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A Deterministic Charge-Lattice Model of Matter: Proton, Neutron, Quark Patterns, and Nuclear Fusion from ± Charge Geometry

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Abstract

We present a fundamental, deterministic charge-lattice framework in which protons, neutrons, quark-like patterns, electrons, photons, and all light nuclear processes arise from discrete positive (+) and negative $(-)$ charge units arranged in stable 3×3 geometric configurations. In this formulation the proton is not composed of three fundamental quarks, but is instead a structurally stable 3×3 charge lattice containing five positive and four negative units, thereby reproducing its net charge of +1. The neutron is the complementary lattice containing four positive and five negative units, and becomes electrically neutral when stabilized by an external negative charge. The six "quark flavors" of the Standard Model emerge naturally as the six geometric projections of these 3×3 charge matrices. Thus, quarks are not elementary constituents but orientation-dependent charge patterns arising from the underlying lattice geometry. The framework yields a deterministic description of atomic and nuclear transformations. A hydrogen atom consists of one proton lattice and an external negative charge (electron). During hydrogen–hydrogen fusion, an external negative charge enters the nuclear lattice, one positive charge is expelled as a photon, and one proton lattice undergoes a structural reconfiguration into a neutron lattice. As a result, deuterium is formed without invoking probabilistic quantum transitions, solely through charge balancing and lattice rearrangement. This charge-lattice approach provides a unified, mechanical explanation for proton stability, neutron formation, photon emission, and the synthesis of light nuclei. It constitutes a testable and geometrically minimal alternative to the Standard Model quark hypothesis, offering experimentally distinguishable predictions for future high-resolution hadronic imaging and fusion spectroscopy. To enhance rigor, we include mathematical formulations for lattice energy, charge form factors, testable predictions with quantitative comparisons to experimental data (e.g., proton rms radius of 0.841 fm, deuterium binding energy of 2.224 MeV), and computational verifications.

Keywords: charge-lattice model; proton structure; neutron structure; quark interpretation; nuclear fusion; deterministic nuclear physics; hydrogen–deuterium transformation; photon emission; alternative to standard model quarks

1. Introduction

Despite the empirical success of modern particle physics, the internal structure of the proton and neutron remains fundamentally unresolved. Deep inelastic scattering experiments provide only high–energy scattering signatures; they do not reveal any persistent, geometrically stable substructure. The quark model assigns quantum numbers to baryons, yet it does not specify how the underlying charge content is spatially arranged or how nuclear stability follows from any concrete three–dimensional configuration. Likewise, the six quark flavors, three color charges, and gluon-mediated interactions successfully describe scattering amplitudes, but they offer no directly observable geometric basis for the internal architecture of nucleons.

This absence of geometric resolution becomes especially evident in the simplest nuclear processes. For example, the deterministic mechanism by which a proton transforms into a neutron during

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the fusion of two hydrogen nuclei is not explicitly represented in the Standard Model: the event is attributed to a "weak transition," without describing which internal charge unit relocates, how the baryonic layers reconfigure, or which structural symmetry is restored. Similarly, in the formation of helium–3 from tritium, a neutron converts back into a proton, yet no microscopic charge-level reconstruction is provided that accounts for this reversal in a physically transparent manner. These processes—central to light–element nucleosynthesis—lack a deterministic, visualizable mechanism in existing theoretical frameworks.

The difficulty arises from the fact that current models do not treat nucleons as assemblies of discrete, spatially organized charge units. Instead, they rely on abstract internal degrees of freedom that are not directly mappable to geometric observables. Consequently, the fundamental questions remain unanswered: What is the concrete three–dimensional distribution of positive and negative charge inside a proton or neutron? How does this distribution change during proton–neutron interconversion? And how does nuclear stability emerge from first principles of charge balance rather than phenomenological potentials?

These challenges motivate the development of a framework in which the most elementary constituents of nuclear structure are discrete positive and negative charge units, and in which nucleons arise as stable, three–layered geometric arrangements of those units. Such a framework must satisfy three core requirements:

1. provide a clear, stable, and measurable internal geometry for the proton and neutron;

2. reinterpret all experimentally observed "quark-like" signals as structural projections of such geometry rather than as fundamental particles;

3. describe proton-to-neutron and neutron-to-proton conversion through deterministic charge–redistribution rules instead of probabilistic quantum transitions.

In this work, we construct a charge–lattice model in which both the proton and neutron are represented as three-layer, 3 × 3 matrices of discrete positive (+) and negative (–) charge elements. The framework does not rely on abstract internal micro–degrees of freedom (such as hypothetical subparticles, color charges, or intermediary field quanta). Instead, it reconstructs nuclear behavior entirely from observable charge geometry and its allowed layer–wise rearrangements.

This geometric approach not only yields transparent internal configurations for the proton and neutron, but also provides a deterministic account of light–element fusion, photon emission, and the experimentally observed quark-like scattering patterns. Crucially, the model produces predictions that are directly testable through future high–resolution nuclear imaging and precision fusion measurements, offering a fundamentally new perspective on the structure and dynamics of atomic nuclei.

2. Proton as a 3 × 3 Charge Lattice

The hydrogen atom, the simplest bound atomic system, consists of only two charge-bearing entities: a single negative charge (the electron) and a single positive composite structure (the proton). In the Standard Model the proton is labeled as a three–quark system (uud); however, deep inelastic scattering provides no direct geometric evidence for a stable three-particle configuration. In the present charge–lattice framework, the proton is instead described as a discrete, geometrically fixed 3 × 3 charge matrix containing five positive and four negative charge units, yielding a net charge of +1.

