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A Classical Derivation of the Neutron Strong Force from Internally Confined Hydrogenic Charge Structure

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Abstract:
This work presents a classical, deterministic derivation of neutron confinement and the strong nuclear force based on an internally confined hydrogenic charge structure. The neutron is modeled as a composite system of discrete charge-confinement units (Qc), each consisting of oppositely charged components confined within a characteristic radius and interacting through Coulomb attraction in a bounded geometry.

Using neutron beta-decay energetics together with deuteron binding energy, a characteristic energy per Qc unit is defined, yielding a discrete estimate of the number of internal constituents, Dqc ≈ 271. Assuming uniform confinement within an effective neutron radius, volumetric scaling leads to a unique Qc length scale of Rqc ≈ 0.155 fm.

The Coulomb interaction within each confined unit establishes an intrinsic inward force and an associated confinement pressure of order Pcbp ≈ 10^{34} newton/m². This pressure, transmitted to the neutron scale through geometric continuity, yields a neutron confinement force of order Fn ≈ 10^5 newton, consistent with established confinement estimates. Notably, the magnitude of the derived pressure is comparable, in order of magnitude, to extreme pressures encountered in dense astrophysical systems, although it arises here purely from charge confinement at the sub-nuclear level.

The results demonstrate that neutron stability and strong-force magnitude can be derived directly from charge interaction and geometric confinement, without invoking phenomenological potentials, quantum chromodynamics, or adjustable parameters. The hydrogenic charge-confinement model thus provides a simple and transparent classical framework for understanding nuclear-scale force generation.

Keywords: Neutron Strong Force; Charge-Confinement Model; Hydrogenic Charge Structure; Coulomb Confinement; Confinement Balancing Pressure; Neutron Internal Structure; Classical Nuclear Model; Force Scaling

1. Introduction:

The problem of neutron confinement and the origin of the strong nuclear force has been studied extensively using both phenomenological and quantum-field-based approaches [1–4]. These frameworks successfully reproduce experimental observations such as binding energies and scattering behavior; however, the confinement scale and force magnitude are typically introduced through effective parameters rather than derived directly from elementary physical principles [5–7]. This leaves open the possibility of exploring whether neutron stability can be understood within a simpler deterministic framework based on force balance and geometry.

In an earlier work [8], neutron confinement was examined using a dipole-based internal charge structure within a classical pressure-balance framework. That analysis demonstrated that the neutron-scale confinement force can emerge from Coulomb interaction combined with geometric scaling. The present work extends this line of inquiry by adopting a different internal representation.

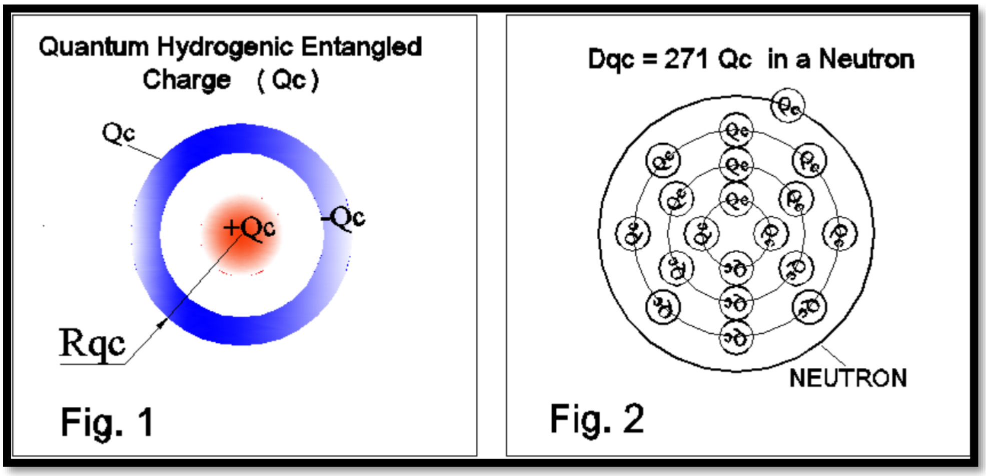
Here, the neutron is modeled as a composite system of discrete charge-confinement units (Qc), each consisting of oppositely charged components interacting through Coulomb forces within a confined geometry. The arrangement of these units is treated as hydrogen-like (hydrogenic) in the sense of a bound charge configuration governed by electrostatic interaction. This analogy is employed purely as a structural guide and does not imply equivalence with the quantum mechanical hydrogen atom [9].

