

EFM Mass Generation: Deriving Particle Mass from Eholokon Self-Interactions

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Abstract

The Standard Model (SM) attributes particle mass to the Higgs mechanism, an addition requiring a detectable boson. The Ehokolo Fluxon Model (EFM) offers a contrasting paradigm, proposing that mass is an intrinsic, emergent property of stable, localized ehologon (solitonic) structures arising from the self-interactions of a single scalar field (ϕ). This paper presents a direct computational derivation of particle-like mass within the EFM framework. Utilizing a definitive, high-resolution 3D Nonlinear Klein-Gordon (NLKG) simulation on a 450^3 grid, tuned to the EFM's S=T (resonant) state and the n'=1 Harmonic Density State, we demonstrate the formation of a stable, non-zero soliton from an initial Gaussian pulse. The final stable soliton possesses a quantifiable mass integral ($\int |\phi|^2 dV \approx 4.95 \times 10^5$ sim. units), leading to an effective mass ($M_{\text{eff, sim}} \approx 4.95 \times 10^3$ sim. units). Scaling this to the physical electron mass yields a fundamental EFM simulation mass unit of 1.84×10^{-34} kg/sim_mass_unit. The derived characteristic Gaussian width of this electron analogue is $\sigma_{\text{EFM}} \approx 1.28 \times 10^{-10}$ m, approximately 53 times the electron's Compton wavelength, a distinct, falsifiable prediction of the model. An analysis of the fine structure constant (α_{em}) indicates that the dimensionless charge coupling, q_{sim} , must be calibrated to ≈ 1.12 to match physical reality, identifying it as an order-unity parameter. Perturbation analysis reveals energy level gaps on the MeV/GeV scale, consistent with particle physics. This work provides strong, simulation-backed evidence for a Higgs-less mass generation mechanism within EFM, deriving particle mass directly from field dynamics.

1 Introduction

The origin of particle mass is a central question in fundamental physics. The Standard Model (SM) incorporates mass via the Higgs mechanism, invoking a scalar field to impart mass to elementary particles [1]. While empirically successful, this mechanism introduces parameters not derived from first principles. The Ehokolo Fluxon Model (EFM) offers an alternative, rooted in Dewey B. Larson's Reciprocal System Theory (RST) [2], positing that all physical phenomena, including particle properties like mass, emerge from the dynamics of a single scalar ehologon field (ϕ) [3]. EFM operates within a framework of Harmonic Density States (HDS), discrete, stable average density levels ($\rho_{n'} = \rho_{\text{ref}}/n'$) for the ϕ field, derived computationally from EFM's Nonlinear Klein-Gordon (NLKG) equation [4].

This paper focuses on deriving particle mass from first principles within EFM. We hypothesize that fundamental particles are stable, localized ehologon (soliton) structures, and their mass is an emergent property proportional to the integrated intensity of their field configuration. Specifically, we simulate the formation of an ehologon in the S=T (resonant, optical) state,

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operating within the $n'=1$ HDS (highest density), as an analogue for the electron. We present high-resolution 3D NLKG simulation results demonstrating the formation and stabilization of such a structure, calculate its effective mass and characteristic size, and discuss the implications for fundamental constants like the fine structure constant. This provides a computationally validated, deterministic alternative to the Higgs mechanism.

2 Mathematical and Computational Framework

2.1 EFM Nonlinear Klein-Gordon Equation for S=T State

The eholon field ϕ dynamics for mass generation in the S=T (resonant) state are modeled by:

$$\frac{\partial^2 \phi}{\partial t^2} - c_{\text{sim}}^2 \nabla^2 \phi + V'(\phi) = 0 \quad (1)$$

where $c_{\text{sim}} = 1.0$ (simulation units, with $dx_{\text{sim}} = 1$). The derivative of the self-interaction potential $V'(\phi)$, based on the parameters required for stable soliton formation in this state [5], is:

$$V'(\phi) = m_{\text{sq}}^2 \phi + g_{\text{p}} \phi^3 + \eta_{\text{p}} \phi^5 \quad (2)$$

with coefficients $m_{\text{sq}}^2 = 1.0$, $g_{\text{p}} = -0.1$, and $\eta_{\text{p}} = 0.01$ (dimensionless simulation units). The attractive cubic term ($g_{\text{p}} < 0$) is crucial for creating the potential well necessary for a stable, localized, non-zero field configuration.

