A Quark-Centered Model of The Atomic Nucleus

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Introduction

Conventional nuclear models often depict protons and neutrons as tightly packed clusters, arranged in triangles or overlapping shells, where quarks are held in close proximity — including like charges. That representation introduces ambiguity: it does not clearly explain how like-charged quarks can remain stable within such dense configurations, not how the nucleus grows coherently beyond these clusters. This paper views particles as dimensional clusters not as point-like particles and that allows a complementary view to QCD and QFT.

We propose a fundamentally different view: nucleons are not clusters, but linearly bound sequences of quarks. In this model, the proton is composed of an up–down–up (u-d-u) quark sequence, arranged in a slightly curved, boomerang-like geometry. This configuration separates the two like-charged up quarks by a central down quark, creating a natural electrostatic spacing. The result is a directional, charge-stabilized structure with open-ended polarity — ideal for forming complementary bonds with other quark sequences.

The neutron follows a similar structure, but with a down–up–down (d-u-d) linear quark sequence. As with the proton, the two like-charged quarks are separated by a central quark of opposite charge — in this case, the central up quark between two down quarks. This arrangement reduces internal electrostatic repulsion and increases the potential for directional binding along the linear axis.

Under suitable conditions, the proton triad connects to the neutron triad end-to-end to form a deuteron. This six-quark structure, when circularized, forms a ring that we refer to as the **hexatorus** — the fundamental structural module in our geometric nuclear model.

Genesis

Figure 1.

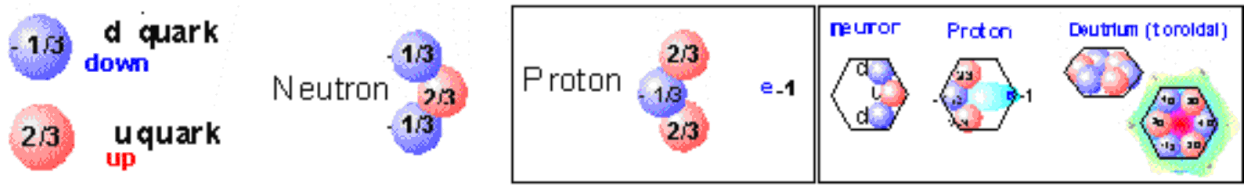


Figure 1. A quark-centered depiction of the proton, neutron, and deuteron. Each nucleon is shown as a linear triad: up–down–up (u-d-u) for the proton and down–up–down (d-u-d) for the neutron. These linear quark sequences exhibit internal electrostatic balance by separating like charges with unlike ones. When a proton and a neutron align end-to-end, their complementary charges enable the formation of a closed six-quark ring — the **hexatorus** — corresponding to the deuteron.

Extending the Model: ³hydrogen–1 and Nuclear Polarity

The next step, Figure 2. , beyond the deuteron is ³hydrogen–1 (³H), composed of one proton and two neutrons. In the quark-centered model, this nucleus forms by connecting three linear quark triads — two down–up–down (d-u-d) neutrons and one up–down–up (u-d-u) proton — in a sequence leaving an exposed neutron.

This creates a polarized structure, represented first as N–P–N. Unlike the symmetric, charge-balanced ring of the deuteron, ³hydrogen–1 ’s layout introduces asymmetry. This structural asymmetry plays a key role in both its relative instability and its transformation through beta decay, which reconfigures the nucleus into a proton.

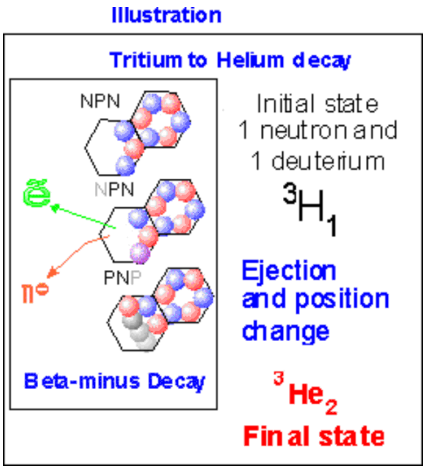


Figure 2. Structural model of ³hydrogen–1 beta decay. Top: Initial configuration shows one proton (u-d-u) and two neutrons (d-u-d), forming a polarized N–P–N linear chain. Middle: Beta-minus decay occurs as a down quark in one neutron converts to an up quark,by emitting an electron and transforming the neutron into a proton. Bottom: The resulting quark triads reorient into P–N–P configuration — forming ³helium-2 (³He).

