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A Structural Model of Neutron Beta Decay Based on Internal Hydrogenic Charge Configuration

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Abstract:

The neutron is conventionally described as undergoing beta decay through a probabilistic process characterized by an exponential decay law, without explicit reference to an underlying internal structural mechanism. In the present work, the neutron is modeled as a confined assembly of discrete quantum charge units (Qc), consisting of 135 entangled pairs and a single unpaired boundary unit.

A boundary-referenced coordinate system is introduced to describe internal structural propagation. Within this framework, decay time is interpreted as emerging from three-dimensional propagation across the internal structure. When combined with the standard exponential decay formulation, the observed decay law is obtained as a consequence of structural dynamics rather than as an independently postulated statistical behavior.

The presence of a single unpaired boundary Qc unit provides a structural basis for decay initiation and explains the preferential emission of the electron. Following decay, the remaining configuration becomes fully paired, accounting for the absence of a second decay under normal conditions. Variations in decay time are attributed to differences in internal propagation depth, leading naturally to a statistical distribution.

The proposed framework offers a structural interpretation of neutron decay in which temporal behavior and probability emerge from internal organization. While the underlying assumptions require further validation, the formulation provides a consistent and potentially useful complementary perspective to existing descriptions.

Keywords: Neutron decay; beta decay; neutron structure; exponential decay law; internal propagation; structural model

1. Introduction:

The decay of the neutron is a fundamental process in nuclear and particle physics, characterized by beta emission and an experimentally well-established exponential decay law [1,2]. The theoretical foundation of beta decay was first established by Enrico Fermi [10], forming the basis for later developments in weak interaction theory.

Subsequent advances in electroweak theory, particularly the unified formulations proposed by Sheldon Glashow [3], Steven Weinberg [4], and Abdus Salam [5], have successfully described neutron decay processes in terms of quantum field interactions. These approaches account for observed decay rates and particle emission with high accuracy. However, the exponential decay law itself is typically introduced as a probabilistic postulate rather than being derived from an explicit internal structural mechanism.

The general quantum-mechanical framework, as developed in foundational works such as those by Paul Dirac [9], provides a statistical interpretation of decay processes, where the lifetime emerges from probabilistic evolution rather than deterministic internal dynamics.

In parallel, classical electrodynamics formulations [7,8] have demonstrated that confined charge configurations can give rise to measurable forces and energy distributions. Earlier work by the present authors [6, 11] explored neutron properties using such charge-based representations, in their VTI neutron model, showing that confinement force and pressure scales can be derived from internal charge structure in terms of Qc charge particle units.

These considerations motivate the question of whether neutron decay can be interpreted in terms of internal organization and structural dynamics of Qc units. In particular, it is of interest to examine whether the observed exponential decay behavior may emerge from deterministic internal processes rather than being introduced solely as a statistical assumption.

In the present work, the neutron is modeled as a confined assembly of discrete quantum charge units (Qc), consisting of entangled pairs and a single unpaired boundary unit. A boundary-referenced coordinate system is introduced to describe internal structural propagation. Within this framework, decay is interpreted as a process initiated at the structurally least constrained boundary and governed by propagation across the internal configuration.

A key objective of this study is to examine whether the exponential decay law can be derived as a consequence of internal structural dynamics. By introducing a cubic scaling relation associated with three-dimensional propagation, the formulation provides a connection between structural depth and decay time, offering a possible structural interpretation of the observed decay distribution.

The proposed framework does not attempt to replace existing theoretical descriptions but instead aims to provide a complementary perspective in which decay behavior is linked to internal organization. Such an approach may contribute to a broader understanding of how probabilistic laws in nuclear processes can arise from underlying structural and dynamical considerations.

2. Main Framework:

2.1 Neutron Structural Model

The neutron is modeled as a confined assembly of discrete quantum charge units (Qc). The total number of Qc units is:

$$N_{qc} = 271 \qquad (1)$$

The internal configuration consists of:

- 135 paired Qc units (i.e., 270 units forming entangled pairs), and
- one unpaired Qc unit located at the boundary.

