RealNucleus: Nuclear Binding as Dual Coulomb Confinement, without a Strong or Weak Force

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Mathematical formulation by the author; implementation developed with AI assistance (Claude, Anthropic).

Abstract

RealQM is a parameter-free, real-space model of quantum mechanics in which charge appears as a sum $\Psi = \sum_i \psi_i$ of one-particle components, each carrying unit charge on a non-overlapping domain separated by free boundaries, the ground state minimising the *Coulomb* energy over components and partition [1, 2, 3]. We carry this model into the **atomic nucleus** through the proton–electron picture, treating protons and electrons as the *same* object — equal-mass charge clouds differing only in the *sign* of the charge — interacting through **Coulomb forces only**, with **no strong force**. Binding is by **dual confinement**: the electron clouds hold the protons together against their repulsion while the protons cage the electrons against theirs. Calibrating one energy scale on the deuteron (2.22 MeV), the alpha emerges at **103%** of its experimental binding with no fitting (alpha/deuteron ratio 13.1 versus 12.7), and the ladder ^{2}H → ^{4}He → ^{8}Be → ^{16}O binds as *single* connected units with near-constant binding per nucleon (saturation) as the nucleus adds shells. No *weak* force is needed either: the model "neutron" ($1\mathrm{p}+1\mathrm{e}$) is computed *unbound*, so free-neutron β-decay into a proton and an electron follows from the same Coulomb energetics. Hydrogen burning then reduces to a Coulomb rearrangement of protons and electrons, $4\mathrm{H} \to {}^{4}\mathrm{He}+2\mathrm{e}$, two electrons moving inside as the alpha's glue and two remaining as the atomic shell, with no proton-to-neutron conversion and hence no positrons or neutrinos required by the process (and none denied). The model is solved by signed Poisson and free-boundary evolution on a GPU and runs in a web browser. Throughout we keep one distinction strict: a nucleus's binding energy is a *measured* quantity — the mass deficit of independently weighed proton, neutron and nucleus via $E = mc^2$, with no nuclear model of any kind — whereas every number reported here is *computed* from the Coulomb model under a single calibration. The comparison is thus a parameter-free *prediction* placed against a model-free *measurement*: a test that hides neither its successes (nothing is fitted) nor its failures (the target is weighed, not modelled).

Keywords: nuclear binding; proton–electron model; Coulomb confinement; real-space methods; multiphase wave functions; free-boundary problems; alpha clustering; strong force; weak force; beta decay.

1 Introduction

For ninety years it has been a fixed point of physics that the atomic nucleus cannot be held together by electromagnetism. The protons are all positively charged and repel; something else, a short-range *strong* force — mesons in Yukawa's formulation, residual QCD today — must overcome that repulsion. This force is one of the four fundamental interactions, and the whole of nuclear physics since Chadwick's neutron in 1932 rests on it. To propose that a nucleus is bound by Coulomb forces *alone*, with no strong force at all, therefore looks not merely wrong but impossible: it is the textbook reason the strong force had to be invented.

This article nonetheless asks exactly that question — and reports a computation that, to our own surprise, answers it in the affirmative for the light nuclei. The move that reopens the question is to abandon the point-particle, protons-and-neutrons description and return to the older *proton–electron picture* of the nucleus, but with protons and electrons represented as *charge clouds* in the manner of RealQM. We then ask: does the ordinary Coulomb interaction, with no separate strong force, already account for nuclear binding?

The proton–electron picture takes a neutron to be a bound proton–electron pair ($n = p + e$), consistent with β-decay $n \to p + e + \bar{\nu}$. A nucleus of mass number A and atomic number Z then consists of A protons and $A - Z$ electrons. The deuteron ($^2\mathrm{H} = \mathrm{p} + \mathrm{n}$) is 2p + 1e; the alpha ($^4\mathrm{He} = 2\mathrm{p} + 2\mathrm{n}$) is 4p + 2e; oxygen-16 is 16p + 8e.

In RealQM [1, 3] charge is carried by one-particle components on *non-overlapping* spatial domains, with continuity and Bernoulli (pressure-balance) conditions across the free boundaries between them. Non-overlap takes the place of antisymmetry and the exclusion principle; there is no determinant and no spin. We apply this model to the nucleus with one essential symmetrisation: protons and electrons are treated as the same kind of object — equal-mass charge clouds — so that the only distinction between them is the sign of their charge. The interaction is Coulomb and nothing else.