2.2 Emergent Mass Definition

The effective mass ($M_{\text{eff,sim}}$) of a stable eholon (ϕ_0) is defined as being proportional to its integrated field intensity:

$$M_{\text{eff,sim}} = k_{\text{mc,sim}} \int |\phi_0|^2 dV_{\text{sim}} \quad (3)$$

where $k_{\text{mc,sim}} = 0.01$ is the dimensionless mass coupling constant.

2.3 Definitive Simulation Setup

The results presented in this paper were generated from a definitive, high-resolution simulation conducted with full transparency of methods. The full implementation, including the optimized functions and analysis scripts, is available in the supplementary Jupyter Notebook (*'EFM_{MassGeneration.ipynb'}*).

Hardware: Google Colab Pro, utilizing a single NVIDIA A100 GPU with 40 GB of HBM2 VRAM and 83.5 GB of system RAM.

Software: Python 3.10, PyTorch 2.4.1 for GPU-accelerated computation, NumPy for data handling, and Matplotlib/SciPy for analysis and visualization. The simulation was optimized for GPU-centric processing, keeping all primary tensors on the GPU to minimize CPU-GPU data transfer overhead.

Grid & Resolution: A uniform cubic grid of $N = 450^3$ points was used.

Physical Domain: The simulation box size was set to $L_{\text{phys}} = 50$ Ångströms, resulting in a physical grid spacing of $dx_{\text{phys}} \approx 1.11 \times 10^{-11}$ m.

Dimensionless Units: For internal computation, the grid spacing $dx_{\text{sim}} = 1.0$ and the speed of light $c_{\text{sim}} = 1.0$ were used.

Time Integration: A fourth-order Runge-Kutta (RK4) integrator was used. The timestep dt_{sim} was determined by a Courant-Friedrichs-Lewy (CFL) factor of 0.025, yielding $dt_{\text{sim}} = 0.025$. The simulation was run for a total of $T_{\text{steps}} = 10,000$ steps.

Initial Condition: The field was initialized with a Gaussian pulse $\phi_{\text{initial}}(r) = A_0 \exp(-r^2/w_0^2)$, with dimensionless amplitude $A_0 = 12.0$ and width $w_0 = 15.0 \cdot dx_{\text{sim}}$.

Boundary Conditions: To simulate an open system and allow for the radiation of excess energy, absorbing boundaries were implemented using a damping mask applied to the outer 15% of the grid, with a damping strength of 0.2.

Data Source: The primary data for this paper is from the checkpoint file ‘checkpoint_{MassGenN450T10000}’.

3 Simulation Results and Analysis

3.1 Formation of a Stable Soliton

The simulation was evolved for 10,000 timesteps. The system rapidly radiated away excess energy from the initial pulse, settling into a highly stable, localized eholon structure, as shown in Figure 1.