Using neutron beta-decay energetics together with nuclear binding energy [10], a characteristic energy per Qc unit is defined, leading to a discrete estimate of the number of internal constituents. The corresponding spatial scale is obtained through volumetric confinement within the neutron radius [11]. The Coulomb interaction at the Qc level then provides an intrinsic inward force and an associated confinement pressure, which is propagated to the neutron scale through geometric pressure continuity.

The resulting confinement pressure is of order 10^{34} newton/m^2, representing the mechanical scale required for neutron stability. Although this value is numerically comparable to c^4, the two quantities are not dimensionally equivalent and are not directly related.

The objective of the present work is therefore to derive, within a classical and deterministic framework, the internal structure of the neutron, its characteristic length scale, the associated confinement pressure, and the magnitude of the confinement force, using only electrostatics, geometry, and experimentally established energy inputs. No phenomenological interaction ranges or quantum-field formalisms are invoked.

The conceptual representation of the hydrogenic Qc unit and the resulting neutron structure are illustrated in Fig. 1 and Fig. 2, respectively.



Conceptual Hydrogenic Qc and Neutron Model

Fig. 1:

A hydrogenic Qc charge-confinement unit composed of two oppositely charged components (+Qc) and (−Qc), each carrying charge q, confined within a characteristic radius Rqc. The interaction is governed by Coulomb attraction within a bounded geometry.

Fig. 2:

Schematic representation of the neutron as a composite system of Dqc ≈ 271 Qc units arranged symmetrically to form an overall neutral structure. The collective Coulomb confinement of these units gives rise to neutron-scale force and internal pressure.

2. Main Framework:

2.1 Derivation of the Number of Qc Units (Dqc) in the Neutron:

Having established the concept of **charge-confinement units (Qc)** and the associated **confinement balancing pressure (Pcbp)**, we now develop a quantitative framework for the internal structure of the neutron. However, this formulation does not replace existing models, but provides an equivalent deterministic interpretation based on charge confinement. The formulation is based on the following physical quantities:

- Qc : Charge-confinement unit consisting of ±q
- Rqc : Effective radius of a Qc unit
- Dqc : Total number of Qc units in the neutron
- En : Neutron rest energy
- Ep : Proton rest energy
- Ed : Beta-decay energy
- Eb : Deuteron binding energy
- Eqc : Energy per Qc unit
- Rn : Effective neutron radius
- Pcbp : Confinement balancing pressure
- Fn : Neutron confinement force

These quantities together establish a direct connection between **charge structure and measurable nuclear parameters**.

2.2 Estimation of Dqc from Beta Decay and Binding Energy:
The neutron beta decay process is:

$$En \rightarrow Ep + e^- + \bar{\nu}e \qquad (2.1)$$

The corresponding decay energy is:

$$Ed = En - Ep \approx 1.293 \text{ MeV} \qquad (2.2)$$

To account for neutron–proton coupling, we include the deuteron binding energy:

$$Eb \approx 2.224 \text{ MeV} \qquad (2.3)$$

We define the characteristic energy per Qc unit as:

$$Eqc = Ed + Eb \approx 1.293 + 2.224 \approx 3.46 \text{ MeV} \qquad (2.4)$$

Assuming the neutron energy arises from Dqc identical units:

$$En = Dqc \times Eqc \qquad (2.5)$$

Thus,

$$Dqc = \frac{En}{Eqc} = \frac{939.565}{3.46} \approx 271 \qquad (2.6)$$

Each Qc unit consists of two opposite charges:

$$q = 1.602 \times 10^{-19} \text{ C} \qquad (2.7)$$

The convergence to Dqc ≈ 271 from independent energy considerations strongly supports the internal charge-confinement model.

2.3 Neutron Radius Definition:
Two physically relevant neutron radii are considered:

- Effective confinement radius:
  Rn ≈ 1.0 fm
- Free neutron radius:
  Ro ≈ 1.23–1.25 fm

The confined radius Rn is used for internal force derivation.

2.4 Volumetric Scaling and Qc Radius:
Assuming uniform packing of Dqc units:

$$Rqc = \frac{Rn}{(Dqc)^{\frac{1}{3}}} \quad (2.8)$$

Substituting:

$$Rqc = \frac{(1.0 \times 10^{-15})}{(271)^{1/3}} \approx 0.155 \times 10^{-15}\ \text{m} = 0.155\ \text{fm} \quad (2.9)$$

For free neutron:

$$Ro = \frac{(1.23 \times 10^{-15})}{(271)^{1/3}} \approx 0.19 \times 10^{-15}\text{m} = 0.19\ \text{fm} \quad (2.10)$$