The paired Qc units are assumed to be strongly entangled and structurally stable, whereas the unpaired Qc unit represents a structurally asymmetric and weakly constrained component.

2.2 Hydrogenic Configuration and Decay Asymmetry :

The internal arrangement follows a hydrogenic configuration [11]:

$$+Qc \rightarrow core$$
$$-Qc \rightarrow outer\ shell$$

Under perturbation, the least confined outer component is preferentially released. This provides a structural basis for the observed predominance of **electron emission in beta decay**.

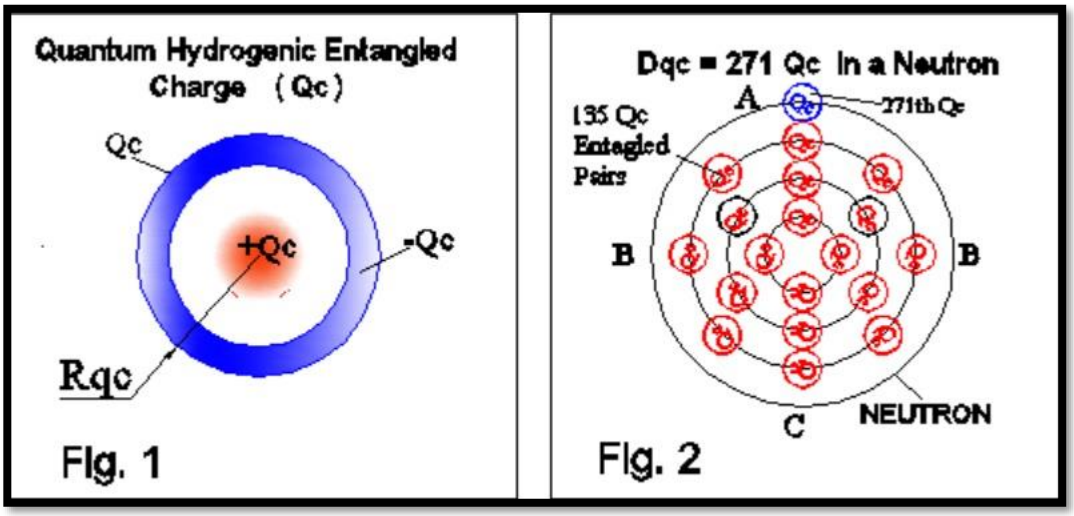

Fig. 1. Schematic representation of the hydrogenic Qc structure, showing a central +Qc core surrounded by a −Qc outer shell. The radial separation produces differing confinement conditions, with the outer −Qc being less constrained, thereby providing a structural basis for decay asymmetry.

Fig. 2. Schematic of the neutron Qc structure showing 271 Qc units arranged as 135 entangled pairs and one unpaired boundary unit (271st Qc). A structural coordinate is defined by:

- A: m = 0 (outer boundary)
- B: m = 135 (central region)
- C: m = 270 (opposite boundary)

2.3 Boundary-Referenced Coordinate System

To describe internal propagation, a boundary-referenced coordinate is defined as:

$$m = 271 - n \tag{2}$$

where *m* represents the effective structural distance from the outermost Qc unit.

Thus:

$m = 0 \rightarrow outer\ boundary$

$m = 135 \rightarrow mid - structure$

$m = 270 \rightarrow opposite\ boundary$

2.4 Structural Vulnerability and Decay Origin

The unpaired boundary Qc unit is not part of the entangled pair network and is therefore energetically less constrained.

Consequently:

- decay is initiated at this boundary location
- the remaining 270 Qc units form a fully paired, symmetric, and stable configuration

In the absence of any further unpaired or weakly constrained Qc unit, **a second beta decay does not occur under normal conditions**.

2.5 Temporal Generation from Structural Propagation

The decay process is not assumed to be instantaneous. Instead, a characteristic time emerges from propagation across the internal Qc structure.