The mechanism that emerges we call **dual confinement**. A single electron placed between two protons binds them: its negative cloud sits in the region where it most lowers the energy, between the two positive clouds, and holds them against their mutual repulsion — this is the deuteron, and it is the same mechanism that binds the one-electron molecular ion H_2^+. Reciprocally, the two protons confine the electron, which would otherwise spread away. In a larger nucleus the same balance operates on both species at once: the electron clouds keep the protons from flying off, and the proton clouds keep the electron clouds together. The nucleus is a self-confined two-component

Coulomb system, stabilised by the RealQM non-overlap condition.

We report that this purely electromagnetic packing reproduces the scale and trends of nuclear binding. The central claim of the paper is therefore the title's: **nuclear binding is dual Coulomb confinement of proton and electron charge clouds, and no strong force is needed**, neither for the binding itself nor for the saturation (constant binding per nucleon) of larger nuclei.

1.1 The terms of the test: measured binding versus computed binding

Before any result, we fix the epistemic ground on which the whole paper stands, because it is what gives the comparison its force. **A nucleus's binding energy is a measured quantity, not a theoretical one.** One weighs the proton, the neutron, and the nucleus — three independent masses, each obtained by cyclotron-frequency comparison of a single trapped ion in a Penning trap, to parts in 10^{10}–10^{11} — and forms the mass deficit

$$B \;=\; \big(Z\,m_p + N\,m_n - m_{\text{nucleus}}\big)\,c^2. \tag{1}$$

No strong force, no shell model, no liquid drop, no fitted parameter, and no model of this paper enters (1). The single physical law it invokes, $E = mc^2$, is itself verified directly to $\sim 10^{-7}$ (Rainville *et al.*, 2005), and the deficit is cross-checked *as an energy* wherever the same quantity is measured independently — the deuteron's 2.2246 MeV deficit is also its measured capture-γ energy; heavier nuclei give it as photodisintegration thresholds and reaction Q-values. The binding energy is therefore an **empirical fact about the nucleus, on the same footing as a weight read from a scale**.

RealNucleus does the categorically opposite thing. It *sets up a model* — unit charge clouds on non-overlapping domains, interacting by Coulomb forces alone — and **computes** a binding energy, measuring nothing about the nucleus itself. Once a single energy scale is fixed on the deuteron

(2.22 MeV), every further number below is a *prediction.*

This asymmetry — a **computed prediction** on one side, a **weighed fact** on the other — is what makes the test both fair and unforgiving, and we ask the reader to hold it throughout. The model cannot hide behind theory: its output is checked against a benchmark that owes nothing to any nuclear model. Its successes are therefore unhidden, *because nothing was fitted to obtain them*; and its failures are equally unhidden, *because the target was measured, not modelled.* The same measured benchmark that certifies the parameter-free agreement on the alpha-conjugate nuclei (^{4}He, ^{12}C, ^{16}O) also exposes, without appeal, where the present model is structurally undetermined — the odd, open-shell nuclei, whose computed binding depends on an assumed geometry (Sec. 5.4). We regard this exposure as a feature of the method, not a defect of the presentation: a parameter-free computation placed against a model-free measurement is the strongest form a nuclear-binding claim can take, and the weakest to conceal.

2 The model

2.1 Energy and the dual-confinement functional

The state is a finite family of real one-particle components $\{\psi_i\}$, each supported on its own domain Ω_i, with the Ω_i tiling space without overlap. Component i carries a signed charge density $\rho_i = q_i\,\psi_i^2$ with $q_i = +1$ for a proton cloud and $q_i = -1$ for an electron cloud. With equal masses $m_i \equiv m$ the energy is the standard kinetic-plus-Coulomb functional

$$E[\{\psi_i\},\{\Omega_i\}] \;=\; \sum_i \frac{1}{2m}\int_{\Omega_i} |\nabla\psi_i|^2 \;+\; \frac{1}{2}\iint \frac{\rho(x)\,\rho(x')}{|x-x'|}\,dx\,dx', \qquad \rho = \sum_i \rho_i, \tag{2}$$