2.5 Coulomb Confinement Force at Qc Level-

The inward Coulomb force within a Qc unit is:

$$Fqc = \frac{q^2}{(4\pi\ \varepsilon_0\ Rqc^2)} \quad (2.11)$$

Where:

- $q = 1.602 \times 10^{-19}$ C
- $\varepsilon_0 = 8.85 \times 10^{-12}$ F/m
- $Rqc = 0.155 \times 10^{-15}$ m

Substituting:

$$Fqc \approx 9.64 \times 10^3 \text{ newton} \quad (2.12)$$

2.6 Qc Surface Pressure:

Surface area:

$$Aqc = 4\pi\ Rqc^2 \quad (2.13)$$

Pressure:

$$Pqc = Fqc / Aqc \quad (2.14)$$

Substituting:

$$Pqc = \frac{q^2}{(16\ \pi^2 \varepsilon_0\ Rqc^4)} \quad (2.15)$$

Numerically:

$$Pcbp \approx 3.2 \times 10^{34} \text{ newton/m}^2 \quad (2.16)$$

This represents the **confinement balancing pressure** at the Qc level.

2.7 Scaling to Neutron-Level Force:
Assuming pressure continuity across scales:

$$Fn / (4\pi\, Rn^2) = Pcbp \quad (2.17)$$

Thus:

$$Fn = 4\pi\, Rn^2 \times Pcbp \quad (2.18)$$

2.8 Numerical Evaluation:
Using:

$Rn = 1.0 \times 10^{-15}$ m

$Pcbp = 3.2 \times 10^{34}$ newton/m^2

$$Fn = 4\pi\,(1.0 \times 10^{-15})^2 \times 3.2 \times 10^{34} \quad (2.19)$$

$$Fn \approx 4 \times 10^5 \text{ newton} \quad (2.20)$$

2.9 Physical Interpretation:
The neutron confinement force:

$Fn \approx 10^5$ newton

emerges directly from:

1. Coulomb interaction at Qc scale
2. Geometric volumetric scaling
3. Surface pressure continuity

This result demonstrates that neutron stability arises from internal charge confinement, without invoking an external short-range force model.

3. Conclusions:
3.1 Central Principle

The present work demonstrates that neutron confinement and the magnitude of the strong force can be derived from a single deterministic principle: internal charge confinement governed by Coulomb interaction within a bounded geometry, combined with geometric scaling across length scales.

3.2 Determination of Internal Structure (Dqc)

Using neutron beta-decay energetics together with deuteron binding energy, a characteristic energy per charge-confinement unit is defined. This leads to a discrete estimate of the number of internal constituents:

$Dqc \approx 271$

This result provides a structured, energy-based description of neutron internal composition.

3.3 Emergence of Characteristic Length Scale (Rqc)

Assuming uniform confinement of Qc units within the neutron, volumetric scaling yields a unique confinement radius:

$Rqc \approx 0.155$ fm

This length scale arises directly from geometric considerations and is not introduced as an adjustable parameter.

3.4 Coulomb-Based Confinement and Pressure Scale

Each Qc unit consists of oppositely charged components confined within a characteristic radius, generating an intrinsic inward Coulomb force. The corresponding confinement pressure at the Qc scale is obtained as:

$Pcbp \approx 10^{34}$ newton/m^2

This pressure represents the internal mechanical condition required for stable charge confinement within the neutron. Notably, this magnitude is comparable, in order of magnitude, to extreme pressures encountered in dense astrophysical systems such as neutron stars [12], although the underlying physical mechanisms are fundamentally different. The present result arises purely from charge confinement and geometric scaling at the sub-nuclear level.

3.5 Derivation of Neutron Strong Force (Fn)

By enforcing pressure continuity between the Qc scale and the neutron boundary, the confinement force scales geometrically to the neutron level, yielding:

$Fn \approx 10^5$ newton

This value is consistent with accepted estimates for neutron-scale confinement and is obtained without invoking phenomenological potentials or quantum-field-based interactions.

3.6 Physical Interpretation

The results indicate that neutron stability can be understood as a consequence of internally confined charge structure and scale-invariant force transmission, rather than as an externally imposed short-range interaction. The strong force is thus interpreted as a macroscopic manifestation of confined Coulomb interactions within a structured system.

3.7 Scope and Positioning

The analysis is restricted to a classical and deterministic framework based on electrostatics and geometry. It does not seek to replace existing quantum descriptions, but to provide a complementary analytical perspective on confinement and force magnitude.

3.8 Final Remark

The hydrogenic charge-confinement model demonstrates that key neutron properties—internal structure, characteristic length scale, and confinement force—can be derived consistently from elementary physical principles, offering a simple and transparent basis for further investigation of nuclear-scale interactions.

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