A cubic scaling relation is introduced:

$$\frac{t}{\tau} = \left(\frac{m}{135}\right)^3 \tag{3}$$

where:

$$\tau = 866\, s \tag{4}$$

This relation implies that the decay time depends on the effective structural depth.

2.6 Boundary Conditions

The above relation satisfies:

$m = 0 \rightarrow t\ approx\ 0$

$m = 135 \rightarrow t = \tau$

$m = 270 \rightarrow t = 8\tau$

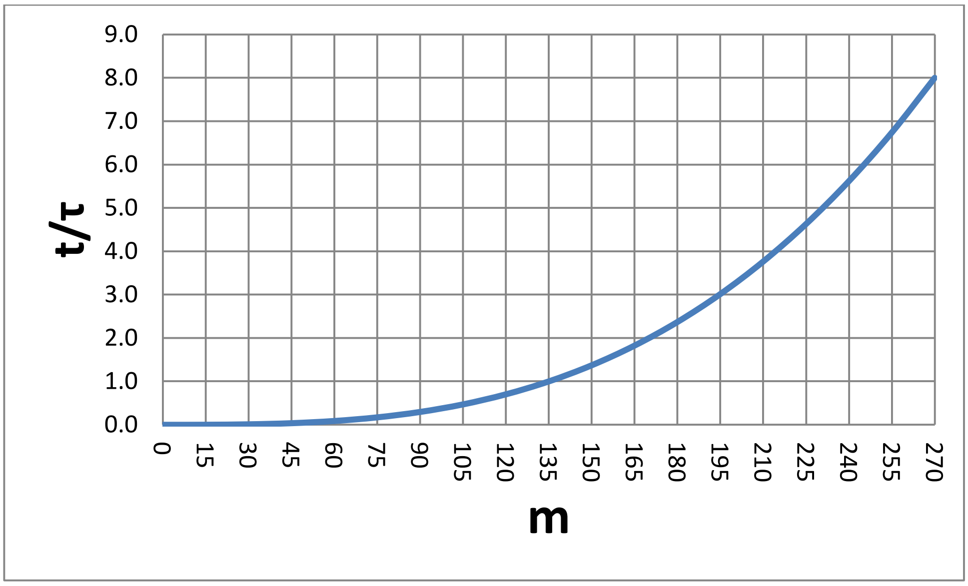

Fig. 3. Structural–Temporal Mapping of Neutron Decay

Structural–temporal mapping of neutron decay showing normalized time t/τ as a function of structural coordinate m. The relation follows cubic scaling $t/\tau = (m/135)^3$, indicating three-dimensional propagation within the Qc structure. The midpoint (m = 135) corresponds to the mean lifetime t/τ =1, while the full structural span (m = 270) corresponds to t = 8τ.

Normalized time (t/ τ) plotted versus structural coordinate (m). The cubic relation:

$$\frac{t}{\tau} = \left(\frac{m}{135}\right)^3 \tag{5}$$

indicates three-dimensional propagation. The midpoint (m = 135) corresponds to mean lifetime, and the full span (m = 270) corresponds to t = 8 τ.

2.7 Emergence of the Exponential Decay Law

The standard exponential decay law is:

$$P(t) = \left(\frac{1}{\tau}\right) e^{-\frac{t}{\tau}} \tag{6}$$

Substituting t(m), we obtain:

$$P(m) = \left(\frac{1}{\tau}\right) e^{-\left(\frac{m}{135}\right)^3} \tag{7}$$

Thus, the exponential decay law emerges as a consequence of internal structural propagation.