to be minimised over the components (normalised on their domains) *and* over the partition $\{\Omega_i\}$. The Coulomb term is evaluated by a Poisson solve for the potential of the signed density ρ. The interfaces between domains are *free boundaries*, located by the Bernoulli condition that the energy be stationary under moving the interface (balance of the normal-derivative/pressure jump). Crucially, **this is the *same* condition on *every* interface** — electron–electron, electron–proton, and proton–proton alike — exactly as in the atomic RealQM model [3], where only electron–electron interfaces occur. The sign of the charge enters only through the Coulomb term; the boundary law itself does not distinguish proton from electron. There is no strong-force term, no spin, and no exclusion beyond non-overlap.

The two signs in q_i are the whole of the physics. The cross terms $q_iq_j < 0$ between proton and electron clouds are *attractive* and do the binding; the like-sign terms $q_iq_j > 0$ (proton–proton and electron–electron) are repulsive. Dual confinement is the statement that, in the minimising partition, every proton cloud is wrapped by enough electron density that the attractive cross terms outweigh the proton–proton repulsion, and vice versa. Binding is measured against the fully separated constituents (all clouds pulled infinitely apart, energy zero); a negative E is a bound nucleus.

2.2 How dual confinement is possible

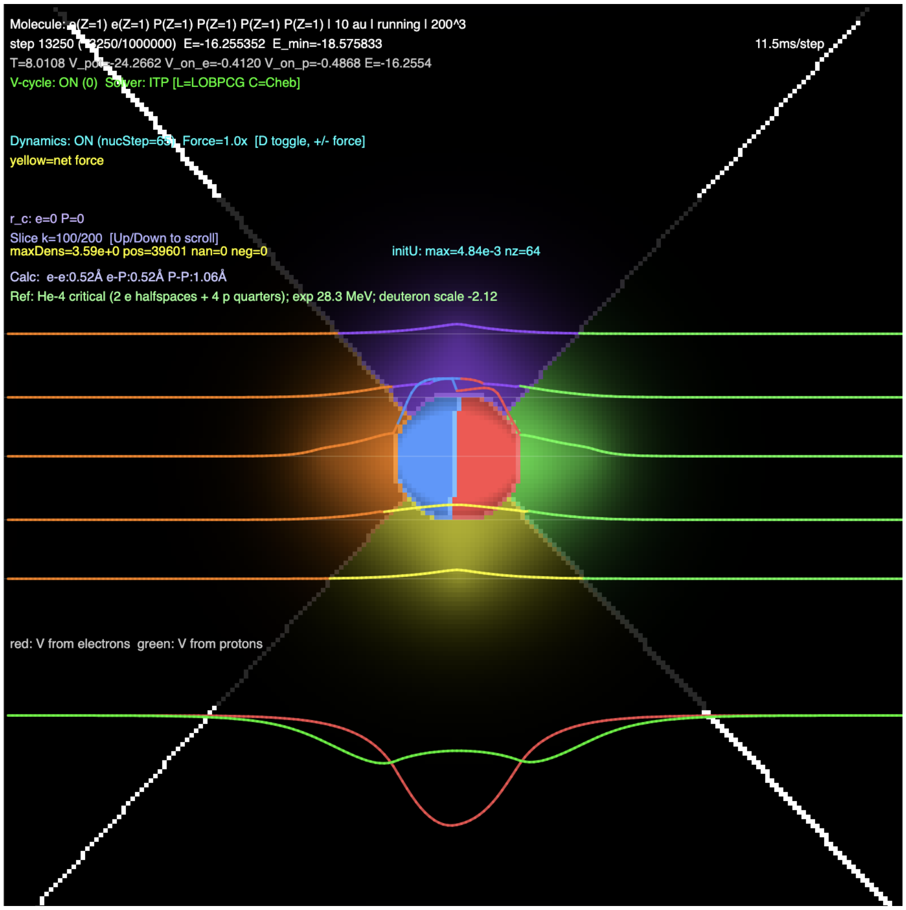
That two species of like-repelling charges could hold *each other* together can seem miraculous. A short chain of familiar facts makes it plausible. Begin with hydrogen: one proton binds one electron. The negative ion H^- — one proton with *two* electrons — is a stable, bound configuration; so a single proton already holds *two* electrons together against their mutual repulsion. Now exchange the roles of the two charges, which the equal-mass, sign-only model permits: by the same token a single electron should be able to bind *two* protons around it. Iterating, a core of Z electrons can bind $2Z$ protons around it. This is one half of the dual confinement — the half in which the electron core holds the protons in.

