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Neutrino: Origin of Its Energy during Neutron Decay - A Classical Perspective within the VTI Framework

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Abstract:
The neutron undergoes beta decay with the emission of a proton, an electron, and a neutrino, yet the origin of the small energy carried by the neutrino remains conceptually unclear within standard formulations. In this work, a purely classical approach is developed within the VTI (Vacuum Tension Interpretation) framework, in which the neutron is treated as a pressure-limited, structurally stable assembly of confined, electrically neutral charge units (Qc units). Each Qc unit stores a fixed Coulomb confinement energy determined by balance with a universal vacuum-tension limit, establishing a natural MeV-scale internal energy reservoir.
Neutron decay is interpreted as a localized redistribution of confined electric field energy in the outermost Qc unit, modeled as an extended charge configuration rather than a point charge. The difference between pre- and post-decay field configurations releases a charge-neutral energy representing a minute fraction of the total Qc confinement energy and is identified with the neutrino. The smallness of neutrino energy thus follows naturally from classical energy scaling and confinement constraints.

Keywords:
Neutron decay; neutrino energy; classical electrodynamics; confined electric field energy; charge confinement; pressure-limited stability; Coulomb interaction; energy scaling; Qc framework.

1. Introduction:

The neutron occupies a central role in nuclear physics, astrophysics, and cosmology, yet its internal structure and decay processes continue to raise foundational questions. While the neutron is electrically neutral and exhibits long-term stability within nuclei, the free neutron undergoes beta decay with a mean lifetime of approximately 880 s, emitting a proton, an electron, and a neutrino. The existence of the neutrino was originally postulated by Pauli to preserve energy conservation in beta decay and later formalized by Fermi within the weak interaction framework [1,2]. Subsequent experimental confirmation established the neutrino as an essential but weakly interacting particle with extremely small mass and energy scale [3–5].

In the standard model, neutron structure is described in terms of quarks bound by quantum chromodynamics (QCD), and neutron decay is mediated by weak interactions involving W bosons and leptonic currents [6–8]. While this framework has achieved remarkable predictive success, it relies on non-classical constructs, multiple coupling constants, and field-theoretic abstractions that obscure simple energetic and structural interpretations. In particular, the origin of the small neutrino energy scale appears as an imposed consequence of weak-interaction dynamics rather than as an emergent property of neutron structure itself.

Parallel to quantum-field approaches, a long tradition of effective and classical modeling has played a crucial role in nuclear physics. Examples include the liquid-drop model, shell model, and collective excitation models, all of which capture essential physical behavior without invoking microscopic field dynamics explicitly [9–11]. These models demonstrate that structural stability, energy confinement, and decay can often be understood in terms of geometry, pressure balance, and energy minimization principles.

Motivated by this perspective, the present work adopts a purely classical framework within VTI (Vacuum Tension Interpretation) framework model [12] in which the neutron is treated as a pressure-limited assembly of confined, electrically neutral charge units (Qc units). Each Qc unit consists of oppositely charged components confined at a characteristic separation and stabilized by a balance between Coulomb interaction and a universal vacuum-tension limit. This balance yields a natural confinement energy scale of a few MeV per Qc unit from first principles, without reference to quantum chromodynamics or weak-interaction fields. The neutron is thus structurally stable while permitting limited internal dynamical reconfiguration.

Within this classical Qc framework, neutron decay is interpreted not as structural disintegration but as a localized reconfiguration involving only a small subset of internal degrees of freedom, particularly the outermost Qc unit. Because the Coulomb confinement energy stored in a Qc unit is large compared to the energy released during decay, only a minute fraction of the confined energy can be liberated without compromising structural stability. When expressed in terms of confined electric field energy, this constraint naturally leads to a very small released energy scale.

The objective of this paper is not to replace established neutrino theory, but to address a more limited question: why the energy carried by the neutrino is so small compared to the total neutron energy. By focusing on classical redistribution of confined electric field energy within a pressure-limited charge structure, the work proposes that neutrino energy arises from a small reduction in confined field energy during decay-triggered reconfiguration.

From a classical standpoint, recoil plays a central role in neutron decay. Although the proton and electron originate from symmetric +Qc and −Qc constituents, their post-decay environments are highly asymmetric. The proton remains embedded within a residual bound structure carrying substantial internal confinement energy, while the electron emerges as a free charge. The total decay energy available in free neutron decay (~0.782 MeV) therefore represents only the small excess energy released during field reconfiguration and charge separation. This excess energy is distributed among electron kinetic energy, proton recoil, and a neutral carrier identified as the neutrino.