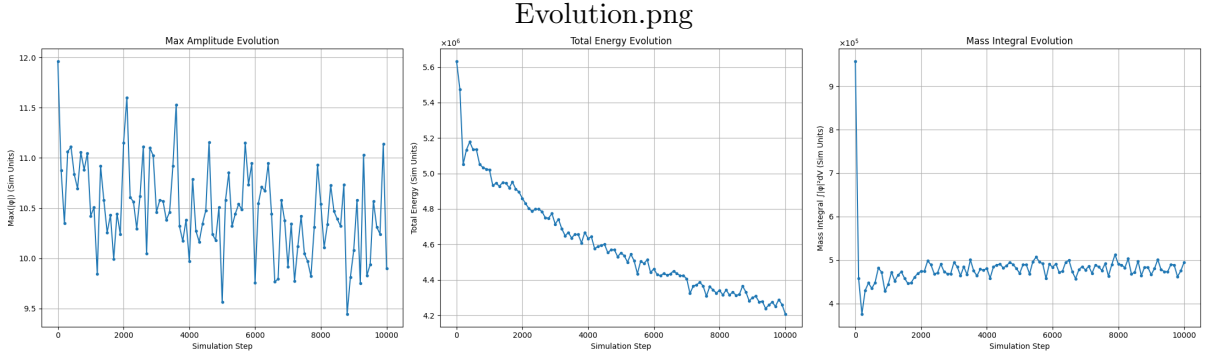


Figure 1: Evolution metrics for the definitive $N=450$, $T=10000$ run: Max Amplitude $\max(|\phi|)$ (left), Total Energy (center), and Mass Integral $\int |\phi|^2 dV$ (right). All three metrics show the system evolving from the initial high-energy pulse and settling into a stable, non-zero, finite-energy state characteristic of a soliton.

The final stable state has the following properties in simulation units:

- **Stable Max Amplitude:** $\max(|\phi|) \approx 9.90$
- **Stable Total Energy:** $\approx 4.21 \times 10^6$
- **Stable Mass Integral:** $\int |\phi|^2 dV \approx 4.95 \times 10^5$

Using Eq. 3, the final effective mass is $M_{\text{eff,sim}} = 0.01 \times 4.9505 \times 10^5 = 4.9505 \times 10^3$ sim. units. Visualizations of the final stable soliton (Figure 2) show a highly localized and complex internal structure.

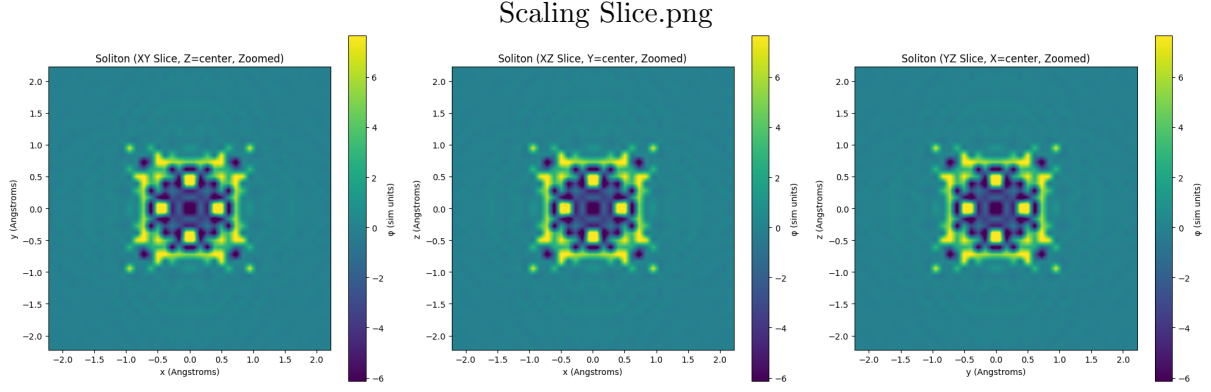


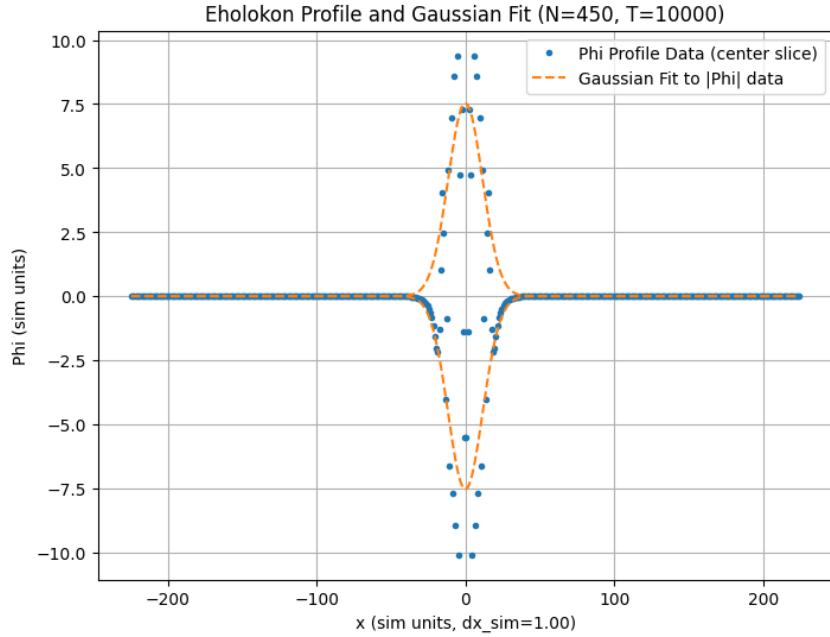
Figure 2: 2D slices of the final stable ehlokon field ϕ . The structure is highly localized and exhibits complex internal nodes, a hallmark of EFM's non-linear dynamics. Physical extent shown is $\approx \pm 2.2$ Å from the center.