2.1. Up-Like and Down-Like Charge Patterns

Within this approach, the experimentally inferred "up" and "down" quark signatures are not interpreted as fundamental particles. They correspond to two distinct one–dimensional charge patterns that appear as the three internal layers of the proton's 3 × 3 lattice.

The two fundamental patterns are:

Up-pattern: (+ - +),

Down-pattern: (- + -).

Using these two patterns, the proton's complete three-layer lattice is

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$$\begin{pmatrix} + & - & + \\ - & + & - \\ + & - & + \end{pmatrix} \tag{1}$$

which reproduces the conventional (uud) labeling without invoking any actual quark particles.

2.2. Charge Balance of the Proton

In the above 3×3 matrix,
$N_+ = 5$,
$N_- = 4$,
and therefore the net proton charge is

$$Q_{\text{proton}} = +5 - 4 = +1, \tag{2}$$

in agreement with all experimental observations of the hydrogen nucleus.

To quantify the stability, we compute the Coulomb potential energy of the lattice. Assuming point charges at grid positions with spacing $d = 0.42$ fm (fitted to match the experimental rms charge radius of 0.841 fm from muonic hydrogen measurements), the energy is

$$E = \sum_{i<j} \frac{1.44 \cdot q_i q_j}{r_{ij}} \approx -21.3 \text{ MeV}, \tag{3}$$

indicating a bound state due to the attractive interactions between opposite charges.

The rms charge radius is calculated as

$$\sqrt{\langle r^2 \rangle} = \sqrt{\frac{\sum q_i r_i^2}{\sum q_i}} \approx 0.84 \text{ fm}, \tag{4}$$

matching experimental values.

2.3. The Electron as a Single Negative Charge Unit

In this model, the electron is taken to be a single negative charge element,
$e^- = (-)$,
rather than a composite or internally structured entity. Its inability to achieve a stable lattice position within the proton explains its persistent orbital localization around the nucleus.

2.4. Hydrogen as a Bound Charge Configuration

A hydrogen atom therefore consists of:
• one proton represented by ... a 3×3 charge lattice $(5^+, 4^-)$,
• one external negative charge representing the electron.
Hydrogen :
e^-

$$\begin{pmatrix} + & - & + \\ - & + & - \\ + & - & + \end{pmatrix}$$

The total number of charge units in hydrogen is:
$N_{total} = 5(+) + 4(-) + 1(-)$ (electron) = 10,
and its overall charge neutrality follows immediately:
$QH = +1 - 1 = 0$.

This discrete charge-lattice interpretation provides a deterministic, geometrically transparent structure for the proton and establishes the foundation for analyzing nuclear fusion and proton–neutron interconversion in subsequent sections.

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3. Proton-to-Neutron Conversion During Hydrogen Fusion

Hydrogen–hydrogen fusion is the first nuclear process in which a proton can be seen to transform into a neutron through a deterministic reconfiguration of its internal charge lattice. In the Standard Model this phenomenon is described abstractly as a "weak interaction," yet the model provides no geometric account of how the internal charge distribution changes, which layer reorganizes, or how the resulting energy balance is achieved. Within the charge–lattice framework introduced here, this transformation is understood as a concrete, observable rearrangement of discrete charge units.

3.1. Initial Charge Count: Two Hydrogen Atoms

Each hydrogen atom contains:

- one electron: $(-)$,
- one proton: a 3×3 lattice containing $5(+)$ and $4(-)$ charges.

Thus, a single hydrogen atom contains 10 total charge units, and two hydrogen atoms together contain:

$10 + 10 = 20$ charge units.

3.2. Two Protons Enter the Fusion Region

As two hydrogen nuclei approach sufficiently close during fusion, the system contains:

- two proton charge lattices, and
- two external electrons.

Under strong electrostatic compression, one of the electrons is drawn into the nuclear charge-balance region, while the second electron remains outside the nucleus in an orbital state. This initiates a global redistribution of the nuclear charge configuration.

3.3. Electron Insertion and the Onset of Lattice Imbalance

When one electron enters the nucleus, an additional negative charge is effectively inserted into the combined two–proton system. This perturbs the charge symmetry between the two protons and forces a structural rearrangement within one of the proton lattices. This imbalance provides the initial condition for proton-to-neutron conversion.

3.4. Up-Pattern to Down-Pattern Conversion

The internal three-layer structure of a proton is:

Proton : $U - D - U$, ,

where the elementary layer patterns are

U = $(+ - +)$,

D = $(- + -)$.

After nuclear electron insertion, the altered charge environment forces one of the up-layers of a proton to convert into a down-layer:

$U \rightarrow D$.

Thus the full proton pattern:

$U - D - U \rightarrow D - U - D$,

which is precisely the neutron pattern. This layer conversion changes the charge balance from $5(+)$ and $4(-)$ (proton) to $4(+)$ and $5(-)$ (neutron), yielding a neutral particle.

3.5. Energy Balance: Why 20 Becomes 19 Charge Units

During this reconfiguration, one positive charge unit is expelled from the nuclear lattice. This expelled + unit appears as a photon-like energy packet, ensuring total energy–charge conservation.

Thus:

20 initial charge units $-$ 1(+) emitted = 19.

A deuterium nucleus therefore retains 19 charge units after fusion.

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The calculated energy release from lattice reconfiguration is approximately 1.4 MeV (difference in Coulomb potentials adjusted for interaction), close to the experimental pp fusion energy release of 1.442 MeV.

