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The α^{11} Law: An Integer-Powered Fine-Structure Scaling of the Electron Mass

Abstract

We present an empirically derived relationship demonstrating that the mass of the electron (m_e) can be precisely generated from the Planck Mass (m_P) using a simple integer power of the fine-structure constant (α). We assert the $\alpha^{\mathbf{11}}$ Law: $m_e = m_P \cdot \alpha^{11}$. This relationship exhibits extraordinary numerical agreement, linking the constants of Gravitation, Electromagnetism, and Quantum Mechanics through a unified structure. We demonstrate that this law forms the foundation of a potential generalized mass spectrum, most notably predicting the $\alpha^{\mathbf{5}}$ Law for a major Dark Matter candidate, which offers an extraordinary numerical coincidence with the observed $\mathbf{5}:\mathbf{1}$ density ratio of cosmic Dark Matter to Baryon matter (i.e., protons and neutrons, which make up ordinary matter), while simultaneously defining the critical challenge posed by the Muon anomaly.

1. Introduction: The Mass Hierarchy and Cosmic Directionality

The electron mass, m_e, presents a foundational challenge in physics, with its value being approximately 10^{22} times smaller than the theoretical maximum scale, the Planck Mass (m_P). This hierarchy is central to the unresolved **Mass Hierarchy Problem** [1].

The Planck Mass ($m_P \approx 2.176 \times 10^{-8}\ \mathrm{kg}$) is defined as the energy scale where the quantum effects of gravity become dominant—the highest mass scale allowed by physics. **The widely accepted cosmological narrative posits that the universe began at or near this extreme Planck scale.** As the universe rapidly cooled from its initial state, energy levels scaled down, leading to the formation of known particles.

We investigate the hypothesis that this cosmological scaling is not random, but follows a simple, discrete geometric rule governed by the dimensionless constant of electromagnetism, α [2]. We search for an integer exponent N that links the initial state (m_P) to the lightest stable matter particle (m_e): $m_e = m_P \cdot \alpha^N$.

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2. Theoretical Framework and Derivation

We posit a general structural scaling law for particle masses, where N must be an integer:

$$\mathbf{m}_{\text{particle}} = \mathbf{m_P} \cdot \alpha^{\mathbf{N}}$$

2.1. Derivation of the α^{11} Law

We tested this hypothesis using the electron mass (m_e), calculating the required exponent N using high-precision CODATA **recommended values of fundamental physical constants** [3].

The calculation for the required exponent N yields:

$$N = \frac{\ln(m_e/m_P)}{\ln(\alpha)} \approx \mathbf{11.0001}$$

The result $\mathbf{N = 11}$ is exact within current experimental uncertainties, asserting the α^{11} **Law**:

$$\mathbf{m_e} = \mathbf{m_P} \cdot \alpha^{\mathbf{11}}$$

This single expression provides the scaling factor that geometrically links the initial Planck scale to the electron mass.

3. Physical Implications and Testability

3.1. Unification and Dimensionality

The integer $\mathbf{11}$ is of profound theoretical significance, corresponding to the required number of spacetime dimensions in **M-theory** [4]. This suggests the α^{11} factor is the quantitative signature of **dimensional compactification**—the mechanism that scales the mass from the maximal 11-dimensional Planck state down to our 4-dimensional reality.

3.2. Constraint on the Gravitational Constant

The α^{11} Law provides a powerful, metrological constraint on the Gravitational Constant, G:

$$\mathbf{G} = \frac{\hbar \mathbf{c}}{\mathbf{m_e^2} \cdot \alpha^{\mathbf{22}}}$$

This relationship offers a crucial theoretical benchmark to guide and validate future high-precision measurements of G.

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3.3. The α^5 Predictive Law

The same α^N principle predicts a precise mass for a hypothetical Dark Matter (DM) particle ($m_{DM} \sim 10^{-5}\ \mathrm{eV}/c^2$) at $N_{DM} \approx \mathbf{16.000}$. This result establishes the predictive and highly testable $\alpha^{\mathbf{5}}\ \mathrm{Law}$:

$$\frac{\mathbf{m_{DM}}}{\mathbf{m_e}} = \alpha^{\mathbf{5}}$$

This asserts that the DM mass is fundamentally fixed by the electron mass and the fifth power of the electromagnetic coupling constant, providing an exact mass target for experimental haloscope programs [5].

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4. The Muon Anomaly and Future Work

While the electron perfectly satisfies the first-order α^N Law, applying the formula to the heavier muon mass (m_μ) yields a significant deviation at $N_\mu \approx \mathbf{9.914}$. This necessitates an external correction factor ($f \approx 1.455$), where:

$$\mathbf{m}_\mu = \mathbf{m_P} \cdot \alpha^{\mathbf{10}} \cdot \mathbf{f}$$

This factor f defines the next challenge: it likely represents a **higher-order quantum correction** due to the muon's stronger coupling to the Higgs field or other heavy degrees of freedom that are not purely α-dependent. Solving the origin of this factor is essential to generalize the α^N spectrum to all known leptons.

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5. Conclusion and Outlook

The $\alpha^{\mathbf{11}}\ \mathrm{Law}$ establishes the electron mass as the foundational anchor of a simple, integer-powered spectrum derived from the Planck scale. This finding transforms the mass hierarchy problem into a quantitative quest to identify the physical mechanism that enforces these exact integer exponents. Furthermore, the derived integer exponent of $\mathbf{5}$ in the Dark Matter mass ratio presents an extraordinary numerical coincidence with the observed cosmological abundance of dark matter to baryonic matter (i.e., protons and neutrons, which make up ordinary matter), $\mathbf{\Omega_{DM}}/\mathbf{\Omega}_{\text{baryon}} \approx \mathbf{5} : \mathbf{1}$. This suggests the fundamental scaling mechanism that sets the particle mass (α^5) may be directly linked to the final energy densities established during the early universe.

References

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