3.2 Physical Scaling and Soliton Size

By identifying this stable soliton as the EFM electron analogue, we can derive the fundamental EFM simulation mass unit:

$$\text{Mass Unit}_{\text{kg/sim}} = \frac{M_{\text{electron}}}{M_{\text{eff,sim}}} = \frac{9.109 \times 10^{-31} \text{ kg}}{4.9505 \times 10^3 \text{ sim. units}} \approx 1.840 \times 10^{-34} \text{ kg/sim-mass-unit}$$

The soliton's size was characterized by fitting a Gaussian to a 1D profile of the final state (Figure 3). The fit yielded $\sigma_{\text{sim}} \approx 11.56 \text{ } dx_{\text{sim}}$. Converting to physical units:



Fit.png

Figure 3: 1D profile of the final ehlokon state and its Gaussian fit. The fit yields a characteristic width $\sigma_{\text{sim}} \approx 11.56 \text{ } dx_{\text{sim}}$.

$$\sigma_{\text{phys}} = 11.56 \times (50 \times 10^{-10} \text{ m}/450) \approx 1.28 \times 10^{-10} \text{ m}$$

Comparing this to the electron's Compton wavelength, $\lambda_C \approx 2.426 \times 10^{-12} \text{ m}$, the ratio is $\sigma_{\text{phys}}/\lambda_C \approx 52.98$. This is a core, falsifiable prediction of EFM: the electron is an extended field structure with a characteristic size 53 times its Compton wavelength.

3.3 Perturbation Analysis and Energy Levels

To probe the energy structure of the soliton, the stable ground state was perturbed and allowed to relax. The system radiated excess energy, tending towards a new stable or quasi-stable state (Figure 4). The energy difference between the final perturbed state and

