$$

where$\sigma$is the surface tension of the wall,$\sigma \approx \int d\Phi\sqrt{2(V(\Phi) - V_{\text{false}})}$. In a model with a single field$\Phi$and a potential$V(\Phi) = \frac{1}{2}m^2\Phi^2 + \frac{g}{4}\Phi^4 + \epsilon\Phi$(small linear perturbation), analytical estimates can be obtained.

For AU scalars, we take the characteristic parameters from the cosmological context: masses of the order of the modern Hubble scale$H_0 \sim 10 - 33^{-33}$eV, or Planck$M_P \sim 10^{10-19}$GeV. Depending on the scale at which the phase transition occurs,Bcan be huge or small.

Approximate formula for$B$in the case when the potential has the form$V(\phi) = \frac{\lambda}{4}(\phi^2 - v^2 v2)^2 + \epsilon\phi$ (small asymmetric term). For the standard model of the axion potential $B \sim \frac{v^4}{\Delta V.}If\Delta\varDelta v \;\sim\; \epsilon v$, then$B \;\sim\; v^3/\epsilon$. For the AU theory, we identify$v\Phi\varPhi\ \varPhi\rangle$,$\epsilon \;\sim \tilde{\mu}S.$.

Numerical estimation(phenomenological): let$m_\Phi \sim H_0 \sim 10 - 33^{-33}$eV,$g \sim 1$(strong coupling), then$v \sim \sqrt{-m_\Phi^2/g} \sim 10 - 33^{-33}$eV. For$S\ of\ the$order of the dark energy density (eV ^{4}),$\tilde{\mu}Ms \sim 10 - 64^{-64}$eV ^{4}? This results in a very small energy difference, and$B$ is colossal (stable vacuum). If the scale of new interactions is Planckian,$v \sim M_P$, then$B \sim (M_P/\tilde{\mu}S)^3$. For a vacuum to be unstable over the lifetime of the universe ($\sim 10^{10-10}$years), you need$B$ $400\ 400$. This would$r\widetilde{equire}Ms \sim 0.1Mp4_P^4$, i.e. the entropy term is comparable to the Planck density – which is unrealistic for the modern universe. Thus, **in the modern era, the AU vacuum is practically stable**.

However, in the early universe or in processes with high energies (for example, near black holes), rapid decay can occur. In particular, the "entropic collapse" scenario assumes that when$S > S_c$is reached, the potential barrier disappears and the transition occurs without tunneling – this is a second-order phase transition or spinodal decay.

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4. Final formulas and conclusions

1. **The one-loop effective potential** for AU scalars is given by the expression above. It can be used to find radiation-induced corrections to masses and coupling constants.

2. **The phase diagram** in coordinates (m_Φ^2, S) shows the region of existence of the phase with $\langle\Phi\rangle = 0$ and the disturbed phase. The transition is a first-order phase transition at $m_\Phi^2 \Phi 2 > 0$ and a second-order phase transition at $m_\Phi^2 \Phi 2 < 0$ (if we ignore quantum effects). A transition line of the first kind is defined by the equation:

$$S_c(m_\Phi^2) = \frac{2}{3\sqrt{3}} \frac{m_\Phi^3}{g^{1/2}\tilde{\mu}}, m_\Phi^2 > 0.$$

3. **The lifetime of a metastable vacuum** depends exponentially on the action of bounce B. In most reasonable cosmological scenarios, $B \gg 1$, therefore, the vacuum is stable for times comparable to the age of the universe. Only if the entropy term $\widetilde{\mu s}S$ becomes of the order $of\ m_\Phi^4$ (i.e., close to the critical point), the barrier disappears and the vacuum decays without tunneling – this corresponds to spinodal decay.

Thus, the Acta Universi hypothesis allows both stable vacuum states and the possibility of catastrophic phase transitions when the critical entropy S_c is reached. This provides a theoretical basis for the "entropy cascade" described earlier.

Quantitative relationship between the annual increase in entropy δ and the critical value $\boldsymbol{S_c}$

1. Initial ratios

In Acta Universi phenomenology, the global entropy of thought forms S_Θ evolves as (file "Possible scenarios of global decrease in δ..."):

$$\frac{dS_\Theta}{dt} = \delta(t)\, S_\Theta,$$

where $\delta(t)$ is the annual relative growth (in%). In the simplest model, $\delta =$ const, then

$$S_\Theta(t) = S_\Theta^0\ e^{\delta t}.$$

Here S_Θ^0 is the entropy value at the initial moment (for example, the beginning of 2026), $and\ t$ is measured in years.

The critical value S_c is the threshold beyond which the field of consciousness Φ loses stability (a phase transition of the first kind), and an "entropic cascade" is triggered – accelerated expansion of the universe, climate and social catastrophes.

2. Expression of $\boldsymbol{S_c}$ in terms of microscopic parameters of the AU theory

From the analysis of the effective potential for the field Φ (for a fixed S_Θ):

$$V(\Phi;S) = \frac{1}{2}m_{\Phi}^2\Phi^2 + \frac{g}{4}\Phi^4 - \tilde{\mu}\,\Phi S, \tilde{\mu} = \mu + \zeta,$$

We obtained a condition for the coexistence of two minima (symmetric $\Phi = 0$ and broken $\Phi \neq 0$) –**the first-order phase transition point**:

$$S_c = \frac{2}{3\sqrt{3}}\;\frac{m_{\Phi}^3}{\sqrt{g}\,\tilde{\mu}}. \qquad (1)$$

(Here we assume$m_{\Phi}^2 > 0$; if$m_{\Phi}^{2\; is\; negative}$, the second kind of transition occurs at$S = 0$.)

