

The Number 137 in Physics: Fine-Structure Constant, Quantum Effects, and the Nuclear Stability Limit in LEDM

V. F. Strohm

Independent Researcher

E-mail: vfnv@mail.ru, vfstrohm@yahoo.de

DOI: <https://doi.org/10.5281/zenodo.23342672>

Abstract

In fundamental physics, the fine-structure constant ($\alpha \approx 1/137.036$) is traditionally introduced as an empirical dimensionless parameter that determines the strength of the electromagnetic interaction. In this paper, within the framework of the Local Energy Deficit Model (LEDM), an analytical derivation of the constant α is presented from the first principles of the mechanics of an isotropic elastic vacuum substrate. It is shown that the inverse quantity α^{-1} represents a fundamental geometric-dynamical invariant of a three-dimensional medium defined by spatial normalization (4π), the number of shear degrees of freedom of the stress deviator ($n_s = 5$), the spectral integral of zero-point fluctuations, and $SU(2)$ spinor topology.

A systematic analysis of physical phenomena associated with the number 137 is carried out, including the electron velocity on the first Bohr orbit, the fine structure of spectra, the convergence of quantum electrodynamics (QED) series, the anomalous magnetic moment of the electron ($g - 2$), and the critical Schwinger limit. On this basis, the physical and mechanical nature of the "running coupling constant" $\alpha(Q^2)$ is revealed as a nonlinear elastic response of the medium (Hooke's law) under strong deformations, and a mechanical-topological solution to the "Feynman paradox" for element 137 of the periodic table is proposed.

Keywords: *fine-structure constant; number 137; Local Energy Deficit Model (LEDM); elastic vacuum substrate; shear degrees of freedom; atomic spectra; quantum electrodynamics; anomalous magnetic moment; Schwinger limit; superheavy nuclei; $SU(2)$.*

1. Problem Statement: The Physical Meaning of the Number 137

In quantum electrodynamics (QED) and the Standard Model, the fine-structure constant is defined as:

$$\alpha = e^2/(4\pi\epsilon_0\hbar c), \alpha^{-1} \approx 137.035999 \text{ (low-energy value).}$$

Here, e is the elementary charge, ϵ_0 is the electric constant, $\hbar$ is the reduced Planck constant, and c is the speed of light. Its value depends on the energy scale: in QED, the effective coupling changes with the transferred momentum; therefore, the number 137 should not be treated as a universal constant at all energies.

Historical attempts to derive the number 137 from purely numerical or geometrical considerations (including the approaches of Arthur Eddington or Wolfgang Pauli) do not constitute a physical derivation by themselves without strictly defined equations and testable consequences.

Within the Local Energy Deficit Model (LEDM), the fundamental quantities c , $\hbar$, e , G are treated as derived dynamic characteristics of an elastic continuum:

- **Speed of light (c)** — the propagation speed of longitudinal and transverse elastic perturbations in a medium with bulk modulus K and density ρ_0 .
- **Planck constant ($\hbar$)** — the characteristic energy scale of stochastic zero-point fluctuations discretization in the medium.
- **Electric charge (e)** — the kinematic power of the topological sink of phase energy deficit or the winding number of the envelope wave function phase.

These propositions set a conceptual framework that requires rigorous mathematical formalization.

2. Approaches to Interpreting α within LEDM

2.1. The Particle as a Vortex Configuration

An elementary particle in LEDM is considered as a localized wave or vortex configuration in an isotropic medium. To transform this image into a physical theory, it is necessary to specify the state field of the medium, its Lagrangian or equations of motion, boundary conditions, and the method for extracting observable quantities.

2.2. Phase Quantization and Energy Balance

For a complex field with phase φ , the uniqueness condition has the form $\oint \Delta\varphi \cdot dl = 2\pi n$, $n \in \mathbb{Z}$). The binding energy e^2 is proportional to the shear flux of the energy deficit through the particle surface, while $\hbar c$ determines the longitudinal elastic rigidity of the vacuum. The dimensionless parameter α reflects the efficiency coefficient of binding the substrate's elastic energy by the vortex sink. Nevertheless, a rigorous derivation of the functional relationship between configuration energy and the $\hbar c$ scale remains a task for further mathematical research.

3. Analysis of Geometric Normalization and the Numerical Series

For the symmetric strain tensor u_{ij} in $\mathbb{R}^3$ space, there are 6 independent components. Separating the spherical (volumetric) part and the traceless deviator leaves $n_s = 5$

independent shear degrees of freedom (corresponding to spherical harmonics Y_{2m} at $l = 2$). The total solid angle of the spherical sink is 4π , yielding a volumetric-geometrical factor of $4\pi n_s = 20\pi \approx 62.83185$.

In a series of model constructions, the following comparative set of terms is considered:

Zero-order spatial harmonic (40π): 125.663706

1. Phase boundary relaxation ($+8/\pi$): +5.729578
2. Core compressibility correction ($+16/3\pi^2$): +0.540380
3. Contribution of zero-point radial oscillations ($+1/12\pi^3$): +0.002687

The sum of these four terms is 131.936351, which by itself does not directly reproduce the final experimental value $\alpha^{-1} \approx 137.036$. For a reproducible derivation, it is necessary to provide: (1) the full initial formula for α^{-1} ; (2) definitions of all dimensionless parameters; (3) the derivation of each numerical term; (4) truncation rules for the spectral series and an error estimate; (5) the exact place of use or non-use of the experimental value of α .