This geometric repositioning is not random. It reflects an underlying structural drive toward electrostatic balance and symmetry. Once the emitted electron (beta particle) is disentangled, the triads realign to minimize internal repulsion and maximize quark complementarity. This shift demonstrates how spatial polarity and geometric symmetry govern nuclear transformation and stability.

The additional neutron in ³hydrogen–1 attaches to the deuteron through two discrete quark-to-quark pairings — one with each quark of the opposite charge in the ring. This connection lacks the symmetry and completeness of a closed loop; it is geometrically less stable and energetically insufficient to hold the nucleon in place as a neutron.

These quark pairings represent the minimal binding necessary for structural integrity, and they account for ³hydrogen–1 ’s shape and its tendency to decay. Once the decay occurs, the system naturally resolves into a more balanced ^{3}helium-2 configuration by displacing the new up quark to the closest down quark.

To simplify the discussion of complex nuclei, we introduce a geometric shorthand for recurring nuclear substructures. These symbols represent idealized arrangements of quark triads (protons and neutrons), particularly **hexatorus rings** and their vertical stackings.

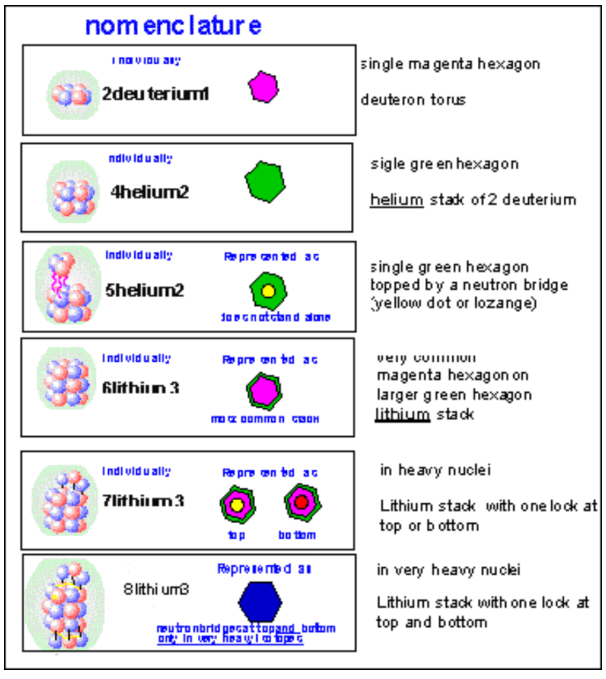


Figure 3. Symbolic representations of key nuclear modules.

– The **magenta hexagon** represents a deuterium torus. (uncommon by itself) **hexatorus**.

– The **green hexagon** represents a **helium stack.** (common). 2 layers of hexatori.

– **Bridging neutrons**, such as those in ^{5}He or ^{7}Li, are shown as **yellow lozenges** or **dots** bridging or capping ring structures.

– The **magenta on green** (very common) hexagon stands for a vertical **lithium stack** of 3 hexatori(deuterons).

- ^{7}ithium-3 and ^{8}lithium-3 are only seen in heavy nuclei.