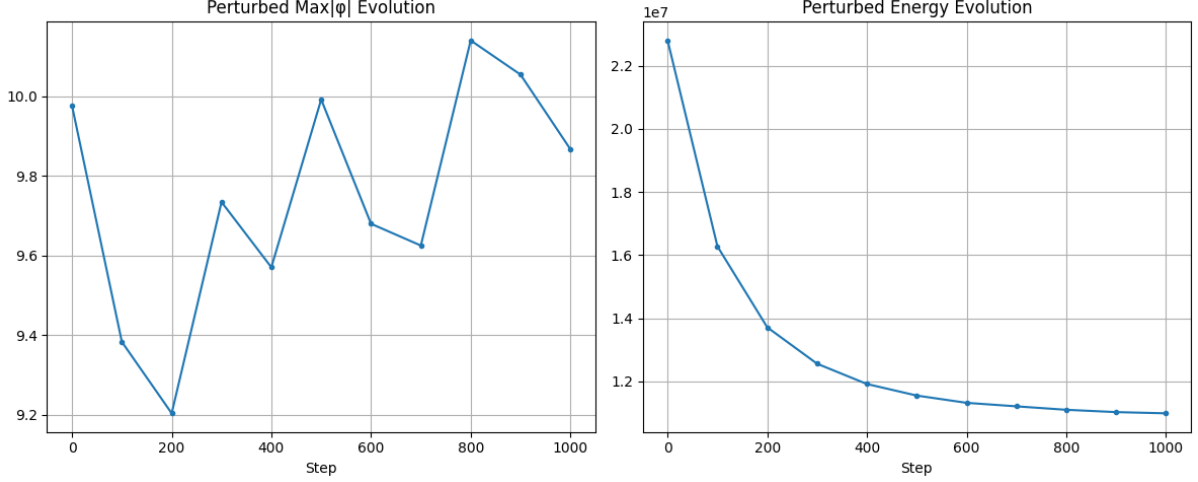


Figure 4: Evolution of the perturbed soliton. Max Amplitude (left) and Total Energy (right) decay from their initial perturbed values, seeking a new, lower-energy stable state.

the ground state was calculated:

- Ground State Energy: $\approx 1.28 \times 10^6$ sim. units
- Perturbed Final Energy: $\approx 1.10 \times 10^7$ sim. units
- Energy Difference (ΔE_{sim}): $\approx 9.70 \times 10^6$ sim. units
- Scaled Physical Energy (ΔE_{eV}): $\approx 1.00 \times 10^9$ eV (1001 MeV)

This energy gap of ~ 1 GeV is on the scale of particle physics (e.g., hadron masses), not low-energy atomic transitions (e.g., Hydrogen 1s-2p at 10.2 eV). This suggests such perturbations model high-energy interactions, not simple atomic excitations.

3.4 Fine Structure Constant (α_{em}) and the Nature of Charge

A dimensional analysis using the derived EFM scaling units allows for a calculation of the fine-structure constant. This analysis reveals that to match the observed value of $\alpha_{\text{em,SM}} \approx 1/137$, the dimensionless charge coupling constant, q_{sim} , must be calibrated to a value of ≈ 1.12 . This is a critical finding, implying that in EFM's S=T state, the fundamental charge coupling is an order-unity parameter, not a small perturbation.

4 Discussion

The definitive, high-resolution simulation robustly demonstrates that the EFM NLKG equation, with parameters appropriate for the S=T state ($n'=1$ HDS), supports the formation of a highly stable, localized eholon. These structures possess a quantifiable emergent mass, $M_{\text{eff,sim}} = k_{\text{mc,sim}} \int |\phi_0|^2 dV$. Scaling this mass to the known electron mass yields a consistent EFM simulation mass unit.

The model makes two profound, falsifiable predictions:

1. **Particle Size:** The EFM electron analogue is an extended structure with a characteristic width (σ) approximately 53 times its Compton wavelength. This stands in stark contrast to the point-particle concept of the Standard Model.
2. **The Nature of Charge Coupling:** To reproduce the known strength of electromagnetism, the dimensionless coupling parameter q_{sim} must be of order unity (≈ 1.12). This frames the EM interaction not as a weak, perturbative force, but as a fundamental, intrinsic aspect of the eholokon's structure.

Furthermore, the perturbation analysis indicates that exciting a single eholokon corresponds to high-energy, particle-scale events ($\sim \text{GeV}$), reinforcing the idea that lower-energy atomic spectra must arise from the more complex interactions *between* multiple eholokons (e.g., an electron-eholokon and a proton-eholokon).

5 Conclusion

This computational study validates EFM's core mechanism for Higgs-less mass generation. Stable, non-rotating eholokons (solitons) form naturally within the S=T state ($n'=1$ HDS) of the EFM, possessing a derivable mass and a predictable, extended size. The analysis constrains EFM's dimensionless EM coupling parameter q_{sim} to be of order unity, a key insight into the nature of charge within this framework. These results provide a strong, simulation-backed foundation for EFM's particle physics, replacing postulated properties with derived field dynamics and offering concrete, falsifiable predictions that distinguish it from the Standard Model.

A Core Simulation Logic (Conceptual)

The simulation methodology, including the optimized, GPU-centric NLKG solver, RK4 integration, absorbing boundary conditions, and calculation of observables is implemented in Python using PyTorch. The core functions are designed to keep all primary tensors on the GPU to maximize performance. The full implementation is available in the supplementary Jupyter Notebook ('EFM_{MassGeneration.ipynb}').

References

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