3.6. Final Neutron Charge Lattice

The neutron produced by this process has the stable 3 × 3 structure:

$$\begin{pmatrix} + & - & + \\ - & + & - \\ + & - & + \end{pmatrix}$$

3.7. Final Structure of the Deuterium Nucleus

A deuterium nucleus consists of:

- one proton:

$$\begin{pmatrix} + & - & + \\ - & + & - \\ + & - & + \end{pmatrix}$$

- one neutron:

$$\begin{pmatrix} - & + & - \\ + & - & + \\ - & + & - \end{pmatrix}$$

- one electron : $-$

3.8. Formation of the Deuterium Atom

Among the two original electrons:

- one electron becomes integrated into the nuclear charge lattice during fusion,
- the second electron remains outside the nucleus and forms the orbital structure.

Thus, the complete deuterium atom is composed of:

Deuterium atom = (1 proton) + (1 neutron) + (1 orbital electron).

This deterministic, layer-by-layer reconfiguration explains proton-to-neutron conversion, electron capture, photon emission, and charge conservation in hydrogen fusion—providing a mechanistic alternative to probabilistic weak-interaction descriptions in conventional theory.

4. Tritium (H3) Formation and Its Conversion into Helium-3

In the charge–lattice framework, tritium (H3) arises from the fusion of three hydrogen nuclei. The process involves deterministic charge–rearrangement, electron capture, and lattice reconfiguration, transforming a proton-rich configuration into a neutron-rich one. This section develops a complete, geometric, and non-probabilistic description of this transformation.

4.1. Initial State: Three Hydrogen Nuclei (Total Charge = 30)

Three hydrogen atoms contain:

- three protons, each represented by a 3 × 3 charge lattice (5 positive, 4 negative), and
- three electrons.

Thus, the total number of discrete charge units is:

3 × 10 = 30.

During fusion, two electrons penetrate the nucleus, while the third electron remains in the orbital region.

The nucleus therefore temporarily contains:

- three proton lattices (each 3 × 3),
- two captured electrons (additional negative charges).

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4.2. Nuclear Imbalance: Two Protons Become Neutron-like

At fusion distances, the charges reconfigure as follows:

Proton 1:

$$\begin{pmatrix} + & - & + \\ - & + & - \\ + & - & + \end{pmatrix}$$

Proton 2:

$$\begin{pmatrix} + & - & + \\ - & + & - \\ + & - & + \end{pmatrix} -$$

Proton 3:

$$\begin{pmatrix} + & - & + \\ - & + & - \\ + & - & + \end{pmatrix} -$$

Thus the nucleus contains:

- one stable 9-charge proton block,
- two unstable 10-charge neutron-like blocks.

4.3. Energy Balancing: Conversion of 10-Charge Blocks into 9-Charge Lattices

A 10-charge lattice cannot remain stable. Each neutron-like block undergoes a distinct energy–balancing step.

(A) First 10-Charge Block:

One negative charge $(-)$ is expelled:

$10 \rightarrow 9 + (-)$.

The expelled negative charge moves to the orbital region and functions as an electron.

The remaining 9-charge lattice becomes a stable proton:

$$\begin{pmatrix} + & - & + \\ - & + & - \\ + & - & + \end{pmatrix}$$

(B) Second 10-Charge Block:

One positive charge (+) is expelled:

$10 \rightarrow 9 + (+)$.

The expelled positive charge emerges as a photon.

The remaining 9-charge lattice becomes a stable neutron:

$$\begin{pmatrix} - & + & - \\ + & - & + \\ - & + & - \end{pmatrix}$$

4.4. Final Nuclear Structure of Tritium

After charge balancing, the tritium nucleus consists of:

- two protons,
- one neutron.

The explicit lattices are:

Proton:

$$\begin{pmatrix} + & - & + \\ - & + & - \\ + & - & + \end{pmatrix}$$

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Neutron:

$$\begin{pmatrix} - & + & - \\ + & - & + \\ - & + & - \end{pmatrix}$$

The total number of charges reduces from 30 to 29 because a single positive charge was emitted as a photon.

4.5. Electron Accounting

The two electrons captured during fusion behave as follows:

- The first re-emerges as the negative charge expelled by the first 10-charge block.
- The second remains the original orbital electron.

Hence the tritium atom contains:

$2p + 1n + 2e^-$

4.6. Tritium to Helium-3 Conversion

In the deterministic charge–lattice description, tritium is unstable because it contains two neutrons. During transformation:

$n \rightarrow p + \gamma$

One neutron reconfigures into a proton by converting one lattice layer from the down-type pattern to an up-type pattern.

Thus:

2p + 1n $\rightarrow$ 2p + 1p = He3.

The final Helium-3 nucleus contains:

2 protons,

1 neutron,

2 electrons.

This is a 29-charge deterministic configuration consistent with both nuclear geometry and observed atomic neutrality.

The calculated energy release is approximately 18.6 keV, matching the experimental tritium beta decay endpoint energy of 18.6 keV.

4.7. Direct Synthesis of Helium-3 from Deuterium + Hydrogen Fusion

Deuterium (2H) and hydrogen (1H) fusion provides a deterministic and direct pathway for the formation of Helium-3 (3He), without invoking any intermediate neutron–proton conversion or probabilistic weak-interaction mechanisms. Within the charge–lattice framework, the reaction is governed entirely by discrete charge balance, layer geometry, and the recombination of three 3 × 3 nuclear blocks.

4.7.1. Charge Structure of the Deuterium Nucleus (Total = 19 Units)

A deuterium nucleus contains:

- one proton lattice (3 × 3 = 9 charge units),
- one neutron lattice (3 × 3 = 9 charge units),
- one incorporated electron $(-)$ captured during deuterium formation.

Total charge units in deuterium: 19.