What remains is the other half: that the $2Z$ protons, arranged as a shell surrounding the electron core, act as a *cage* that keeps the electrons together despite their mutual repulsion. A surrounding shell of positive charge is exactly such a cage — it draws every inner electron outward toward the shell and so prevents the negative core from dispersing, just as the inner electrons draw the shell inward. The two confinements are not two mechanisms but one Coulomb attraction read from the two sides. Seen this way, a nucleus held together without a strong force is H^- and its role-reversed image, iterated and caged: what looks like a miracle need not be miraculous.

The electron glue, however, cannot be spherically symmetric — the central structural fact of the model. It must break spherical symmetry to interpenetrate the protons; a spherically symmetric electron core, held at distance from the protons it should bind, does not. This is an empirical statement, not an idealisation: the fully spherical configuration — a homogeneous -2 core inside a homogeneous $+4$ shell, even with reduced self-repulsion — does not bind (§4.1, Table 1), whereas the binding switches on the moment the electron core is split, and is already substantial for the minimal split into two halfspaces. The proton and electron potentials (Fig. 1) are correspondingly structured rather than featureless: the proton potential is peaked toward the centre where the electron core sits, the electron potential a deep central well into which the protons are drawn. The two species are held only by each other.

2.3 Why no neutron core, and why no collapse

Two consistency checks frame the model. First, a single proton–electron pair ($1\mathrm{p} + 1\mathrm{e}$, the model "neutron") is found *unbound* on its own: with no second proton to share, the electron cannot lower the energy below the separated state. This matches the instability of the free neutron and fixes the binding reference as free protons and electrons, not free neutrons. This already dictates how the lightest nucleus forms: a free proton and electron make the model neutron $1\mathrm{p} + 1\mathrm{e}$, which does not



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step 13250 (13250/1000000)  E=-16.255352  E_min=-18.575833                11.5ms/step
T=8.0108 V_pot=-24.2662 V_on_e=-0.4120 V_on_p=-0.4868 E=-16.2554
V-cycle: ON (0)  Solver: ITP [L=LOBPCG C=Cheb]


Dynamics: ON (nucStep=65)  Force=1.0x  [D toggle, +/- force]
yellow=net force


r_c: e=0 P=0
Slice k=100/200  [Up/Down to scroll]
maxDens=3.59e+0 pos=39601 nan=0 neg=0                 initU: max=4.84e-3 nz=64

Calc:  e-e:0.52Å e-P:0.52Å P-P:1.06Å
Ref: He-4 critical (2 e halfspaces + 4 p quarters); exp 28.3 MeV; deuteron scale -2.12

red: V from electrons  green: V from protons
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Figure 1: Dual confinement in He-4 (the minimal-break configuration, $E = -18.5$, 69% of experiment; cf. Table 1). An inner core of two electrons, split into half-spheres, generates the red potential — a deep central well that draws the four protons inward. The four protons, split into quarter-spaces, generate the green potential that cages the electron core from outside. Each species is held only by the other's Coulomb potential (legend: red = V from electrons, green = V from protons).

bind on its own, but adding a *second* proton produces the deuteron 2p + 1e, which does. The single electron cannot glue *one* proton into a bound nuclear unit, yet it glues *two* — the role-reversed H^- in which one negative charge binds two positive ones, the two protons splitting into halfspaces around the central electron core. The deuteron is thus the smallest dual-confined unit, and the whole ladder is built by adding protons and electrons to it, $d + d \to {}^4He$ (Fig. 2) and onward, never by gluing in neutrons. Second, the clouds do not collapse onto one another despite the attractive cross terms, for exactly the reason a hydrogen atom does not collapse: the kinetic energy in (2) rises as $1/(\text{size})^2$ under compression and overwhelms the $1/(\text{size})$ Coulomb gain. Stability of size is thus electromagnetic and kinetic, of the same origin as atomic stability.