3. Time to reach the threshold

The threshold$S_c$will be reached at timet_c, determined from

$$S_{\Theta}^0\, e^{\delta t_c} = S_c \Rightarrow t_c = \frac{1}{\delta}\ln\frac{S_c}{S_{\Theta}^0}. \qquad (2)$$

If the cascade is required to start in$[the\ interval\ _{t1}, t_{-\ t2}]$(for example, 2026-2028), then it is necessary that for some$t_c tc \in [t1_1, t2_2]$(2) is fulfilled. For the given$S_{sc\ and\ S}S_{\Theta}^0$, this imposes a condition onδ:

$$\delta \geq \frac{1}{t_2 - t_1}\text{t1}\ln\frac{S_c}{S_{\Theta}^0}\,(\text{if } S_c > S_{\Theta}^{0\;0}).$$

Conversely, knowing the observed$\delta$and time, we can estimate how$much\ S_c$exceeds the current value:

$$\frac{S_c}{S_{\Theta}^0} = e^{\delta t_c}.$$

4. Interpretation of values from a social file

The file "Possible scenarios..." contains:

- The current level$of\ \delta$in 2026 is ≈ 1.5-2.5 % per annum.
- Target reduction to 0.5–1.0% per annum by 2028.
- Critical Window – 2026-2028

It follows from this that, according to their model, the initial entropy$S_{\Theta}^0$is already very close to the thresholdS_c. Indeed, if$S_c$were significantly larger, it would take a giant δ to reach the threshold in 2 yearsδ(for example, when$S_c/S_{\Theta}^0 = 10, \delta = \ln\ 10/2/\approx 1.15$= 115 % per annum, not 2%). So, in this scenario:

$$\frac{S_c}{S_{\Theta}^0} = e^{\delta t_c}tc \approx e^{0.02\cdot 1} \approx 1.02\text{and}e^{0.025\cdot 2} \approx 1.05.$$

That is**, the critical entropy exceeds the current one by only 2-5 %**. Therefore, even a small increase$in\ \delta$leads to a transition over the threshold within 1-2 years.

5. Quantitative expression of the relation $\boldsymbol{\delta}$ and $\boldsymbol{S_c/S_\Theta^0}$

From (2) we obtain the universal relation:

$$\boxed{\delta = \frac{1}{\Delta t} \ln \frac{S_c}{S_\Theta^0}},$$

where$\Delta\delta t$is the characteristic time (in years) that the transition is expected to take (for example,$\Delta\delta t =$ 1year for 2026→2027, or 2 years for 2026→2028). If$\delta$is measured in year $^{-1}$, then we substitute a numerical value (for example, 0.02 for 2 %).

Inverse formula: required relative threshold exceedance for a given δ:

$$\frac{S_c}{S_\Theta^0} = e^{\delta\,\Delta t}.$$

6. Evaluation of model parameters based on social data

Assuming that the current entropy S_Θ^0 is already ~97-98 % of S_c, we can estimate the mass / bond ratio in (1). LetS_Θ^0be known (for example, from the estimate of the human component: $S_\Theta^0 \approx 10^{30}$bits/s-see the file " Mathematical Model..."). Then

$$\frac{m_\Phi^3}{\sqrt{g}\,\tilde{\mu}} \approx \frac{3\sqrt{3}}{2}\,S_c \approx 2.6\ S_c \approx 2.6\,S_\Theta^0\,e^{\delta\Delta t}.$$

Substituting $S_\Theta^0 = 10^{30}$bps,$\delta = 0.02$,$\Delta t = 1$, we get $S_c \approx 1.02 \cdot 10^{30}$bps, and, therefore, the combination of parameters:

$$\frac{m_\Phi^3}{\sqrt{g}\,\tilde{\mu}} \approx 2.65 \cdot 10^{30}\ \text{bps}..$$

Conversion to energy units requires knowledge of the effective temperature of the AU field (via the Landauer principle$E = k_B T$Kbt $\ln\ 2$per bit). If we assume$T_{\text{AU}} \sim$ 2.7K (relic radiation), then one bit corresponds$to\ \sim 10 - 22^{-22}$joules. This gives$S_c \sim 10^8$J / s, which is too small. It is more realistic to assume that the entropy$S_\Theta$in theory is a dimensionless quantity (as is usual in information). Then$m_\Phi$and$\tilde{\mu}$must be expressed in the same units. However, quantitative predictive power requires calibration based on observed cosmological data (for example, the rate of change$\Lambda_{\text{of eff}}$).

7. Conclusion

- **Key relationship**:$\delta = \frac{1}{\Delta\delta t} \ln \frac{S_c}{S_\Theta^0}$.
- For the 2026-2028 scenario, the file shows that$S_c$exceeds$S_\Theta^0$by only 2-5 % (at$\delta \approx$ 1.5-2.5 % / year).
- To prevent an "entropy cascade", it is necessary to keepδbelow the value$\delta_{\text{crit}} = \frac{1}{\Delta\delta t} \ln{(1 + \varepsilon)}$, where$\varepsilon$is the margin to the threshold. If there is no margin ($\varepsilon \to 0$), then the very fact of any positive$\delta\ is\ critical.$

- The established connection makes it possible, knowing the microscopic parameters of the theory ($m_{\Phi}, g, \tilde{\mu}$) from (1), to calculate the required$\delta_{\text{crit}}$for a given timeΔt, and vice versa-from the observed$\delta$to estimate how close the system is to the phase transition threshold.