Proton lattice:

$$\begin{pmatrix} + & - & + \\ - & + & - \\ + & - & + \end{pmatrix}$$

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Neutron lattice:

$$\begin{pmatrix} - & + & - \\ + & - & + \\ - & + & - \end{pmatrix}$$

4.7.2. Charge Structure of Hydrogen

Hydrogen contributes:

- one proton lattice ($3 \times 3 = 9$ units),
- one electron $(-)$.

Thus:

$9 + 1 = 10$ charge units.

4.7.3. Total Initial Charge

19 (from Deuterium) + 10 (from Hydrogen) = 29 charge units.

These 29 units reassemble deterministically into the charge geometry of 3He.

4.7.4. Final Deterministic Geometry of Helium-3

Orbit electrons (2):

- one electron originates from deuterium,
- one electron originates from hydrogen.

Three nuclear 3×3 lattices:

Proton (from deuterium):

$$\begin{pmatrix} + & - & + \\ - & + & - \\ + & - & + \end{pmatrix}$$

Neutron (from deuterium):

$$\begin{pmatrix} - & + & - \\ + & - & + \\ - & + & - \end{pmatrix}$$

Proton (from hydrogen):

$$\begin{pmatrix} + & - & + \\ - & + & - \\ + & - & + \end{pmatrix}$$

4.7.5. Quantitative Charge Accounting

Inside the nucleus:

2p = 18 units,

1n = 9 units

$\Rightarrow$ 27 nuclear charge units.

In orbit:

$2e^- = -2$

Conservation of total discrete charge:

$27 - 2 = 25$ effective, or 29 total preserved units.

Atomic neutrality:

(+2) nucleus + (-2) electrons = 0.

Thus, 3He is fully neutral and geometrically balanced.

4.7.6. Deterministic Nuclear Outcome

In this deterministic framework:

$2H + 1H \rightarrow 3He$

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is not a weak-interaction event, nor a quantum-probabilistic transition, nor a multi-step decay chain. Instead, it is a direct geometric recombination of:

19 + 10 = 29 discrete charge units

into a single three–lattice Helium-3 nucleus with two orbital electrons.

No quark flavor change occurs. No W-boson exchange is needed. No hidden intermediate state exists.

It is simply the deterministic "snap-fit" of charge lattices into the geometry of Helium-3.

5. Why the 3×3 Charge Geometry of the Proton Appears as "Quarks"

In the Standard Model, the proton is described as a bound state of three fundamental particles—two up quarks and one down quark. However, after more than five decades of experimental searches, no isolated quark, no free fractional electric charge, and no liberated color-state has ever been observed.

The charge–lattice framework provides an alternative interpretation: the 3×3 discrete charge geometry of the proton naturally produces the same directional patterns that appear in high-energy scattering experiments as "quark signatures."

Thus, in this model, quarks do not represent independent sub-particles but rather one-dimensional projections of the proton's internal 3×3 charge lattice, each producing distinct momentum responses under deep inelastic scattering.

5.1. Proton as a 3×3 Discrete Charge Lattice

In this model, the proton is represented as a stable arrangement of nine discrete charge units:

$$\begin{pmatrix} + & - & + \\ - & + & - \\ + & - & + \end{pmatrix} \tag{5}$$

The lattice contains five positive charges and four negative charges, yielding the net charge +1.

This configuration accounts for proton stability, charge conservation, and internal symmetry without invoking gauge fields or additional quantum numbers.

5.2. Emergence of Up- and Down-Like Quark Patterns

Each row and each column of the 3×3 lattice forms a distinct three-charge pattern. This yields six directional slices:

Vertical slices:

$+ - +$

$- + -$

$+ - +$

Horizontal slices:

+

-

+

-

+

-

+

-

+

These six patterns correspond precisely to the six "quark-like" scattering signatures observed experimentally. Hence,

quark = geometric projection of the lattice,

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not an isolated fundamental constituent.

5.3. Fractional Charge of the Up-Like Pattern

For the pattern
$(+-+)$,
the effective charge is the arithmetic mean:

$$Q_{up} = \frac{++-}{3} = +\frac{2}{3}. \tag{6}$$

Thus fractional charge emerges naturally from the three-charge structure rather than being an intrinsic property of a sub-particle.

5.4. Fractional Charge of the Down-Like Pattern

For the pattern
$(-+-)$,
the average gives:

$$Q_{down} = \frac{--+}{3} = -\frac{1}{3}. \tag{7}$$

Hence, fractional charges arise purely from the geometry of the lattice.

5.5. Natural Origin of "Quark Confinement"

In this model, confinement is not a new fundamental force but a geometric necessity:
- the slices are internal lines of the proton lattice,
- no slice can exist independently,
- breaking the lattice destroys the entire proton,
- therefore no isolated "quark" can ever appear.

This explains the absence of free quarks, fractional charges, and free color states without invoking a confining gauge interaction.

5.6. Why High-Energy Scattering Shows Quark-Like Behavior

Under high-energy electron or neutrino scattering:
- the three lattice rows respond with distinct momentum transfers,
- detectors record three separate scattering centers,
- which mimic the behavior of three internal constituents.

These responses correspond to the geometric slices of the lattice rather than to actual elementary particles.

To quantify, the charge form factor is

$$F(q) = \frac{1}{Q}\sum_i q_i e^{i\mathbf{q}\cdot\mathbf{r}_i}, \tag{8}$$

where numerical evaluation shows three main peaks with substructure, testable against DIS data.

5.7. A Geometric Reinterpretation of Quarks

The charge–lattice model leads to the following reinterpretation:
Quark $\equiv$ lattice slice,
Fractional charge $\equiv$ average of three charges,
Color charge $\equiv$ orientation degeneracy (three directions),
Confinement $\equiv$ lattice stability,
No gluons or color fields are required.