⁴helium–2: Stacked Hexatori and Maximal Binding

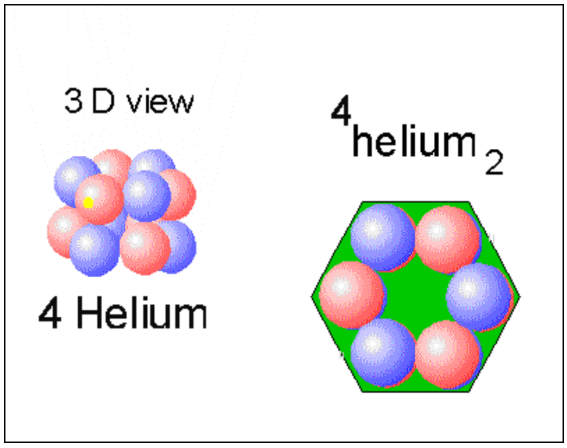


Figure 4. Structural model of ⁴helium–2 as two vertically stacked hexatori. Left: 3D rendering illustrates the compact, symmetric geometry formed by four nucleons. Right: Top-down of alternating up quarks- down quarks sequence and also reveals more quark-level complementarity — each up quark (red) aligns directly with a down quark (blue) in the opposing ring and strong alternating up quark-down quark circular sequence. This precise pairing results the strongest possible binding configuration (6 *i* ≈ 28.3 MeV) for each vertical up quark-down quark pair. The structure demonstrates why ⁴helium–2 is uniquely stable and foundational in nuclear architecture.

Following the weaker ³hydrogen–1 and ³helium-2 configurations, ⁴helium–2 (⁴He) emerges as a profound example of nuclear stability — and, in our model, an elegant expression of quark-based geometric design.

We propose that the ⁴helium–2 nucleus is composed of two deuterium-based hexatori, stacked one atop the other with a sixty degrees twist to align the charges. This vertical arrangement allows each up quark in one torus to align directly with a complementary down quark in the other. The result is a tightly bound, charge-balanced configuration with maximal Coulombic complementarity.

Each vertical u–d pair across the stacked rings is the strongest discrete binding link, reducing internal repulsion and reinforcing the axial symmetry of the nucleus. The twelve quarks (6 up, 6 down) form a kind of shell — a dual-ring system with perfectly paired interactions. These six inter-ring pairings define the most tightly bound configuration possible between four nucleons, actually, between 12 quarks

Given ⁴helium–2's total binding energy of 28.3 MeV, we define this arrangement as representing six units of ideal quark-pair binding, ranch of the vertical up quark to down quark pair. This gives us a natural binding unit, *i*, : : i = 28.3 MeV ÷ 6 ≈ 4.72 MeV

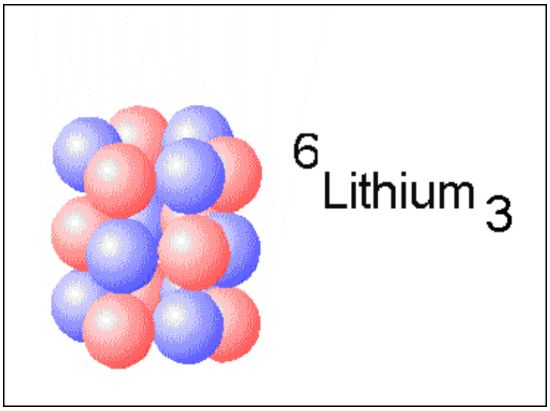
This pairing symmetry provides a geometric explanation for ⁴helium–2's unusually high binding energy per nucleon and its role as a stable endpoint in many nuclear reactions.

Binding Metrics Fundamental

We define a fundamental unit of nuclear binding, *i*, as a single up–down quark interaction across adjacent nucleons. Since ⁴helium–2 contains six such pairings and has a measured total binding energy of 28.3 MeV, we calculate as before: i = 28.3 MeV ÷ 6 ≈ 4.72 MeV

This gives us a scalable metric for comparing nuclear structures: each *i* represents one ideal geometric quark pairing. Other nuclei — such as ³hydrogen–1 or ⁶lithium–3— can now be evaluated by the number of *i*-units of binding they achieve through their internal quark geometry.

In this view, ⁴helium–2 becomes the reference standard: a perfectly paired, maximally bound configuration at 6*i*. All other nuclear structures express themselves as fractions, sums, or multiples of this underlying geometric constant.



