Rest Mass as Elastic Hysteresis of the Quantum Vacuum

Abstract

We propose a reinterpretation of rest mass m_0 as a hysteretic energy load of a locally deformed quantum vacuum state. Instead of treating mass as an intrinsic property of a particle, we define it as a stiffness echo of the vacuum response to a persistent excitation. Assuming an exponential correlation between energy cost and state duration,

$$\Delta E(\tau) \propto e^{\alpha\tau}, \tag{1}$$

we argue that measured particle masses correspond to the energy dissipated or stored by the vacuum during the lifetime τ of the excitation.

1 Axiom: Vacuum Stiffness Principle

Axiom 1 (Vacuum Stiffness). The quantum vacuum possesses an intrinsic elastic response to local excitations, characterized by a stiffness tensor $\boldsymbol{S}$. For any localized state with lifetime τ, the energy required to sustain the excitation is given by

$$E(\tau) = E_0 \, e^{\alpha\tau}, \tag{2}$$

where:

- E_0 denotes a fundamental excitation threshold,
- α is the vacuum viscosity (stiffness coefficient),
- τ is the observed lifetime of the excitation.

The parameter α encodes the non-equilibrium response of the vacuum and may be interpreted as an effective dissipative constant in a generalized Hamiltonian framework.

2 Hysteretic Mass Load

We define the rest mass m not as an intrinsic invariant, but as the accumulated hysteretic load over the excitation lifetime:

$$mc^2 = \int_0^\tau \dot{E}(t)\, dt. \tag{3}$$

Under the exponential stiffness relation, this yields:

$$mc^2 = E_0 \left(e^{\alpha\tau} - 1\right). \tag{4}$$

Thus, mass emerges as the integrated elastic stress stored in the vacuum during the persistence of the excitation.

Long-lived states correspond to deeply coupled vacuum deformations and exhibit stable mass values. Short-lived states appear as sharp resonances in the hysteresis curve.

3 Implications for High-Energy Physics

If mass is a hysteretic load of the vacuum:

- Massless excitations correspond to the limit $\alpha \to 0$, i.e., zero hysteresis response.
- Particle resonances represent transient elastic saturation points of the vacuum.
- The Higgs mechanism may be reinterpreted as a specific form of plastic deformation of the vacuum background rather than a fundamental field interaction.

This framework suggests that particles observed in high-energy collisions are not elementary building blocks, but metastable elastic configurations of a dynamically stiff vacuum substrate.