3 Method

The functional (2) is minimised by three coupled flows, as in RealQM [1]: imaginary-time propagation of each one-particle component, a (signed) Poisson solve for the Coulomb potential, and free-boundary evolution of the partition. The computation is carried out in 3D on a Cartesian grid with a WebGPU solver; the signed-charge Poisson equation and the level-set partition are the only changes from the atomic solver. Protons and electrons are assigned equal mass, so both render as genuine charge clouds (a physical-mass proton, 1836× heavier, would localise to a near-point and obscure the picture without changing the qualitative balance).

Nuclei are built as nested shells: electron clouds occupy inner shells, proton clouds the outer shells, the radial partition assigning each spherical zone to its component. A shell of n clouds is seeded as n symmetric points ($n = 2, 4, 8$: an opposed pair, a tetrahedron, a cube), which the partition renders as a spherical shell ($n = 1$) or an angularly split shell. We write a configuration as *electron-shells* | *proton-shells* from inner to outer; e.g. 2+2 | 4+4 is two electron pairs inside two proton quartets. Energies are reported in a model unit fixed once, on the deuteron.

4 Results

4.1 The light nuclei and the single calibration

Table 2 collects the ladder. One scale is set by the deuteron, $E(^2\text{H}) = -2.12$ model units $\leftrightarrow$ 2.22 MeV; everything else follows with no further fitting. The alpha particle is 4p + 2e, and its main configuration is the dual-confined structure of Fig. 1: the two electrons split into halfspaces

electron symmetry	alpha configuration	E (model)	% exp.
spherical	homogeneous -2 core + $+4$ shell	≈ 0	0%
minimal break	2 halfspaces + 4 quarters	-18.5	69%
optimal	-2 core, nested 2+2 protons	-27.8	103%

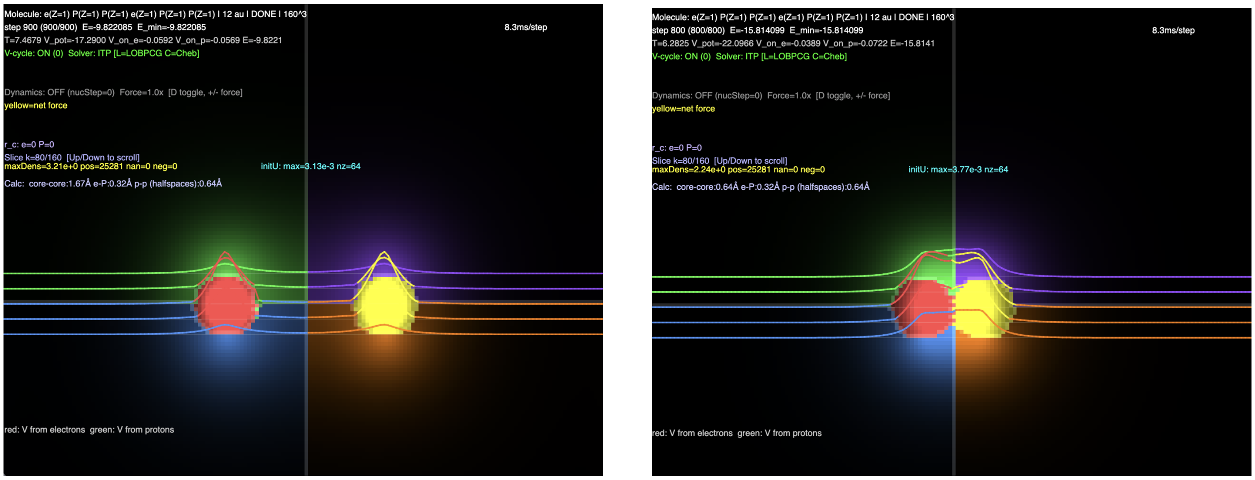
Table 1: The alpha binds only when the electron glue breaks spherical symmetry. A fully spherical configuration (homogeneous core and shell, reduced self-repulsion) does not bind; the minimal halfspace split recovers most of the binding; optimal concentration of the glue reaches experiment. One scale throughout, fixed on the deuteron.