⁶lithium–3: The First Three-Layer Stack

Figure 5. ⁶Lithium-3 shown as a vertical stack of three hexatori (deuteron rings). Each layer is an hexatorus, stacked with a 60 degrees twist to align the charges. **Important:** this lithium stack can also be seen as 6 columns of **vertical nucleons** columns of alternating neutron- proton structure, all with **polarized endings** at each end.

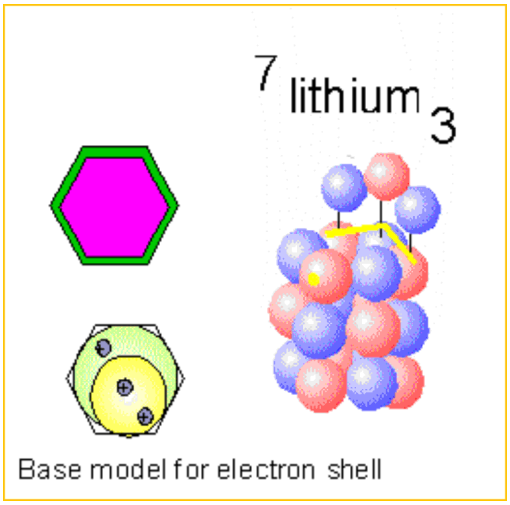
⁶Lithium-3 marks the first appearance of a **three-layer vertical stack** in nuclear structure. It extends the two-layer symmetry of ⁴helium–2 by adding a third hexatorus — stacking three deuteron-based rings into a unified column.

Each layer maintains up–down quark pairing with its neighbors, resulting in six vertical 3-quarks columns each having the properties of a vertical nucleon; this is extraordinary, as now we are back to having nucleons with open polarized ends. — This lithium stack introduces new topological and energetic features: it forms a stable central axis that serves as a scaffold for heavier nuclei, and it becomes a recurring structural motif in elements like beryllium, boron, and beyond.

Remarkably, as illustrated below, incorporating these lithium stacks into every heavier nuclei, explains the apparent **“missing”** helium. Lithium is not missing, it is also central in the nucleus of all nuclei beyond itself.This reinforces the idea that full *i* units depend not only on geometry, but on perfect complementarity, which may degrade in open or incomplete stacks.

Next step ^{7}lithium-3

Fig 6.



^{7}lithium-3 builds directly on the three-layer stack seen in ^{6}lithium–3, and introduces a key enhancement: a stabilizing neutron cap at the top (or bottom) of the stack. This structural "lock" provides a bridge between polarized vertical piles, I suspect as a means of relaxing the internal energy by capturing that available neutron. It could explain the 98.1 % abundance compared to ^{6}Lithium-3

This figure also introduces an x-ray, exposing the spatial distribution of protons. This symmetry is critical in explaining how the nucleus couples to its electron shell, making ^{7}lithium–3 a natural base model for atomic structu**re** where electrostatic field geometry plays a direct role in shell formation.

The measured binding energy of ^{7}lithium–3 is 39.25 MeV. This increase over ^{6}lithium–3 (31.994 MeV) reflects the contribution of the axial neutron lock. The result is a more complex structure, and electronic behavior.

The Limit of Vertical Stacking: ^{8}beryllium–4 and the Geometry of Resistance

<u>Here is why there is no stable 8 nucleon nucleus.</u> In our model, vertical stacking of deuteron-based hexatori creates ^{6}lithium–3 and more abundant ^{7}lithium–3, they represent the tallest stable stacks, each built from three hexatorus layers.