Thus, the social parameter$\delta$is directly related to the fundamental constants of the AU field through the evolution of the macroscopic entropyS_{Θ}. This turns the futurological forecast into a verifiable prediction of the theory.

Review of experimental verification of dynamic dark energy

Review of experimental verification of dynamic dark energy

Testing the fundamental AU prediction of **the redshift-dependent** cosmological constant $\Lambda_{\text{eff}}(z)$ is not a speculative exercise. It is in this direction that all observational cosmology is moving today. Moreover, as we will soon see, the most recent data from 2025-2026 already provide **the first statistical hints** that dark energy can indeed be dynamic, and precisely in the redshift range that the AU theory points to as a key one.

DESI: The strongest hint yet on the evolution of dark energy

The second release of data from the DESI (Dark Energy Spectroscopic Instrument) spectroscopic instrument — DR2, published in 2025-2026-provided the most accurate three-dimensional map of the distribution of galaxies to date. DESI scanned the light **of 15 million galaxies** over a record time span of**11 billion years**.

Analysis of these data using baryon acoustic oscillations (BAO) as a "standard ruler" for measuring space distances, I identified the following anomaly:: **The influence of dark energy is about 10% weaker today than in earlier epochs**.

2.1. Parameterization$of\ w_0 w_a$CDM

In modern cosmology, the evolution of dark energy is most often described by two free parameters in the so$w_{-called}w0\ w_a$CDM model, where the equation of state of dark energy has the form:

$$w(a) = w_0 + w_a(1 - a)$$

Here a is the scale factor, w0 is the value of the parameter of the equation of state today (w0=PDE/PDE at z=0), and wa describes the rate of its evolution.a — масштабный фактор, w_0 — значение параметра уравнения состояния сегодня ($w_0 = p_{\text{DE}}/\rho_{\text{DE}}$ при $z = 0$), а w_a описывает скорость его эволюции.

2.2. Unusual behavior of the best DESI models

A study by Matilde Abreu and Michael Turner (2026) showed that the best-described DESI models in the $w_0 w0\ w_a$CDM framework behave in an**unusual and mysterious way**: they reach a maximum energy density around the redshift$z \simeq 0.5$and decrease sharply before and after this peak.

The authors **critically reflect on these results**. They show that this behavior does not correspond to any simple physical mechanism for dark energy and can be explained by the limitations$w_{of\ the\ w0wa\ parametrization\ itself}\,w_a$in modeling complex evolution. Moreover, the report emphasizes that**" hints do not yet reach a convincing level for asserting an evolving dark energy**."

2.3. Evidence of dynamic dark Energy: the nature of DESI data

However, if we consider the DESI data **not in isolation, but in combination with data on type Ia supernovae (SNe) and CMB**, the picture becomes more interesting. The combination of DESI, CMB (Planck) and SNe data gives preference to non-zero evolution of the parameter wa_aat the level**of 95% confidence interval**.

There is also **an alternative interpretation**: a group of researchers led by Swagat Mishra demonstrated that the observed behavior of dark energy **naturally occurs** within simple models of a scalar field in a multidimensional space (braneworld framework). In their model, the dark energy equation of state$is\ w\ (z)$ it evolves from phantom ($w < -1$) in the past ($z \approx 0.5$) to quintessence ($w > -1$) in the present — which in itself sounds like evidence of its**evolution**.

So the current situation with DESI data is **"dynamic dark energy on the horizon, but not beyond the event horizon"**. Significance level (2-4σ) not enough to open, but too high to ignore.

Euclid: The Next Observational revolution that will solve the problem

If DESI is a hint, then **the Euclid space Telescope Euclid)** is a tool that should either confirm or refute this hint at a new, much higher level of statistical significance.

Key dates and plans:

- **End of 2026:** The European Space Agency plans to publish **the first major** Euclid dataset covering observations **of approximately 14% of the celestial sphere**.
- **October 2026:** Планируется The next release of Euclid data with **preliminary cosmological results is planned**.

Planned tests under the AU hypothesis

It is with the release of these data that we will be able to conduct **quantitative tests** that will not only confirm or refute the existence of the evolution of dark energy, but also choose between different explanations, including AU.

Below is a summary table of key data types, their status at the beginning of 2026, and the projected role of Euclid:

Data type	Current Status (≈2026)	Contribution of Euclid
Baryon Acoustic Oscillations (BAO)	DESI: ~15 million galaxies, hints of$w(z) evolution$	A huge leap in accuracy and coverage area

Data type	Current Status (≈2026)	Contribution of Euclid
of Gravitational lensing	Mostly ground-based surveys, Euclid is still waiting.	Euclid will detect **>100,000**gravitational lenses, which will map the distribution of dark matter in unprecedented detail.
Clustering	of DESI and eBOSS galaxies.	Provides information about the growth of a large-scale structure that is sensitive to modified gravity and dynamic DE models.

In addition, the Euclid survey is specifically designed to **test modified gravity models** and alternatives to ΛCDM. If Euclid detects significant deviations from ΛCDM, then our **model**$w_0 w0\ w_a$will only become a**phenomenological template**, and the problem of choosing between a finite number of microscopic theories that could give rise to it will arise.

JWST: Key to large redshifts ($z > 10$)

Although JWST is not specifically designed to study dark energy, its data reveals **the most distant past** The universe is exactly the area where AU predictions can be most pronounced.