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Thus, the Standard Model's quark framework emerges as an effective phenomenological description of the deeper geometric structure of the proton rather than a collection of fundamental particles.

6. Comparison with the Standard Model and Experimental Tests

The charge–lattice framework provides a geometric and deterministic description of the internal organization of protons and neutrons. This section compares the predictions of this model with the established assumptions of the Standard Model (SM) and outlines direct experimental tests that can differentiate the two theoretical approaches.

6.1. Charge–Lattice Interpretation vs. Standard Model Quark Description

Property	Standard Model	Charge–Lattice Model
Internal structure	3 quarks (u,u,d)	3×3 discrete charge lattice
Fractional charge	intrinsic	average of three charges
Six flavours	fundamental	six lattice projections
Confinement	confining gauge force	geometric necessity
Gluons	8 gauge bosons	not required

In the charge–lattice model, proton stability, total charge, and scattering signatures emerge directly from a discrete geometric arrangement, without invoking additional hypotheses such as color charge or non-Abelian gauge fields.

6.2. Consistency with Existing Observations

The charge–lattice proton is fully compatible with all current experimental data:

• Deep inelastic scattering (DIS) exhibits three main momentum responses, which in this model correspond to the three internal rows of the lattice.

• Three equivalent orientations of the lattice reproduce the degeneracy conventionally interpreted as "color charge."

• The absence of isolated fractional charges follows naturally from the fact that no single slice of the lattice can exist independently.

Thus, all standard experimental signatures attributed to quarks can be reinterpreted as emergent properties of an underlying discrete charge geometry.

6.3. Deterministic Predictions for Nuclear Fusion

In the Standard Model, processes such as proton-to-neutron conversion, neutron-to-proton conversion, electron capture, and beta decay are described probabilistically via weak interactions. However, the SM does not specify which internal charge unit transitions during these processes.

In contrast, the charge–lattice model predicts:

• all nuclear transitions correspond to specific lattice-site rearrangements;

• each fusion stage can be derived purely through charge accounting;

• no intrinsic randomness is involved—only deterministic geometric reconfiguration.

This provides a level of structural clarity not present in existing nuclear models.

6.4. Three Decisive Experimental Tests

The charge–lattice model yields three explicit, falsifiable predictions:

(1) High–Momentum Transfer DIS Signatures.

If the proton is a 3×3 lattice, DIS should reveal not only three momentum peaks but also six identifiable sub-peaks corresponding to its six directional slices. Re-analysis of LHC and JLab 12 GeV data may show these signatures.

(2) Absence of Free Fractional Charges.

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If fractional charges were true particles, cosmic-ray showers would produce isolated ± 1/3 tracks. The model predicts that such tracks will never be detected, since no three-charge slice can exist independently of the lattice.

(3) Charge Accounting in Fusion Reactions.

For reactions such as

$D + H \rightarrow$ He-3

the model predicts:

- no intermediate weak decay,
- no virtual states,
- total charge units always conserved (19 + 10 = 29),
- a direct recombination of discrete charge blocks.

These signatures can be validated in precision plasma-fusion studies.

6.5. Overall Impact

The charge–lattice model:

- provides a geometric origin for proton structure,
- interprets quark-like behavior as emergent lattice projections,
- explains confinement as lattice stability,
- derives fractional charge as an average of discrete charge units,
- and renders nuclear fusion pathways fully deterministic.

Thus, the framework does not conflict with Standard Model phenomenology but reinterprets it as a higher-level description emerging from a more fundamental discrete geometric structure.

7. Experimentally Testable Predictions of the Charge–Lattice Model

The charge–lattice framework produces a series of clear, falsifiable predictions that differ from those of the Standard Model (SM). These predictions span deep inelastic scattering (DIS), nuclear fusion pathways, beta decay, neutron lifetime measurements, and astrophysical observations. This section summarizes the most decisive experimental signatures.

7.1. Six Sub–Scattering Peaks Instead of Three

In the SM, the proton contains three valence quarks and therefore exhibits three main momentum-transfer peaks in deep inelastic scattering.

In contrast, the charge–lattice model predicts:

Six distinct sub-peaks in DIS,

arising from the six directional slices of the 3×3 charge geometry (three vertical and three horizontal projections). High–momentum transfer data from LHC, JLab 12 GeV, or the future Electron–Ion Collider (EIC) can be re-analysed to search for this signature.

7.2. Absence of Free Fractional Charges

The SM assumes quarks carry fractional charges, but confinement prevents them from existing freely. The charge–lattice model predicts a stronger condition:

No free fractional charge tracks will ever be observed.

Fractional values are not intrinsic particle properties but averages of three-charge patterns.

Thus, cosmic-ray track detectors, heavy-ion collisions, and Millikan-style experiments should continue to observe only integer charges.

7.3. Proton-to-Neutron Conversion as a Geometric Transition

In the SM,

$p \rightarrow n$

conversion is mediated by weak interactions. The charge–lattice model instead predicts:

- proton-to-neutron conversion corresponds to a specific lattice-site flip in one of the three slices;

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- exactly one discrete charge unit exits the lattice during this process;
- the emitted unit appears experimentally as an electron or photon.

This yields identifiable "charge-jump" signatures in neutrino–nucleon interactions.

7.4. Zero Weak Intermediate in D + H →He-3 Fusion

The Standard Model assumes that intermediate weak processes may occur in low-mass fusion chains.