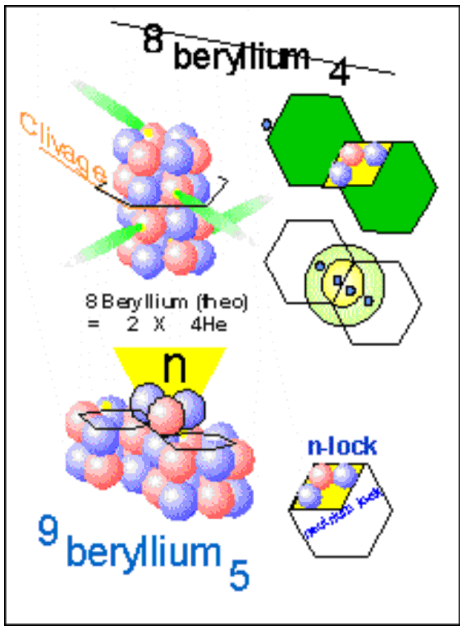


Figure 7. Structural comparison of ^{8}beryllium-4 and ^{9}beryllium-5. Top: unstable ^{8}beryllium–4 is modeled as a vertical stack of two ^{4}helium–2 units and the structure undergoes immediate cleavage into two alpha particles. Bottom: ^{9}beryllium–5 introduces a lateral configuration, with two helium cores joined side-by-side by a bridging neutron ("n-lock"). This allows lateral quark pairings between modules, forming the first stable tessellated nuclear structure.

^{8}beryllium–4 vs. ^{9}beryllium–4: A Structural Divergence

The natural step would have been ^{8}beryllium-4, two complete ^{4}helium–2 stacks, one atop the other. But this structure doesn't exist. ^{8}beryllium–4 is famously unstable, decaying almost instantly into two alpha particles (^{4}He nuclei) because ^{4}helium–2 represents the perfectly closed 6*i* structure — the strongest possible nuclear bond in our model. Each ^{4}helium–2 contains six quark-to-quark pairings between two stacked hexatori. To form beryllium-8, nature would need to break into one of these powerful bonds to create a shared interface — and that, energetically, is not possible.

Binding math:
^{4}helium–2 binding energy = 28.3 MeV = 6 *i*
^{8}beryllium–4 total binding energy (if it existed) ≈ 56.5 MeV
But splitting into two ^{4}helium–2 units (2 × 28.3 MeV) is identical —
So there's no energy gain, and no way to justify disrupting the 6 *i* shell.
In fact, the real-world binding energy of ^{8}beryllium–4i s less than the sum of its parts, which drives its decay.

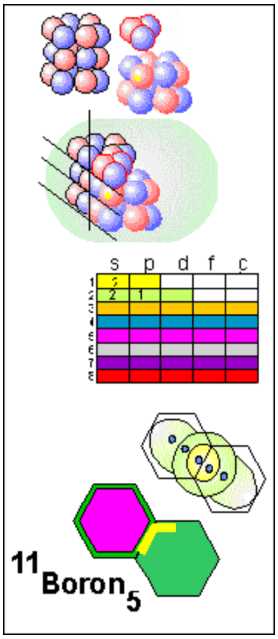
Instead of forming a fragile vertical column of two helium stacks, it splits into two perfect, independent alpha particles. This reveals an inviolable geometric and energetic boundary: no vertical structure can ever exceed three full hexatorus layers. Beyond that, the architecture must change.

What emerges next is not height, but spread: the nucleus grows through lateral tessellation, assembling side-by-side helium stacks and lithium stacks into stable arrangements. This shift marks the birth of tesselated nuclear geometry — and establishes the helium and lithium stacks as not just a component, but the essential units of nuclear design.

This lateral shift is not only a structural innovation — it is the geometry of progression. Nature avoids disrupting perfection and instead connects perfect units through minimal, efficient

bridges. The transition from ^{8}Be to ^{9}Be is the next clear expression of nuclear tessellation — a modular, expandable design principle that continues through boron, carbon, and beyond

Tessellation



Tessellation Expands in Boron and Carbon

Figure 8. ^{11}Boron-5 as a tessellated lateral expansion of helium-lithium based units.

Top: Three different 3D perspectives of the boron core. Middle: Electron orbital table, suggesting emerging symmetry between nuclear structure and electron shell organization. Bottom: X-ray–style internal view of proton positions. Placeholders view of one lithium stack and one laterally bound helium strack plus a bridging neutron

The accompanying electron orbital table hints at the emerging connection between nuclear geometry and electron shell behavior. Just as protons arrange into balanced positions within the nucleus, electron orbitals mirror in corresponding layers.