4.1. The mystery of massive galaxies in the early Universe

JWST data for 2025 revealed a significant population of massive galaxies at redshifts up to$z$ 12 12, which contradicted expectations based on previous surveys and**challenges the ΛCDM**.

4.2. Interpretation in favorof $\Lambda_{\mathrm{eff}}(z)$

Interpreted as a cosmological problem, this anomaly may mean that the Planck collaboration underestimated either the matter density wm_mor the physical matter density$\Omega_m h^{wm\ h2}$at large redshifts. In this interpretation, correlated quasar datasets (QSOs) indicate thatwm_mincreases with the effective redshiftz_{zeff}, remaining abnormally large at large redshifts.

Synthesis and communication with Acta Universi

Thus, by the beginning of 2026, we have **a mosaic of three fragments**:

1. **DESI** (in combination with other data) provides a statistical "candidate signal" for the evolution of dark energy ($wa_a \neq 0$) with a significance level not sufficient for discovery.
2. **Euclid** should either confirm this signal with high significance, or show that it was just a fluctuation in the DESI data.
3. **JWST** indicates that even in the most proven models of structure formation, there are inconsistencies at extremely high redshifts.

To test the Acta Universi hypothesis, the following plan will be proposed. This plan offers a program of actions that will make AU predictions verifiable:

1. **Cosmological analysis (2026-2027)**

- Extract Euclid **an independent**$w(z)$ *reconstruction from the Euclid data.*
- If the evolution of dark energy is detected, measure its parameters: $w_0$andw_a.
- Check whetherΛ reaches$_{\text{eff}}(z)$ the maximum in a certain$z$ *range*, and whether it coincides with the AU predictions.
- Perform a similar analysis for the JWST data: plot the dark matter halo mass function at$z > 10$and compare it with the predictions.

2. **Model calibration** (after Euclid data is released)

   - If evolution is detected, adjust the model parameters$(g, \tilde{\mu}, m_\Phi^2, \ldots)$from the formula

$$S_c = \frac{2}{3\sqrt{3}} \frac{m_\Phi^3}{\sqrt{g\tilde{\mu}}} \Leftrightarrow \Lambda_{\text{eff}}(z) = f(S_\Theta, m_\Phi, g, \tilde{\mu}, \ldots)$$

so that the theoretical curve$\Lambda_{\text{eff}}(z)$ best described the observational data.

   - Check whether the fitted model provides **physically reasonable** values for its parameters.

3. **Forecast and new tests**

   - Using a calibrated model, you can make a quantitative forecast for future, even more accurate observations (for example, **the Vera Rubin Observatory)**).
   - This will allow us to introduce AU into the framework **of standard scientific methodology**, where the theory is evaluated by its ability to make verifiable predictions.

Thus, the AU hypothesis is in an ideal position to either receive **strong observational confirmation** within the next 2-3 years, or to be **definitively refuted** in the part of it that concerns cosmological dynamics. If the Euclid data unambiguously confirms ΛCDM ($w = -1, w_a wa = 0$), then the basic AU mechanism (the relation$\Lambda_{\text{of }\lambda\text{eff}}$with entropy$S_\Theta$) will face a very serious challenge. A more interesting and likely scenario is the detection of evolution, which then requires a detailed comparison of the AU predictions with those of other competing theories (String/Braneworld, Modified Gravity, etc.).

Mathematical apparatus of the mechanism of thought forms

1. The mathematical nature of thought forms in AU

In the Acta Universi hypothesis, thought forms are **quantum information structures** that arise in the AU field and are described as coherent states of the field of consciousness$\Phi(x)$with the addition of non-local correlations. They have their own entropy$S_{\text{tf}}$and can be recorded in the AU-log-a global archive of events.

Basic postulates:

1. **Thought form = excitation of the field Φ above a certain threshold** (conscious thought, intention, image).

2. Each thought form is characterized by:

   - **Probability distribution in 27 modalities** (according to the Pereslegin classification: Being, Non-being, Non-being, each with 9 subtypes).
   - **With proper entropy**$S_{\text{tf}} = -p_{pi}\ln\ p\ _{pi} + S_{\text{cog}}$(coherent additive).
   - **Non-local correlation radius**$r_{\text{corr}} \sim 1/m_{\text{AU}}$, where$m_{\text{AU}}$is the effective mass of the AU field (it can be very small, allowing long-range action).

3. Thought forms interact with the AU field via the term$\lambda\Phi\epsilon\,\partial A\,\partial A$and with the metric via$C_{\mu\nu}\,\partial^{\mu}\Phi\,\partial^{\partial}\text{v}\,\Phi$.

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2. Quantum field description

2.1. The field of consciousness$\boldsymbol{\Phi(x)}$

$\Phi(x)$ — real scalar field, Lagrangian:

$$\mathcal{L}_{\Phi} = \frac{1}{2}(\partial\Phi)^2 - V(\Phi) + \lambda\Phi\,\epsilon^{\mu\nu\rho\sigma}\,\partial_{\mu}A_{\nu}\,\partial_{\rho}A_{\sigma} + \beta_3 C_{\mu\nu}\,\partial^{\mu}\Phi\,\partial^{\nu}\Phi.$$

Potential$V\ (\Phi)$ It includes the mass term, the quarteric relation, and the linear relation with the macroscopic entropy S_{Θ}:

$$V(\Phi) = \frac{m_{\Phi}^2}{2}\Phi^2 + \frac{g}{4}\Phi^4 - \mu\Phi S_{\Theta}.$$

The stationary equation for Φin the presence of a source$S_{\Theta}$and a background AU field gives several vacuums corresponding to different levels of"conscious activity".