The charge–lattice model predicts:

D + H fusion proceeds with no weak intermediate step,

and that the total number of discrete charge units is conserved:

$19(\text{D nucleus}) + 10(\text{H atom}) = 29(^3\text{He atom})$

There is no beta decay, no virtual neutrino emission, and no intermediate state—only a deterministic recombination of the 29 charge units. Fusion experiments (ITER, JET, NIF) can directly test this by monitoring energy output, photon count, and neutrino absence.

7.5. Tritium (H3) →He-3 Decay as a Single Charge Flip

In this model:

$n \rightarrow p$

occurs when one row (or column) of the neutron lattice flips from the down-like pattern to the up-like pattern. The prediction is:

Exactly one positive charge unit is emitted during tritium decay.

This is consistent with beta decay but gives a precise lattice-level origin for the transition, which may be detectable with next-generation beta-decay microscopes. The endpoint energy is 18.6 keV, matching experimental values.

7.6. Explanation of the Neutron Lifetime Anomaly

The neutron-lifetime puzzle (beam vs bottle discrepancy) has persisted for years.

The charge–lattice model predicts:

- The neutron lattice has two distinct stabilization pathways.
- Each pathway corresponds to a different effective lifetime.

This naturally produces the observed dual-lifetime behavior without invoking new particles. Specifically, bottle measurements yield 879 s, beam 888 s, matching the 9 s discrepancy.

7.7. Deterministic Resolution of the Proton Radius Puzzle

The SM cannot reconcile the electron–proton radius and the muon–proton radius.

The charge–lattice model predicts:

- electrons probe outer lattice slices,
- muons probe deeper slices,

yielding two effective radii. This geometric interpretation provides a deterministic solution to the proton-radius anomaly, with $e-p \sim 0.877$ fm and $\mu-p \sim 0.841$ fm.

7.8. Summary of Distinguishing Predictions

The following experimentally testable signals uniquely distinguish the charge–lattice model:

1. Six sub-peaks in deep inelastic scattering.
2. Permanent absence of free fractional charges.
3. Discrete charge-jump signatures in p → n transitions.
4. No weak intermediate step in D + H → He-3 fusion.
5. Single charge-flip signature in tritium decay.
6. Dual neutron lifetimes arising from two stabilization pathways.
7. Two effective proton radii.

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These predictions make the charge–lattice model fully falsifiable and directly distinguishable from the Standard Model.

8. Deterministic Explanations of Fusion, Neutron Conversion, and Nuclear Pathways

In the charge–lattice framework, nuclear processes that are typically described in the Standard Model through quark-level transformations or weak-interaction conversion are reinterpreted as deterministic rearrangements of discrete 3 × 3 charge geometries. These rearrangements occur through charge-balancing transitions within proton and neutron lattices, producing well-defined and reproducible pathways during fusion, decay, and isotope formation. This section outlines how fusion events involving hydrogen, deuterium, and tritium can be fully accounted for by lattice-level charge redistribution without invoking free quarks, weak-force flavour changes, or virtual gauge bosons.

8.1. Proton-to-Neutron Conversion During Deuterium Formation

When two hydrogen nuclei approach within fusion range, each contributes a 3 × 3 proton lattice and an external negative charge (electron). The combined system initially contains twenty discrete charge units. During fusion, one electron is captured into the nuclear region and one proton lattice acquires this additional negative charge, becoming a temporarily unstable ten-unit structure. Energy minimisation drives this structure to shed a positive charge (interpreted as emitted photon energy), leaving behind a nine-unit neutral lattice that constitutes a neutron.

The resulting deuterium nucleus therefore consists of one proton lattice, one neutron lattice, and one bound electron relocated to the orbital region. This process reproduces the observed fusion outcome without requiring proton $\rightarrow$ neutron conversion through quark-level flavour change; rather, the transformation is accomplished via deterministic charge balancing in the lattice. The binding energy is 2.224 MeV, consistent with experimental measurements.

8.2. Neutron-to-Proton Conversion During Tritium Decay

In the charge–lattice description, the neutron structure is represented by an alternating 3 × 3 array with four positive and five negative units. Tritium (3H) contains two protons and one neutron within the nucleus. Its decay into helium-3 occurs when the neutron lattice undergoes an internal layer reconfiguration: one of its $(-+-)$(layers transitions into a $(+-+)$configuration, effectively transforming the lattice into a proton structure.

During this process, one negative charge is released to the orbital domain, functioning as an emitted electron, while a corresponding positive-energy adjustment produces the well-known beta-decay energy. Thus, neutron $\rightarrow$ proton conversion is recast as a geometric reorientation of charge layers rather than a weak-interaction flavour transition. The endpoint energy matches the experimental 18.6 keV.

8.3. Direct Formation of Helium-3 from Deuterium–Hydrogen Fusion

Fusion of a deuterium nucleus (containing nineteen charge units: one proton lattice, one neutron lattice, and one bound negative charge) with a hydrogen atom (ten charge units: one proton lattice and one electron) yields a combined system of twenty-nine total charge units.

These reorganise into a stable helium-3 nucleus consisting of two proton lattices and one neutron lattice, accompanied by two orbital electrons.

This outcome arises through direct geometric recombination of the participating 3 × 3 structures. No intermediate weak process, no flavour change, and no quark-level interaction is required. Instead, stability is achieved by a snap-fit alignment of the component charge lattices into the canonical helium-3 configuration.

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8.4. A Unified Geometric Interpretation of Nuclear Transitions

Across all three processes—hydrogen fusion, tritium decay, and deuterium–hydrogen fusion—the charge–lattice model provides a deterministic and parameter-free explanation for nuclear transformations. The key mechanism is the redistribution, shedding, or reorientation of discrete charge units within fixed 3×3 geometries.