2. Conceptual Framework and Field-Energy Derivation:

2.1 Conceptual Framework

Within the Qc-based classical framework [12], the neutron is treated as a structurally stable assembly of electrically neutral Qc units. Each Qc unit consists of oppositely charged components ±Q separated by a characteristic distance

$$d = 2r. \tag{1}$$

The global stability of the neutron is ensured by a pressure balance at the universal vacuum-tension limit derived in the main framework. This balance fixes the confinement energy of each Qc unit while preserving structural integrity.

Although the neutron is globally stable, the internal electric field configuration of an individual Qc unit need not be strictly static. During neutron decay, particularly involving the outermost Qc unit, a small redistribution of the confined electric field may occur without altering the overall structure.

The physically relevant quantity is the total electric field energy

$$U = \frac{\varepsilon_0}{2} \int E^2 \, dV. \tag{2}$$

Any departure from equilibrium corresponds to a change in this stored field energy.

2.2 Qc Confinement Energy

The classical Coulomb confinement energy of a Qc unit is

$$E_{Qc} = k\frac{Q^2}{d} = k\frac{Q^2}{(2r)}. \tag{3}$$

This energy is fixed by the confinement condition and is of order

$$E_{Qc} \approx 3.3\text{–}3.5 \text{ MeV}.$$

It represents the total confined electric field energy of a single Qc unit.

2.3 Parametric Representation of Field Redistribution:

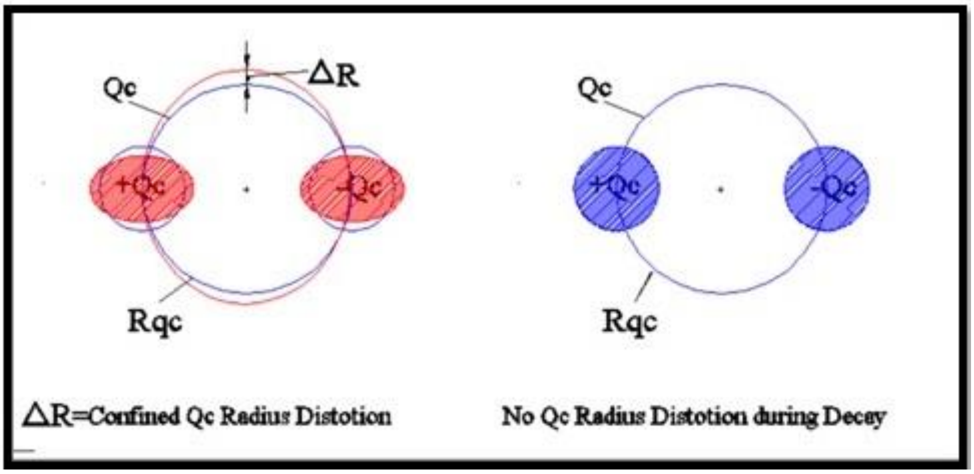

Figure-1

Schematic (not to scale) representation of the outermost Qc unit illustrating the confined electric field configuration before decay (left) and during decay-triggered reconfiguration (right). The +Qc and –Qc components are treated as extended charge structures that remain spatially anchored within the neutron framework in both configurations.

The indicated transition from an effective separation r + Δr to r does not represent physical displacement of the charge centers. Rather, it parameterizes a small redistribution and partial relaxation of the confined electric field configuration associated with the outermost Qc unit.

Prior to decay, this Qc unit exists within the collective confinement equilibrium of the neutron, where its field structure is constrained by the surrounding pressure-limited assembly. As charge separation proceeds during decay, the local confinement boundary condition changes, leading to a modified electric field configuration.

The difference between the pre- and post-transition field configurations corresponds to a change in confined electric field energy. This released field-energy difference, ΔE field, is identified with the neutrino energy emitted during decay, while the overall Qc confinement structure of the neutron remains intact.

To describe small internal reconfiguration, we parameterize the confined field using the effective separation r. Let the outermost Qc unit undergo a small distortion

$$r \rightarrow r + \Delta r, \text{with } \Delta r \ll r. \qquad (4)$$

This does not represent mechanical displacement of the charges but rather a small redistribution of the confined electric field.