2.2. Condensate of thoughtforms

The collective state of many thought forms is described as**конденсат**a condensate $\langle\rangle\Phi 0\ 0$, which occurs spontaneously at$S_{\Theta} > S_c$. Fluctuations above the condensate are separate thought forms.

In the approximation of weak fluctuations$\Phi = \langle\Phi\rangle + \varphi$, the quadratic Lagrangian forφgives an effective mass$m_{\text{TF}} = \sqrt{3g\langle\Phi\rangle^2 + m_{\Phi}^2 - \tilde{\mu}S_{\Theta}/\langle\Phi\rangle}$(including the contribution fromS_{Θ}).

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3. Entropy of thought forms:$\boldsymbol{S}_{\text{tf}}$

The file" Mathematical Model of entropy s_Θ " contains a hierarchical formula. For thought forms, the **generalized Shannon information entropy** is used with an additional term that takes into account entanglement with the AU field:

$$S_{\text{th}} = -\sum_{i=1}^{27} p_i \ln\ p_i\ +\ \alpha\,\text{Tr}(\rho_{\text{ent}}\ln\ \rho_{\text{ent}})\ +\ \beta\,\langle\Phi\rangle^2.$$

Here:

- $pi_i$is the probability of the thought form remaining in$the\ i$-th modality (27 variants: 9 × 3).
- $p_{\text{ent}}$is a reduced density matrix that describes the entanglement of a thought form with its environment (AU-field, other thought forms). For two thought formsA, B,entanglement entropy$S_{\text{ent}} = -\text{Tr}(Pa_A \ln\ Pa_A)$.
- $\alpha$is a coefficient that relates quantum entanglement to information entropy.
- $\beta\langle\Phi\rangle^2$-contribution from the condensate energy (the stronger the field, the higher the entropy of ordering? Usually$\beta < 0$to lower the entropy during condensation).

The entropy dynamics of thought forms follows the equation (see the file):

$$\frac{dS_{\text{th}}}{dt} = \sum_i \frac{\partial S_{\text{th}}}{\partial p_i}\dot{p}_i + \alpha\frac{d}{dt}S_{\text{ent}} + 2\beta\langle\Phi\rangle\langle\dot{\Phi}\rangle.$$

$\dot{p}_{pi}$is determined by the "speed of thinking" and external influences (for example, AU chip technologies).

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4. Non-local connection of thought forms: a correlator

The paper "UAP and non- local correlations in the Acta Universi hypothesis" introduces a two-point correlator for the fieldΦ:

$$G(x, y) = \langle\Phi(x)\Phi(y)\rangle - \langle\Phi\rangle^2.$$

In the presence of the Chern-Simonov term$\frac{k}{4\pi}\epsilon AFA$and the term$\lambda\Phi\epsilon\ \partial A\ \partial A$, the correlator acquires non-local components. In the approximation of a slow background change:

$$G(x, y) \approx \frac{e^{-m_{\text{eff}}|x-y|}}{4\pi\ |\ x-y\ |^2} + \frac{\chi}{|\ x-y\ |^2}\sin\left(\frac{k}{2\pi}\ |\ x\ -\ -y\ |\right)\text{(oscillating nonlocal term).}$$

The second part describes **long-range correlations** of thought forms, which can manifest as telepathy, collective unconsciousness, synchronization of thoughts at a distance.

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5. Collective states: a 27-dimensional space of modalities

By analogy with Pereslegin's cognitive codes, each thought form has$\mathbf{p}a\ vector\ p =$ $(_{p1}, \ldots, p27_{27})$satisfying$\sum p_i pi = 1$. **The phase space** is a simplex$\Delta 26_{26}$. The microscopic dynamics$pi_i(t)$is given by an analog of the Landau-Lifshitz equation for the probability density:

$$\frac{dp_i}{dt} = \sum_j \gamma_{ij}\,p_j + \sum_{j,k}\eta_{ijk}\,p_j p_k + \xi_i(t) + \int d^4x\,K_i(x)\,\Phi(x),$$

where:

- $\gamma_{ij}$is a matrix of transitions between modalities (for example, from fear to anger or gratitude).
- n_{ijk}— nonlinear interaction (cognitive distortion, increased polarization),

- $\xi_i(t)$— white noise (entropy source),
- The last term is the influence of the global field of consciousnessΦ.

Entropy of a collective of thought forms= average Shannon entropy over an ensemble of individuals plus the entropy of correlations.

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6. Recording thought forms in the AU-log (jump operators)

The file "Hamiltonian AU" introduces jump operators$\hat{f}_i$at moments$t_i$ti, which quantum describe the irreversible recording of a thought form in the global archive. Matrix element:

$$\langle \text{final} \mid \hat{f}_i \mid \text{initial} \rangle \propto \int d^3x \, \Psi_{\text{tf}}(x) \; \Phi(x) \; \rho_{\text{AU}}(x) (\text{typical structure}).$$

Conservation of energy-information: $\Delta\Delta e_{\text{system}} = -\Delta\Delta e \, AU_{\text{AU}}$.
The action$\widehat{of \ f\iota}_i$on the state of the thought form can change$the\ probabilities\ _{pi}$and increase the global entropyS_{Θ}.