It is critically important to exclude circular reasoning: if model parameters are chosen to yield 137.035999, the agreement with CODATA is not an independent prediction. A genuine derivation must obtain this number from predefined equations and independently determined parameters.

4. Physical Phenomena Associated with the Fine-Structure Constant

Below are physical phenomena and their possible interpretations within LEDM, requiring independent verification:

- **Electron Velocity in the Bohr Model:** In the non-relativistic approximation for the hydrogen atom, the velocity on the first orbit is $v = \alpha c$. In LEDM, this is interpreted as the baseline "slippage" regime of elastic phase deformation around the proton.
- **Fine Structure of Spectra:** The spectral line splitting is proportional to $\alpha^2 R_y$. In the model, this is described as an interference between the volumetric scalar deficit (mass component) and the shear circulation deformation.
- **Perturbation Theory in QED:** The smallness of $\alpha \ll 1$ ensures rapid damping of Feynman diagram terms. In the hydrodynamic analogy of LEDM, this corresponds to the rapid damping of nonlinear corrections to the elastic response of the medium.
- **Anomalous Magnetic Moment ($g - 2$):** The leading contribution $\frac{\alpha}{2\pi}$ is associated in LEDM with stochastic fluctuations of the elastic substrate around the vortex core.
- **Schwinger Critical Field:** The scale $E_c = \frac{m_e^2 c^3}{e\hbar}$ determines the threshold for pair production from the vacuum. In LEDM, this is interpreted as a macroscopic threshold for the loss of elastic stability of the substrate.

5. Stability Limit of Superheavy Nuclei ($Z = 137$)

In the simplest relativistic point-charge model at $Z \geq 137$, the parameter $Z\alpha \geq 1$, leading to a formal singularity (the "Feynman paradox"). In LEDM, this boundary is treated not as a prohibition on the existence of elements, but as a **physical limit of substrate stability**:

1. The circulation velocity of the shear phase wave reaches the limiting speed of the medium c .
2. A nonlinear elastic response (a nonlinear analog of Hooke's law) is activated, eliminating the mathematical singularity through stress saturation.
3. Upon further increase in stress, the substrate sheds excess energy via the production of topological pairs (positrons).

Summary Table: Model Parameters and Related Physical Phenomena

Parameter / Phenomenon	Physical-Geometrical Meaning in LEDM	Numerical Expression / Value
$n_s = 5$	Number of shear degrees of freedom of the stress deviator in $\mathbb{R}^3$	5
$4\pi \cdot n_s$	Volumetric-angular shear factor of the medium	$20\pi \approx 62.83185$
Series sum	Model sum of the basic spectral series terms	≈ 131.936351
Bohr orbit	Ratio of deformation circulation velocity to c	$v/c = \alpha \approx 1/137$
Magnetic moment $g - 2$	Fluctuational "jitter" of the particle core	Correction $\approx \alpha/2\pi$
Schwinger limit	Threshold of elastic dissipation and pair production in vacuum	$E_c = m_e^2 c^3 / e\hbar$
$Z_{\max} = 137$	Threshold of phase winding and	$Z = 137$

Parameter / Phenomenon	Physical-Geometrical Meaning in LEDM	Numerical Expression / Value
	nonlinear substrate relaxation	

Conclusion

The Local Energy Deficit Model offers a cohesive conceptual framework for understanding the fine-structure constant and related quantum electrodynamic effects through the mechanics of an elastic vacuum substrate. The analysis shows that while geometric considerations (accounting for shear degrees of freedom $n_s = 5$ and spatial harmonics) bring one close to the number 137, a complete analytical derivation requires rigorous mathematical formalization of the medium's equations of state and the elimination of gaps in intermediate derivations.

Until independent quantitative checks are completed and mathematical inconsistencies in the spectral series are resolved, the interpretation of the number 137 and its associated thresholds ($Z = 137$, Schwinger field) should be regarded as a promising research hypothesis.

References

1. Strohm, V. F. Local Energy Deficit Model (LEDM): Mechanics of an Elastic Vacuum Substrate as the Foundation of Gravitational, Optical, and Quantum Phenomena. Zenodo Preprint, 2026. <https://doi.org/10.5281/zenodo.23314113>
2. Strohm, V. F. Methodology of studying the two-body problem via ellipse kinematics. Zenodo Preprint, 2026. <https://doi.org/10.5281/zenodo.21336988>[cite: 7, 8].
3. Feynman, R. P. QED: The Strange Theory of Light and Matter. Princeton University Press, 1985[cite: 7, 8].
4. Schwinger, J. On Quantum-Electrodynamics and the Magnetic Moment of the Electron. Physical Review, 1948, vol. 73, p. 416[cite: 7, 8].
5. Tiesinga, E., Mohr, P. J., Newell, D. B., Taylor, B. N. CODATA recommended values of the fundamental physical constants[cite: 8].