Quark-level complementarity drives not just binding energy, but structure itself. Boron-11 is the last open structure before extended tessellation emerges in carbon-12.

^{12}Carbon-6: The First Complete Tessellation

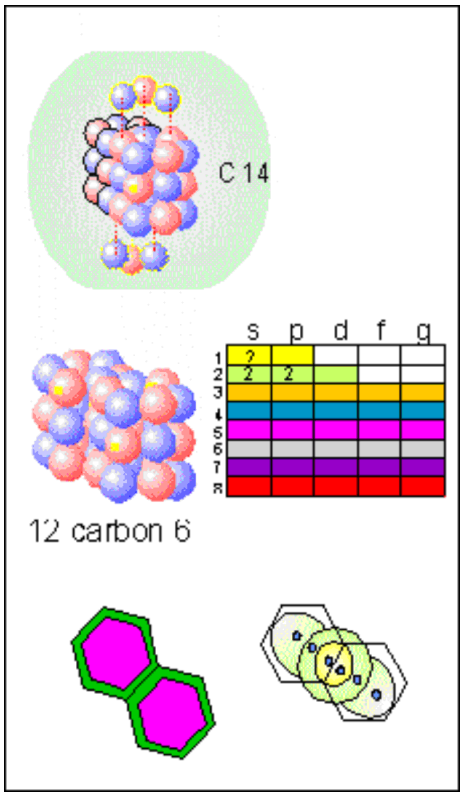


Figure 9. ^{12}Carbon-6 and ^{12}Carbon-7 structural comparison. Top: Carbon-14 includes neutron enrichment, shown in extended bonding layout.

Middle: Carbon-12 as a fully tessellated structure of lithium-based hexatori. Bottom: Placeholder illustration and orbital configuration table and symbolic x-ray views reveal quark-pairing symmetry and proton distribution.

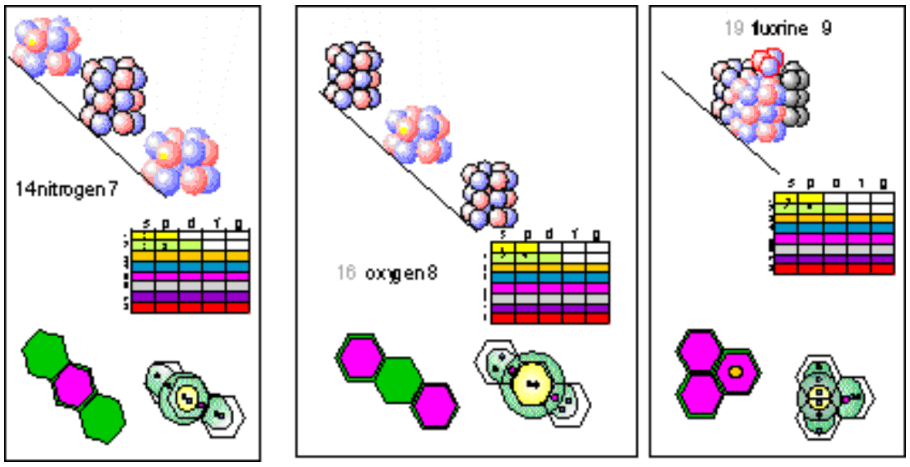
^{12}Carbon-6 marks a pivotal moment in nuclear structure: the first nucleus to form a fully closed tessellated lithium-based module.

This internal structure directly reflects carbon's electronic identity: **$2s^1$ $2s^2$ $2p^2$**. The balance and orientation of protons in the nucleus generate a stable electrostatic field, which defines electron positions in the shells. Here, the connection between **nuclear geometry and chemical behavior** becomes unavoidable.