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The confinement energy becomes

$$E_{Qc(r+\Delta r)} = k\frac{Q^2}{[2\,(r+\Delta r)]}. \qquad (5)$$

For $\Delta r \ll r$, expand to first order:

$$E_{Qc(r+\Delta r)} \approx \left(k\frac{Q^2}{2r}\right)\left(1 - \frac{\Delta r}{r}\right). \qquad (6)$$

The decrease in confined field energy during relaxation is therefore

$$\Delta E_{field} = E_{Qc(r)} - E_{Qc(r+\Delta r)}. \qquad (7)$$

Substituting from (6),

$$\Delta E_{field} \approx \left(k\frac{Q^2}{2r}\right)\left(\frac{\Delta r}{r}\right). \qquad (8)$$

Using equation (3), this reduces to

$$\Delta E_{field} \approx E_{Qc}\left(\frac{\Delta r}{r}\right). \qquad (9)$$

This result follows directly from Coulomb scaling and serves as a parametric representation of small field-energy redistribution.

2.4 Consequence of Structural Stability

Because the neutron remains structurally stable, the internal distortion must satisfy

$$\Delta r \ll r, \qquad (10)$$

which implies

$$\Delta E_{field} \ll E_{Qc}. \qquad (11)$$

Because the confinement energy per Qc unit is of order

$$E_{Qc} \approx 3.5\ \text{MeV}, \qquad (12)$$

the released energy scales directly with the fractional redistribution Δr / r. For illustration:
If

$$\frac{\Delta r}{r} \sim 10^{-2}, \qquad (13)$$

Then

$$\Delta E_{field} \sim 3.5 \times 10^{-2} MeV \approx 35\ keV. \quad (14)$$

If

$$\frac{\Delta r}{r} \sim 10^{-3}, \quad (15)$$

Then

$$\Delta E_{field} \sim 3.5 \times 10^{-3} MeV \approx 3.5\ keV. \quad (16)$$

Thus only a small fraction of the total confinement energy can be released.

2.5 Postulation: Neutrino as Released Field Energy

During neutron decay, the outermost Qc unit undergoes rapid internal field reconfiguration as charge separation transitions into observable decay products. The excess confined electric field energy released during this process is identified with the neutrino energy:

$$E_\nu \equiv \Delta E_{field} \approx E_{Qc}\left(\frac{\Delta r}{r}\right), \text{with } \Delta r \ll r. \quad (17)$$

Within this framework:
• the neutron's structural integrity is preserved,
• no additional energy reservoir is required,
• neutrino energy represents a small reduction in confined electric field energy,
• electric field energy being scalar and charge-neutral naturally explains the neutrality of the emitted energy.

2.6 Scope and Limitation

This formulation:
• uses only classical Coulomb interaction and electric field energy,
• remains anchored to the pressure-limited Qc structure derived earlier,
• establishes only the origin and scale of neutrino energy,
• does not address neutrino propagation, interaction cross-sections, or weak-interaction dynamics.

3.Conclusions:

The present work establishes a classical energetic interpretation of neutron beta decay based exclusively on the confined electric field structure of a Qc unit. Starting from the Coulomb confinement energy

$E_{Qc} = k\frac{Q^2}{(2r)}$,

a small internal redistribution of the confined field configuration,

$r \rightarrow r + \Delta r, \text{with } \Delta r \ll r,$

produces a proportional reduction in stored field energy,

$$\Delta E_{\mathrm{field}} \approx E_{\mathrm{Qc}}\left(\frac{\Delta r}{r}\right).$$

Because neutron stability constrains Δr to be much smaller than r, the resulting released energy is necessarily a small fraction of the MeV-scale confinement energy of the Qc unit.

Within this framework, neutron decay is viewed as an event that permits localized internal field redistribution in the outermost Qc unit. The difference between the pre- and post-reconfiguration confined field energies becomes available as emitted energy. This released energy is identified with the neutrino. Although the confined electric field originates from oppositely charged components, the field energy itself is a scalar quantity proportional to E^2 and carries no charge information. Consequently, any released field-energy difference is intrinsically charge-neutral, consistent with the neutrality of the emitted neutrino.

The central contribution of the work is therefore the establishment of a classical scaling relation linking confined field-energy redistribution to the neutrino energy scale. The analysis shows that neutrino-scale energies emerge naturally from Coulomb confinement scaling under structural stability constraints.

The framework provides an energetically transparent description of how a small charge-neutral energy component can arise from internal field reconfiguration within a pressure-limited charge structure. Spin and helicity properties lie outside the scope of the present field-energy analysis.

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