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7. Predictions tested experimentally

1. **Корреляции Biophoton correlations** – in experiments with raster biophoton systems, a non-local correlation is predicted at a rate $\gtrsim of \ \sim^{10.7} s$(not yet observed, but can be explained by a small cross-section). This can be checked in advanced installations.
2. **Influence of collective meditations** on the parameterS_{Θ}-measure the change in entropy through the analysis of big data of social networks and geomagnetic fluctuations.
3. **The effect of a decrease**$in\ \delta$during a mass switch to Being is a verifiable futurological scenario.
4. **AU chips** (quantum chips based on the fractional quantum Hall effect) – must register and modulate thought forms, which is a direct engineering application.

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8. Conclusion

The mathematical apparatus of thought forms in AU theory includes:

- A field$\Phi$with a Lagrangian that provides condensation of consciousness;
- Probability space of 27 modalities with nonlinear dynamics;
- Non-local correlators due to the Chern-Simonov interaction;
- EntropyS_{tf}as a measure of the chaos/order of collective thought forms;
- Jump operators$\hat{f}_i$for writing to the AU log.

This construction allows making specific predictions (correlations, entropy evolution, effects on dark energy) and can in principle be tested both in laboratory (biophotonics, quantum chips) and in cosmological experiments.

Numerical estimation of AU-effects for laboratory experiments

To estimate the laboratory manifestations of the AU field, it is necessary to choose **a realistic range** of theory parameters that does not contradict existing experimental limitations, but still allows for unique predictions.
We will start with expressions for the main effects, then substitute the characteristic numerical values, and finally compare them with the achievable sensitivity of modern experiments.

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1. Key parameters of the AU model that determine laboratory effects

From the Lagrangian, we select the main constants available for laboratory measurement:

Parameter	Designation	Dimension	Physical meaning
AU-charge	e_{AU}	dimensionless (or$1/\sqrt{\text{energy}}$)	electric charge analog for the AU field
Mass of the AU photon	m_A	MeV or eV	if any – determines the long-range
effect Chern-Simons constant	k	dimensionless	topological mass, non-locality
Coupling constantλ	λ	eV^{-1}	coupling of the consciousness fieldΦcA_μ
Constant $\beta 2_2$	$\beta 2_2$	eV^{-2}(inverse mass squared)	relation of the AU field to the energy-momentum tensor of matter → violation of equivalence
Field mass Φ	m_Φ	eV	mass of the consciousness/thought-form quantum
Mixing parameter $\tilde{\mu}$	$\tilde{\mu}$	eV	Relation Φ with S_Θ

Important assumption: for laboratory experiments, we assume that the background values$of\ S_\Theta$and$\langle\Phi\Phi\ \Phi\rangle$are negligible (there is no macroscopic condensate of consciousness in a vacuum). Then the main effects are created**by the exchange of virtual AU photons** and by the **direct interaction of the AU field with matter** through the$\beta_{terms}\beta 2 c_{\mu\nu}\ T^{\mu\nu}_{\text{MAT}}ande_{\text{AU}} EAU\ A_\mu \bar{\psi}\gamma^\mu\psi$.

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2. Fifth force potential (massless AU photon exchange)

If$m_A = 0$(massless AU photon), then a coulomb-like potential occurs between two bodies with AU chargesQ_{Q1}, Q_{Q2}:

$$V_{\text{AU}}(r) = \frac{e_{\text{AU}}^2}{4\pi}\frac{Q_1 Q_2}{r}.$$

Here$Q_i$is the total AU charge of the body, which is proportional to the number of baryons (or, possibly, the number of particles with spin). In the simplest model, an AU charge is assigned to each fermion: $Q = e_{\text{AU}} N_f$, where$N_f$is the number of fermions in the body.

For two macroscopic bodies with mass$M$, the number of nucleons$is\ N \approx M/m_p$. Then the ratio of the AU-force to the gravitational one is:

$$\frac{F_{\text{AU}}}{F_G} = \frac{e_{\text{AU}}^2/(4\pi)}{Gm_p^2} \cdot Q_1 Q_2/(N_1 N_2) \approx \frac{e_{\text{AU}}^2}{4\pi G m_p^2}.$$

Substituting$G = 6.674\ \times 10 - 11^{-11}$m3/(kg * s2),$m_p = 1.673 \times 10 - 27^{-27}$kg, we get$Gm_p^2 = 1.87 \times 10 - 64^{-64}$J·m.

If we put$e_{\text{AU}}^2/(4\pi) \approx \alpha_{\text{AU}}\hbar c$(as in electrodynamics), where$\alpha_{\text{AU}} AU e_{=}^{EAU2}/(4\pi\hbar c)$ - AU is an analog of the fine structure constant, then

$$\frac{F_{\text{AU}}}{F_G} \approx \frac{\alpha_{\text{AU}}\hbar c}{Gm_p^2} \approx \alpha_{\text{AU}} \cdot \frac{1.05 \times 10^{-34} \cdot 3 \times 10^8}{1.87 \times 10^{-64}} = \alpha_{\text{AU}} \cdot 1.68 \times 10^{38}.$$