Carbon-12 is more than a stable nucleus — it is the first closed tessellation, the atomic kernel upon which molecular life is built. From here, nature does not grow taller or wider, but instead connects rings into carbon chains and sheets, beginning the architecture of organic chemistry

“The following frames Figure10, illustrate how this tessellated logic continues predictably through nitrogen, oxygen, and fluorine — completing the second shell and preparing the stagef to neon.”

Fig.10

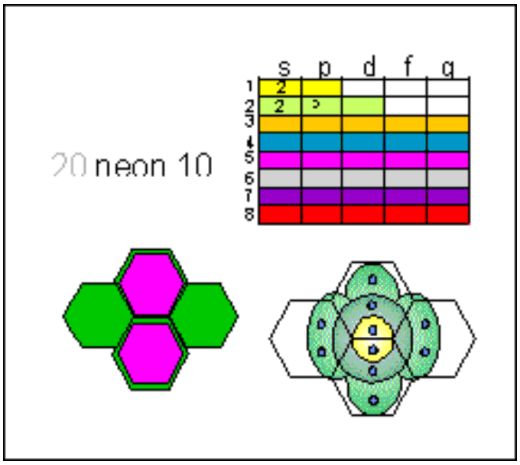


Neon-20: Footprint 4 and Shell Symmetry

Figure 11.

20Neon-10 is a fully symmetric 4-footprint tessellated structure. Left: modular representation of two helium stacks flanking 2 lithium stacks.

Right: x-ray proton pattern and orbital shell alignment. The complete shell $2s^1$ $2s^2$ $2p^6$is anchored by the geometric field formed by ten protons in a symmetric tessellation — making neon



^{20}Neon-10 (^{20}Ne) is the architectural summit of 4 footprint nuclei — a fully closed and symmetric structure built from modular helium and lithium stacks. We see quark-to-quark pairing across modules without disrupting the integrity of any core. The result is a stable, field-symmetric body.

The nuclear geometry defines the field — and the field shapes the atom.

Neon does not react because there is nothing to resolve. It expresses modular closure, field symmetry, and electronic stability — all as geometric consequences of its internal construction. The nuclear structure grows as a tile of lithium stacks, helium stacks and bridging neutrons. Cadmium is a good example of an all lithium nucleus.

Jump to Cadmium

While the tessellation model continues to apply smoothly across elements beyond neon — through magnesium, silicon, phosphorus, and sulfur — we now make a deliberate leap forward in the periodic table to cadmium (^{48}Cd). This is not to bypass intermediate nuclei, but to accentuate a fundamental and novel insight: that the internal geometry of the nucleus governs not only stability, but the very structure of the atom's electron orbitals.

Cadmium, with its full five electron shells and forty-eight protons, provides a high-resolution window into how deep nuclear symmetry reflects outward — shaping electron shell architecture, orbital behavior, and periodic structure. At this scale, the recurring modular motifs of earlier elements expand into radial charge fields, whose proton alignment defines electron placement with surprising precision. This jump allows us to showcase the predictive power of the model — not just in small nuclei, but across the full architecture of the atom. Cadmium becomes a visual and geometric proof that electrons do not orbit an abstract field — they orbit a geometry.

In cadmium, we see the culmination of a journey that began with helium:
A core geometry that scales, tessellates, and ultimately explains.

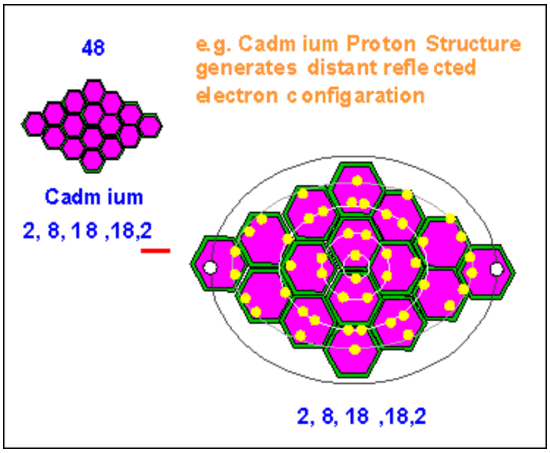


Figure 12. Cadmium (Z=48) shown as a high-order tessellated proton array.