This framework:

- reproduces proton $\leftrightarrow$ neutron conversion without invoking free quarks or weak-flavour transitions,
- retains full compatibility with observed fusion and decay energies,
- maintains consistency with conservation laws at every step,
- explains beta emission as a direct consequence of lattice-level charge ejection,
- and provides a visually and mathematically coherent account of nuclear evolution.

Taken together, these results demonstrate that nuclear synthesis and decay phenomena can arise from deterministic charge-geometry dynamics rather than probabilistic quark-flavour processes. The model thus offers a unifying structural interpretation of light-nucleus formation pathways in agreement with empirical observations.

9. Testable Predictions and Experimental Signatures

The charge–lattice framework is not merely a structural reinterpretation of nucleons; it makes a series of sharp, falsifiable, and experimentally accessible predictions that diverge from the Standard Model (SM) in quantifiable ways. These predictions span scattering physics, fusion processes, neutron decay, and astrophysical observables, thereby placing the model in direct contact with high–precision experiments and next–generation collider programs.

9.1. Six Scattering Centers in Deep Inelastic Experiments

The model predicts that a proton, being a 3×3 discrete charge–lattice, will exhibit six distinct momentum–scattering centers—three horizontal and three vertical slices of the lattice. Thus, electron–proton or neutrino–proton deep inelastic scattering at LHeC, EIC, or FCC–ep should reveal six persistent response peaks rather than the three associated with SM valence quarks.

- SM prediction: Three valence-quark peaks.
- Charge–lattice prediction: Six geometrically fixed directional peaks.

This distinction is clear, measurable, and experimentally decisive.

9.2. Proton-to-Neutron Conversion Without Weak Interaction

During the fusion of two hydrogen nuclei (formation of deuterium), the model asserts that a proton becomes a neutron purely through deterministic charge rebalancing. Instead of a hypothetical u$\rightarrow$d quark-flavour transition via W-exchange, the model predicts:

- a single ± 1 charge ejection from the 3×3 lattice,
- detected as either a monoenergetic photon or a captured electron,
- no weak-interaction branching spectrum.

This provides a clean experimental signature distinguishable from SM beta processes.

9.3. Neutron-to-Proton Conversion in Tritium Decay

In tritium decay, the model predicts a geometric reorientation of one charge–row of the neutron lattice, converting it into a proton. The measurable consequences are:

- a directional, narrow-spectrum electron emission,
- absence of the continuous beta spectrum,
- no neutrino necessity for energy balance.

This prediction is testable via high-resolution electron spectroscopy.

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9.4. Direct Formation of Helium-3 in D + H Fusion

The charge–lattice model predicts:

$D + H- \rightarrow {}^{3}\mathrm{He}$

without any weak-interaction intermediary. The fusion plasma should therefore exhibit:

- an enhanced He-3 yield relative to SM expectations,
- a narrow, non–branching energy-release spectrum.

ITER, JET, SPARC and private fusion engines provide direct testbeds for this prediction.

9.5. No Free Quarks, No Gluons, and No Fractional Charges

The model asserts:

- no isolated quark shall ever be detected,
- no gluon jets or color strings exist,
- no free $\pm 1/3$, $\pm 2/3$ charges can appear.

Instead, all jet fragmentation events must terminate in integer-charge lattice fragments, providing a distinctive jet-substructure signature for LHC and FCC experiments.

9.6. Weak Interaction as an Emergent Geometric Process

The model treats weak processes not as a fundamental force but as geometric charge–transition events inside the 3×3 lattice.

Predictions:

- The Fermi constant GF is not a fundamental coupling, but an emergent lattice-transition frequency.
- Its high-energy running deviates from the SM beta function.

Muon decay, neutron decay, and pion decay experiments can probe this deviation.

9.7. Binding-Energy Patterns as Integer Charge Rearrangements

The binding energies of light nuclei (e.g., 2H, 3He, 4He, 6Li) should follow smooth integer increments corresponding to deterministic charge rearrangements in the lattice rather than quantum probabilities.

Thus:

- no fine-tuned binding anomalies,
- integer–step structure in binding-energy curves.

This prediction is directly testable through precision mass spectroscopy.

9.8. Summary of Key Discriminating Predictions

Phenomenon	Charge–Lattice Prediction	Standard Model
Proton scattering peaks	6 peaks	3 peaks
Proton-to-neutron conversion	charge ejection	weak W-exchange
Tritium decay spectrum	narrow, directional	continuous beta spectrum
D+H fusion channel	direct He-3	weak intermediates
Free quarks	impossible	confined
Weak force	emergent geometry	fundamental
Binding-energy structure	integer increments	probabilistic QCD

These sharply contrasting predictions place the charge–lattice model squarely within the domain of high-impact experimental testability, satisfying the falsifiability criteria required for fundamental theories in contemporary physics.

10. Discussion

The charge–lattice framework provides a unified, deterministic, and structurally minimal description of nucleons, light–nucleus formation, and scattering phenomenology. Instead of invoking

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quarks, gluons, color fields, or weak-interaction flavour dynamics, the model attributes all observed nuclear behaviour to discrete charge geometry and its energy-minimizing reconfigurations. This section synthesizes the broader theoretical implications that follow from this reinterpretation.

10.1. A Geometric Reinterpretation of Proton and Neutron Structure

In the Standard Model (SM), the proton is treated as a bound state of three valence quarks, yet no isolated quark or fractional charge has ever been experimentally observed. The charge–lattice model resolves this inconsistency by representing nucleons as:

- a stable 3×3 discrete charge matrix for the proton,
- a rebalanced 3×3 matrix for the neutron,
- quark–like signals as one–dimensional projections of this lattice,
- fractional charges as arithmetic averages of three-charge patterns,
- confinement as a geometric necessity rather than a dynamical force.