The huge coefficientmeans that even at$\alpha_{\text{AU}} AAU \sim 10 - 40^{-40}$AU, the force can be comparable to that of gravity. Experiments to test the law of universal gravitation (for example, torsional scales) limit the additional force on scales from mm to km. For a massless carrier, the restriction on$\alpha_{\text{AAU}}$is extremely tight: $\alpha_{\text{AU}} \lesssim 10 - 45^{-45}$(so that the AU-force is no more than 1% of gravity).
Therefore,**laboratory experiments impose an upper limit**:

$$e_{\text{AU}} \lesssim 10 - 22^{-22}(\text{in units } of\ e).$$

You can circumvent this restriction if the AU photon **is massive** – then the force becomes Yukawa and is effectively turned off on scales larger than the Compton wavelength $\lambda_A = \hbar/(m_A c)$. For laboratory distances$r \ll \lambda_A$, the force remains Coulombic, so the mass must be large enough$that\ \lambda_A$is smaller than the characteristic size of the experiments (say,<1mm). Thus,

$$m_A \gtrsim \frac{\hbar}{c\ \cdot\ 1\text{ mm}} \approx\ 2\ \times 10 - 10^{-10}\text{ eV}.$$

Such a mass does not violate cosmological constraints (light bosons are allowed). Thene_{EAU} can be significantly larger, but the force at distances > 1 mm is exponentially suppressed. In the laboratory, this results in the **absence of a fifth force at large distances**, but effects on micron scales are possible.

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3. Violation of the equivalence principle (term $\boldsymbol{\beta 2_2 C_{mv} T^{mv}_{\text{mat}}}$)

Взаимодействие $\beta_2\ C_{In} the^{\mu\nu}_{\text{nonrelativistic limit, the interaction of β2 with}}$mvt and mvt gives an additional contribution to the potential energy of the body, which depends on its composition (for example, the ratio of the number of neutrons to protons, or spin, or internal structure). This leads to**a violation of the universality of free fall** (the equivalence principle).

It is known that experiments such as STEP and MICROSCOPE limit the relative acceleration of bodies of different compositions to the value$of\ n < 10 - 15^{-15}$. Parameterizing:

$$n = \frac{22\ |_{a1} - a2_2\ |}{|\ a_{|\ |a1} + a_{a2}\ |} = \frac{\delta E}{Mc^2} \cdot \frac{\beta_2}{G_N} \cdot \text{ (composition factor)},$$

where$\delta E$is the difference in the binding energy of the nuclei (eV),$and\ M$is the mass (GeV). For two test bodies made of different materials (for example, beryllium and titanium), the numerical factor is about$10 - 4 - 10 - 3^{-4}$–10^{-3}. Hence, we get the constraint:

$$|\ \beta_2 \beta 2\ | \lesssim 10 - 8^{-8}\ \text{eV}^{-2} (\text{or m}^{-2} \text{ in natural units}).$$

A weaker restriction follows from experiments on finding deviations from the inverse square law at small distances (torsional scales, atomic interferometers).: $|\ \beta 2_2\ | \lesssim 10 - 5^{-5}\ \text{eV}^{-2}$on a scale of 100 microns.

Thus, **laboratory experiments already give strong bounds** on $\beta 2_2$. If the AU predictions require significantly large values, the model must provide screening (for example, through the mass of the AU photon).

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4. Chern-Simons effects: rotating the polarization of light

The term$\mathcal{L}_{\text{CS}} = \frac{k}{4\pi} \epsilon^{\mu\nu\rho\sigma} A_\mu F_{\nu\rho} A_\sigma$in the presence of a background field$\langle A_\mu \rangle$(for example, condensate) leads to**birefringence of the vacuum**: the linear polarization of the electromagnetic wave rotates during propagation. The effect is similar to cosmic birefringence, but in the laboratory you can try to create a strong background AU field.

Angle of rotation on the length$L$:

$$\Delta\theta \approx \alpha_{\text{AU}} \cdot k \cdot \frac{\langle A_0 \rangle}{M_{\text{Pl}}} \cdot \frac{L}{\lambda},$$

where$\lambda$is the wavelength of light. For laboratory fields$\langle A_0 \rangle\ \sim 1$ V / m =3 $\times\ 10 - 9^{-9}$ эВ ^{2}ev2 in natural units. Then$\langle A_0 \rangle / M_{\text{Pl}} \sim 10 - 33^{-33}$. Even for$k \sim 1andL/\lambda \sim 10^{106}$(1 m, λ = 1 μm), we get$\Delta\theta\ \sim 10 - 27^{-27}$radians – undetectable.

This means that the Chern-Simon effect in the laboratory **is immeasurably small**, unless the AU scale is close to the electroweak. Or you need **an astrophysical** search.

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5. Interaction of the field of consciousness $\boldsymbol{\Phi}$ with matter (term $\boldsymbol{\lambda\Phi\epsilon\partial A\partial A}$)

In the absence of a background AU field, the vertex$\lambda\Phi\epsilon\,\partial A\,\partial A$gives the process$\Phi \to AA$– the decay of the consciousness field quantum into two AU photons. The scattering cross-section of AU photons on a substance through the exchangeof $\Phi$is of the order:

$$\sigma \sim \frac{\lambda^2}{16\pi} s \text{ (for } s \ll m_\Phi^2\text{)or}\sigma \sim \frac{\lambda^2}{16\pi}\frac{s^2}{m_\Phi^4} \text{(for } s \gg m_\Phi^2\text{)},$$

where$\sqrt{s}$is the energy in the center of mass system. For laboratory AU photons (hypothetical ones), they can be generated, but are difficult to detect. It is more practical to look for anomalous energy losses in particle beams or non-standard matches in calorimeters. Modern searches for" hidden photons " give constraints for the mass$m_A \lesssim 10-5^{-5}$eV and mixing$\chi \lesssim 10-9-10-12^{-9}$–$10^{-12}$. If an AU photon is mixed with an ordinary photon through a term of type$\chi F_{\mu\nu} f^{\mu\nu}$ (not included in our Lagrangian, but possible), then the constraints are strong. Without mixing, the limits are weaker.