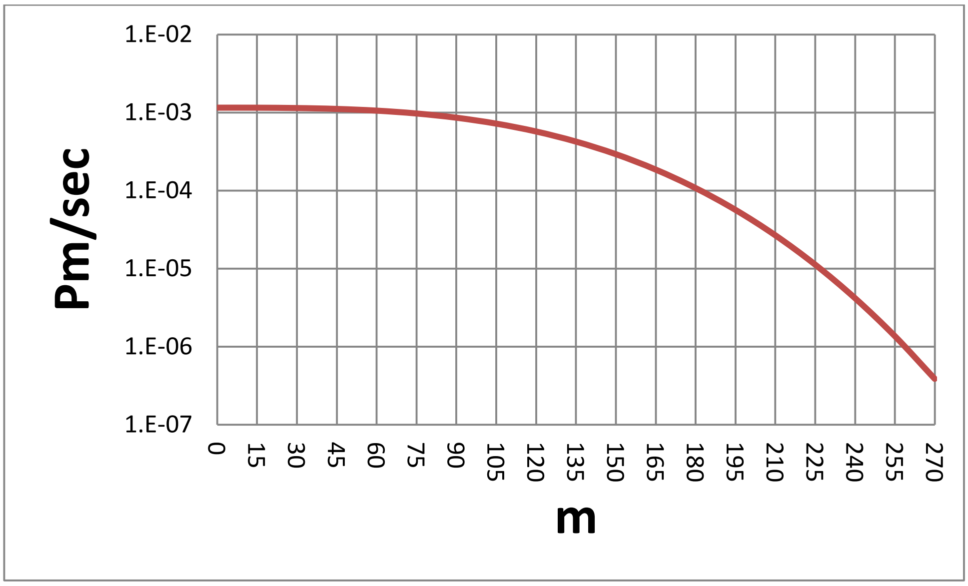

***Fig. 4.* Decay Probability Distribution**

Decay probability P(m) as a function of structural coordinate m, plotted on a logarithmic scale. The distribution follows $P(m) = \left(\frac{1}{\tau}\right) e^{-(m/135)^3}$, exhibiting exponential decay governed by cubic structural scaling within the Qc framework.

2.8 Origin of Temporal Variability

The variability in neutron decay time arises from differences in propagation depth within the Qc structure.

Since internal fluctuation paths vary, the time required to reach the decay-triggering condition is not fixed, leading to a statistical distribution of decay times.

2.9 Summary of the Framework

The neutron is treated as a structured system composed of:

- 270 paired Qc units forming a stable entangled core
- one unpaired boundary Qc unit responsible for decay initiation

Decay originates at the boundary and is governed by propagation through the internal structure. The cubic scaling of this propagation naturally leads to the observed exponential decay law.

3. Conclusion

In this work, the neutron has been modeled as a structured assembly of discrete quantum charge units (Qc), consisting of 135 entangled pairs and a single unpaired boundary unit. This structural asymmetry provides a natural origin for decay initiation without requiring additional external mechanisms.

By introducing a boundary-referenced coordinate system, the decay process is interpreted as a propagation phenomenon within the internal structure. A cubic scaling relation,

$$t/\tau = \left(\frac{m}{135}\right)^3 \quad (8)$$

is proposed to represent three-dimensional structural propagation. This relation establishes a direct connection between internal structural depth and the observed decay time.

When combined with the standard decay expression,

$$P(t) = \left(\frac{1}{\tau}\right) exp(-t/\tau) \tag{9}$$

the exponential decay law emerges as a consequence of structural propagation rather than as an independent statistical postulate. The resulting formulation,

$$\mathrm{P(m)} = (1/\,\tau)\ \mathrm{exp}\ (-\left(\frac{m}{135}\right)^3) \tag{10}$$

provides a structural interpretation of decay probability in terms of internal configuration.

The presence of a single unpaired boundary Qc unit explains both the preferential emission of the electron and the absence of a second beta decay under normal conditions. Following the initial decay, the remaining configuration becomes fully paired and structurally stable, eliminating further sites of instability.

The variability in neutron lifetime is attributed to differences in internal propagation depth and fluctuation pathways within the Qc structure, leading naturally to the observed statistical distribution of decay times.

Overall, the present framework offers a deterministic structural perspective on neutron decay, in which temporal behavior and probabilistic decay laws arise from internal organization and propagation dynamics. While the assumptions regarding Qc structure and hydrogenic configuration require further validation, the consistency of the resulting formulation suggests that such an approach may provide a useful complementary viewpoint to existing descriptions.

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