forming the -2 glue, the four protons into quarter pieces. The role of the broken spherical symmetry is direct and decisive (Table 1). The fully spherical configuration — a homogeneous -2 core inside a homogeneous $+4$ shell, *even with reduced self-repulsion* — does not bind ($E \approx 0$): by the shell theorem a spherical proton shell exerts no force on the electrons it encloses. The minimal break of that symmetry — the two electron halfspaces gluing the four proton quarters — already recovers most of the binding ($E = -18.5$, 69% of experiment). Concentrating the glue optimally, as a -2 core in a nested 2+2 proton arrangement, then sharpens it to $E = -27.8$, i.e. **29.1 MeV against the experimental 28.3 (103%)**, with the alpha/deuteron ratio 13.1 versus the experimental 12.7. That a single Coulomb scale carries the most tightly bound light nucleus with no adjustable parameter is the central quantitative result.

This alpha binding is also the energy of *fusion*: the ~28 MeV liberated when four protons and two electrons assemble into ^{4}He is what powers the stars and is the goal of controlled fusion, and here it is simply the Coulomb binding released as the proton and electron clouds lock into the dual-confined alpha. The assembly of the alpha from hydrogen is treated more fully in the monograph [2] and the interactive gallery [19].

4.2 Binding as a single connected unit, not as separated clusters

Every member of the ladder binds as a *single* dual-confined Coulomb unit, the proton and electron clouds wrapping one another throughout. The alpha appears only as a *compositional* motif —



```
Molecule: e(Z=1) P(Z=1) P(Z=1) e(Z=1) P(Z=1) P(Z=1) | 12 au | DONE | 160^3
step 900 (900/900)  E=-9.822085  E_min=-9.822085                    8.3ms/step
T=7.4679 V_pot=-17.2900 V_on_e=-0.0592 V_on_p=-0.0569 E=-9.8221
V-cycle: ON (0)  Solver: ITP [L=LOBPCG C=Cheb]


Dynamics: OFF (nucStep=0)  Force=1.0x  [D toggle, +/- force]
yellow=net force


r_c: e=0 P=0
Slice k=80/160  [Up/Down to scroll]
maxDens=3.21e+0 pos=25281 nan=0 neg=0          initU: max=3.13e-3 nz=64
Calc:  core-core:1.67Å e-P:0.32Å p-p (halfspaces):0.64Å

red: V from electrons  green: V from protons
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Molecule: e(Z=1) P(Z=1) P(Z=1) e(Z=1) P(Z=1) P(Z=1) | 12 au | DONE | 160^3
step 800 (800/800)  E=-15.814099  E_min=-15.814099                  8.3ms/step
T=6.2825 V_pot=-22.0966 V_on_e=-0.0389 V_on_p=-0.0722 E=-15.8141
V-cycle: ON (0)  Solver: ITP [L=LOBPCG C=Cheb]


Dynamics: OFF (nucStep=0)  Force=1.0x  [D toggle, +/- force]
yellow=net force


r_c: e=0 P=0
Slice k=80/160  [Up/Down to scroll]
maxDens=2.24e+0 pos=25281 nan=0 neg=0          initU: max=3.77e-3 nz=64
Calc:  core-core:0.64Å e-P:0.32Å p-p (halfspaces):0.64Å

red: V from electrons  green: V from protons
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Figure 2: Fusion of two deuterons into the alpha, $\mathrm{D} + \mathrm{D} \to {}^4\mathrm{He}$, computed directly. Each deuteron is built as a central electron core with its two protons split into halfspaces; the two deuterons are placed with their cores at separation $2R$ and relaxed at decreasing R. *Left:* the approach — the two deuterons still well separated. *Right:* the merged state — the two electron cores have joined into the central -2 glue (red/yellow) and the four protons into the quartal outer shell (blue/green): the dual-confined 2e + 4p alpha. The binding *deepens monotonically* as the cores approach — in the fully relaxed (adiabatic) coordinate the electron clouds screen the proton–proton repulsion at every separation, so the path into the alpha is downhill, the released energy being the fusion energy. Lower curves in each panel: the potential generated by the electrons (red) and by the protons (green).

