Analytical Derivation of Electron Mass from Electromagnetic Self-Energy

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Overview

In this document, we analytically derive the electron mass from its electromagnetic self-energy, based on the hypothesis that the electron is a topological excitation of the Θ_1 field.

Assumptions and Ansatz

We assume that the charge distribution of the electron is spherically symmetric and approximated by a Gaussian:

$$\rho(r) = \frac{e}{\pi^{3/2} R^3} \exp\left(-\frac{r^2}{R^2}\right)$$

This allows analytical treatment and captures the finite localization scale of the electron.

Electrostatic Potential

The electrostatic potential $\phi(r)$ is given by solving Poisson's equation:

$$\phi(r) = \frac{1}{4\pi\epsilon_0} \int \frac{\rho(r')}{|\vec{r} - \vec{r'}|} \, d^3r'$$

For the Gaussian source, this results in:

$$\phi(r) = \frac{e}{4\pi\epsilon_0 r} \operatorname{erf}\left(\frac{r}{R}\right)$$

Self-Energy Integral

The total electromagnetic self-energy is:

$$\delta m_e c^2 = \frac{1}{2} \int \rho(r)\phi(r)\, d^3r$$

Evaluating the integral yields:

$$\delta m_e = \frac{e^2}{\sqrt{\pi}\epsilon_0 R c^2}$$

Interpretation

This result links the electron mass to the scale R of its internal structure, with no new parameters introduced. The remaining task is to derive R from the stress-energy distribution of the Θ_1 Hopfion solution.

Author's Note

This work was developed solely by Ing. David Jaroš. Large language models (ChatGPT-4o by OpenAI and Gemini 2.5 Pro by Google) were used strictly as assistive tools for calculations, LaTeX formatting, and critical review. All core ideas, equations, theoretical constructs and conclusions are the intellectual work of the author.