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6. Effects expected in the nearest experiments (2026-2030)

Despite the smallness of most of the AU parameters, there **are experiments specifically aimed at finding new weak interactions**:

Experiment	Sensitivity	of the AU effect	Expected limitation				
of LIGO/Virgo/KAGRA (gravitational waves)	$\delta \ln\ h \sim 10-3^{-3}$	modification of the wave dispersion due to the mass of the AU photon	(	m_A	\lesssim 10^{-20}\text{eV}) for d=100 Mpc		
Torsional scales (Eot-Wash, MICROSCOPE)	(	\eta	\lesssim 10^{-15})	equivalence violation	(	\beta_2	\lesssim 10^{-8}\text{ev}^{-2})
Search for axion-like particles	$g_{a\gamma\gamma} \lesssim 10^{-11}$ Ge	interaction $\lambda\Phi F\tilde{F}$	constraint (	\lambda	\lesssim 10^{-7}\		

Experiment	Sensitivity	of the AU effect	Expected limitation	
(ALPS II, IAXO)				\text{GeV}^{-1})
Quantum chips (fractional Hall effect)	ΔR/R ~ 10^{-8}	AU -dependent correction to	$the\ conductivit$ $10-6^{-6}$if the massis $\sim$1 MeV	

Of particular interest are **AU chips based on the fractional quantum Hall effect** (see Yashchenko's preprints 2026). They predict that the AU field can modify the Berry phase of electrons in a two-dimensional electron gas, which leads to a shift in the Hall conductivity by$\delta\sigma_{xy} \sim e_{\text{AU}}^{2}\text{AU}2/\hbar$. Modern accuracy in the fractional quantum Hall effect (10^{-9} of the conduction quantum) makes it possible to detect$e_{\text{AU}} \gtrsim 10^{-5}EAU \gtrsim 10-5\ e$(provided that the effect is not suppressed by the mass of the AU photon). This enables **direct detection** of the AU field in the laboratory.

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7. Summary table of numerical estimates

Effect	Formula (approximation)	Numerical estimation with reasonable parameters	Modern constraint
Fifth force (without mass)	$F_{\text{AU}}/F_G \approx \alpha_{\text{AU}} \cdot 1.7 \times 10^{38}$	$\alpha_{\text{AU}} \sim 10-40^{-40}$gives a force comparable to gravity	$\alpha_{\text{AU}} \lesssim 10-45^{-45}$(strong)
The fifth force (massive	is the same, but$m_A > 1\ \text{mm}^{-1} \approx$	for$m_A = 10-8^{-8}$eV and$r = 10\ \mu$m is an	$\alpha_{\text{AU}} \lesssim 10-10^{-10}$

Effect	Formula (approximation)	Numerical estimation with reasonable parameters	Modern constraint				
carrier, $r\, \lambda\, \lambda$)	$2 \times 10 - 10^{-10}$eV	almost Coulomb force					
Equivalence violation	(	β_2	$\lesssim \eta / (\text{composition factor} \cdot G_N)$)	$n\ 10 - 1510 - 15^{-15}$ → (	β_2	$\lesssim 10^{-8}\text{eV}^{-2}$)	already achieved
The polarization rotation (CS) has already been achieved	$\Delta\theta \sim \alpha_{\text{AU}} k \frac{\langle A\rangle}{M_P} \frac{L}{\lambda}$	$\alpha_{\text{AU}} k \sim 1, \langle A\rangle \sim 1/m \to \Delta\theta \sim 10^{-27}$	undetectable				
AU-chips ($\delta\sigma_{xy}$)	$\delta\sigma_{xy} \sim e_{\text{AU}}^2 / h$	$e_{\text{AU}} = 10^{-5}e \to \delta\sigma/\sigma_K \sim 10^{-10}$	achievable in 2026-2030				

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8. Conclusions for laboratory search

- **The most promising laboratory test** is quantum chips with a fractional Hall effect. They may reach a sensitivity$of\ e_{\text{AU}} \sim 10 - 6 - 10 - 5^{-6}$–$10^{-5}$in the next few years.
- **The restrictions on a massless AU photon are extremely strict** (the force should not exceed 1% of gravity). Therefore, the AU photon should most likely have a mass$m_A \gtrsim 10 - 10^{-10}$ eV, which makes it impossible to observe it in direct laboratory experiments using the fifth force (the

force decreases exponentially on scales > mm). However, at distances of < 10 microns, the effect can be significant – this is a problem for experiments with atomic force microscopes.

- **The equivalence violation** already limits$\beta 2_2 to < 10 - 8^{-8}$ eV^{-2}. If AU predictions require more, the model should provide for screening or lead to other observed effects (for example, spin dependencies).
- **The Chern-Simon rotation of the polarization** in the laboratory is practically zero, unless the AU scale drops to MeV (then$\langle A_{A0} \rangle$can be made large in strong fields).

So, **recommended laboratory experiments:**
(1) Precision measurements of the fractional quantum Hall effect in search of a shift dependent on geometry and spin.
(2) Experiments on gravity at micron distances (Casimir forces, neutron interferometers) to search for the Yukawa contribution from a massive AU photon.
(3) Search for anomalous rotation of the laser beam polarization in a strong magnetic field (analogous to PVLAS) – expand the search area to new pseudoscalar particles, which can be the fieldΦ.