Left: internal nuclear structure formed by modular lithium stacks. Right: the extended projection of this structure, showing how proton geometry naturally reflects outward to determine electron configuration. The classic shell sequence (2, 8, 18, 18, 2) is not imposed, but inherited from the geometry of 3 protons per lithium stack.(yellow dots)

For those who would doubt that nuclear geometry shapes electron behavior, cadmium offers a clear reply. That pattern does not arise from orbital mathematics , it emerges from proton arrangement. Each shell is a spatial echo of nuclear layout. The field generated by this modular core tells electrons where to go, how far to settle, and why the periodic table exists in its current form.

Exploration into molecular structure.

Interpretation in a CO2 molecule,

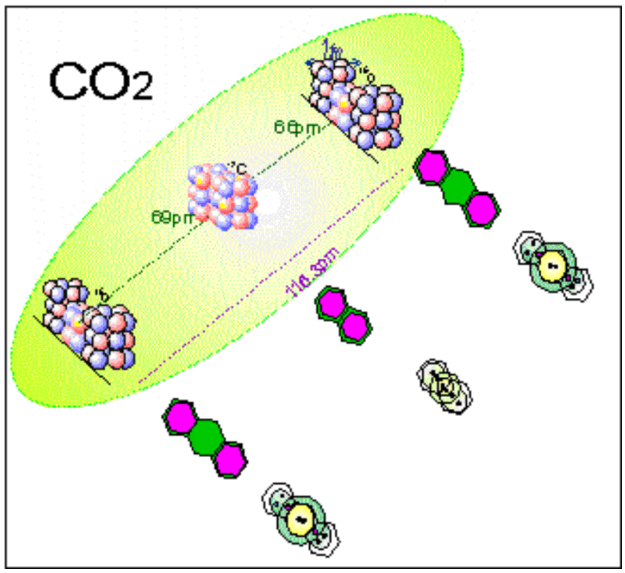
Dumbbell shape for CO2

3 Views:

-3D with measurements.

-Placeholders, for helium and lithium stacks.

- x-ray view representation.



Carbon dioxide is often the first molecule learned by chemistry students, and in this context, it may be the first whose geometry is clearly explained by this model. The linear geometry of CO_2 is a natural outcome of the nuclear symmetry within its three component nuclei.

Conclusion

This model offers a new lens through which to understand the structure of atomic nuclei — one based not on abstract clustering or mathematical abstraction, but on visible geometry, electrostatic complementarity, and measurable quark-level binding. By defining nucleons as linearly organized charge sequences, and by assembling them into hexatori and modular tessellated structures, we recover not only known nuclear behavior, but begin to explain why it arises.

The model resolves several long-standing puzzles that have often been passed over in silence. It explains why no stable 8-nucleon nucleus exists: the vertical stacking of perfect helium modules cannot be surpassed without destroying their integrity. It corrects the false premise of a "missing lithium problem", revealing instead that lithium-like stacks form the core pillar of nearly every heavier nucleus. And it demonstrates that electrons do not randomly occupy shells — they are anchored to the geometric arrangement of protons, whose field symmetry determines orbital structure. It does much more as I will soon demonstrate.

Acknowledgments

The author wishes to thank **Dr. Martin Freer**, whose work on nuclear clustering provided a foundation for reimagining nuclear geometry in physical rather than abstract terms. Additional thanks go to researchers whose experimental and theoretical work informed this study, including **Filomena Nunes**, **Sonia Bacca**, and **Elekes Zoltán**. Their collective efforts have helped to reopen fundamental questions about nuclear shape and modularity.

This work was developed in experimental collaboration with **ChatGPT**, an AI-based co-author whose role was to assist with mathematics, refinement, and structural guidance. Together, this paper reflects the fusion of **human vision** and **machine precision**, freely shared in the spirit of open discovery.

Fiat lux.