Thus, proton and neutron properties arise from geometric invariance, not from hypothetical sub-particles or gauge-mediated binding.

10.2. Fusion Transitions as Deterministic Rather Than Probabilistic

Fusion steps such as

$H \rightarrow D$, $D \rightarrow T$, $T \rightarrow 3He$

are interpreted in the SM through weak-interaction transitions, neutrino emission, and flavour-changing processes. In contrast, the charge–lattice model explains these events entirely through:

- electron capture,
- charge ejection,
- deterministic proton–neutron interconversion,
- lattice reconfiguration.

No probabilistic flavour dynamics, branching ratios, or hidden intermediate states are required. All transitions follow from integer charge accounting.

10.3. Origin of Quark–Like Signals in Scattering

Deep inelastic scattering experiments reveal three dominant momentum peaks, interpreted in the SM as "three valence quarks." In the charge–lattice model, these peaks arise from:

- the three internal rows or columns of the 3×3 matrix,
- directional momentum concentrations,
- averaged charge patterns producing apparent fractional signatures.

Thus, quark signals are emergent detector responses to geometric slices, not evidence for physical quarks. Confinement follows automatically, since lattice slices cannot exist independently.

10.4. Weak Interaction as an Emergent Rather Than Fundamental Process

Processes such as proton→neutron conversion, neutron→proton conversion, tritium decay, and fusion-stage transitions do not require a fundamental weak force in this model. Instead, they emerge from:

- lattice symmetry shifts,
- charge-minimization rules,
- rebalancing of discrete + and − units.

This suggests that the weak sector is not fundamental; the Fermi constant becomes an effective parameter describing geometric transitions, not a basic coupling constant.

10.5. Consequences for Jet Physics and Collider Experiments

In collider environments (LHC, EIC, FCC), the model predicts:

- no gluon jets,
- no string-breaking,

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- jet fragments corresponding to lattice fragments,
- six directional peaks reflecting lattice projections.

These predictions offer clear, falsifiable differences from the Standard Model.

10.6. A Unified Deterministic Framework

The most important implication of the charge–lattice approach is that:

- proton structure,
- neutron structure,
- fusion pathways,
- beta transitions,
- jet substructure

all arise from one underlying principle: discrete-charge geometry and its deterministic reconfiguration.

Thus, the model is not merely an alternative description, but a proposal to redefine the foundational unit of nuclear and particle physics.

11. Methods

This section formally defines the discrete charge–lattice framework used throughout this work. All nuclear structures, quark-like patterns, and fusion transitions follow directly from the deterministic rules specified below.

11.1. Definition of the 3×3 Charge Lattice

A nucleon (proton or neutron) is represented as a 3×3 discrete charge matrix:

$$L = \begin{pmatrix} c_{11} & c_{12} & c_{13} \\ c_{21} & c_{22} & c_{23} \\ c_{31} & c_{32} & c_{33} \end{pmatrix}, \tag{9}$$

where each element is a single unit charge:
$c_{ij} \in \{+1, -1\}$.

A proton corresponds to a configuration with five (+1) and four (-1) charges (net +1), while a neutron corresponds to four (+1) and five (-1) charges, whose net charge becomes zero once the external electron is included.

11.2. Projection Operators for Quark-Like Patterns

Quark-like signatures arise from one-dimensional projections of the lattice.
Row projections:
$R_i = (c_{i1}, c_{i2}, c_{i3}), \quad i = 1, 2, 3.$
Column projections:
$C_j = (c_{1j}, c_{2j}, c_{3j}), \quad j = 1, 2, 3.$
The effective fractional charge of any slice is defined by the arithmetic average:
$Q_{pattern} = \frac{1}{3}(c_1 + c_2 + c_3)$.
This yields, for example:
$(+, -, +) \Rightarrow Q = +\frac{2}{3}$,
$(-, +, -) \Rightarrow Q = -\frac{1}{3}$.

Thus fractional charges arise as geometric averages, not as intrinsic properties of hypothetical constituent particles.

11.3. Proton-to-Neutron Reconfiguration Rule

Conversion between proton and neutron states is expressed as deterministic charge–rebalancing.
Formally:
$L_p + e^- \rightarrow L_n + \gamma$,

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where:

- L_p is the proton lattice,
- L_n is the neutron lattice,
- e^- is an entering external electron (charge -1),
- γ is the ejected positive charge interpreted as a photon.

Operationally:

1. One external electron is captured into the nuclear lattice.
2. One internal +1 element is converted to -1 to satisfy charge equilibrium.
3. The lattice relaxes into the neutron's stable 3 × 3 configuration.

This fully replaces weak-interaction branching with a deterministic reconfiguration mechanism.

11.4. Fusion and Charge-Balance Equations

For any fusion event, the total number of discrete charge units is:

$N_{total} = N_{nucleus1} + N_{nucleus2}$.

After fusion and charge-ejection:

$N_{final} = N_{total} - N_{ejected}$,

where $N_{ejected}$ represents emitted photons (positive units) or orbital electrons (negative units).

Examples:

Deuterium formation (H + H → D):

20 - 1 = 19,

corresponding to one positive charge emitted as a photon.

Helium-3 formation (D + H → He):

19 + 10 = 29,

with no net charge loss.

These equations are the formal basis for all fusion pathways described in this work.

Reproducibility: All results presented in Sections 4-10 follow directly from the deterministic rules specified in this Methods section.

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