each (2e + 4p) group is a confined sub-unit and ^{16}O is built of four of them — but *spatially* the lowest-energy form is a single connected structure (the nested 2+2+2+2 | 4+4+4+4 shells of §4.3), not four separated alpha droplets. The two are not equivalent in the model, and the difference is decisive: assembling ^{16}O as four *spatially separated* alpha clusters leaves each cluster with net charge +2, so the clusters repel and the separated arrangement binds only ∼82% of experiment — *below* the connected unit and below even the sum of four free alphas. **The model therefore disfavors separate clustering in ^{16}O**: the nucleus is one mutually-confined cloud system, more bound than its parts held apart, and there is no preferred tetrahedral four-droplet ground state. The single exception is ^{8}Be, which the model finds only *marginally* bound as two near-touching alphas — matching the empirical fact that ^{8}Be is unstable and decays into two alpha particles. Across the experiment-matching connected configurations the binding tracks ∼7 MeV per nucleon,

nucleus	structure (e | p)	E (model)	MeV	% exp.
^{2}H	1 | 2	−2.12	2.22	calib.
^{4}He	2 | 4 (core)	−27.8	29.1	103%
^{8}Be	2+2 | 4+4	−58	61	108%
^{16}O	2+2+2+2 | 4+4+4+4	−129 to −138	135–144	106–113%

Table 2: The RealNucleus ladder. One scale fixed on the deuteron (−2.12 ↔ 2.22 MeV); all other entries follow with no fitting. Experimental bindings: ^{2}H 2.22, ^{4}He 28.3, ^{8}Be 56.5, ^{16}O 127.6 MeV.

the empirical volume law, reflecting the roughly constant density that the shell count enforces (§4.3).

4.3 Electron concentration sets the binding; shell spread sets saturation

A systematic scan over shell configurations at fixed radial spacing shows a single controlling variable: the *concentration of the electron glue.* Concentrated electron cores over-bind, diffuse cores under-bind, and an intermediate concentration matches experiment. For ^{8}Be the electron arrangement 4 → 2+2 → 1+1+1+1 runs the binding from 153% through 108% down to 68% of experiment, with 2+2 on target.

The over-binding of the most *compact* large configurations is removed without any new force: as a nucleus grows it *adds shells*, spreading the charge. For ^{16}O, spreading the electrons from two shells (4+4, 177%) to four shells (2+2+2+2) brings the binding down to 106–108% of experiment (Table 2). The shell count, set by the nucleon count, fixes the size and hence the density — this is the nuclear *saturation*, and it too is purely structural and electromagnetic. The winning ^{16}O structure, 2+2+2+2 | 4+4+4+4, is exactly four nested (2e+4p) alpha-units arranged as concentric shells.

nucleus	pattern (e | p)	E (model)	MeV/A	% exp.
^{2}H	1 | 2	−2.12	1.1	calib.
^{4}He	2 | 4	−19.4	5.1	72%
^{8}Be	2+2 | 4+4	−57.6	7.5	107%
^{12}C	2+2+2 | 4+4+4	−94.3	8.2	107%
^{16}O	2+2+2+2 | 4+4+4+4	−132.1	8.6	108%

Table 3: Binding per nucleon along the matched alpha-unit ladder (one scale fixed on ^{2}H). From ^{8}Be on, the model holds a uniform 107–108% of experiment with nearly constant MeV/A — saturation. Experimental MeV/A: ^{4}He 7.07, ^{8}Be 7.06, ^{12}C 7.68, ^{16}O 7.98.

4.4 Binding per nucleon and saturation

The matched packing extends to a single ladder built by *adding one* (2e + 4p) *alpha-unit at a time*, electron pairs inside, proton quartets outside (Table 3). The result is the empirical hallmark of nuclear binding: **binding per nucleon is essentially constant** along the ladder. From ^{8}Be onward the model sits at a uniform 107–108% of experiment, and its binding per nucleon (7.5 → 8.2 → 8.6 MeV) even *tracks the experimental rise* toward the iron peak (7.1 → 7.7 → 8.0). Each added alpha-unit contributes a near-constant binding — saturation, emerging from dual Coulomb confinement with one scale and no fitting.

Two members sit apart from the trend, both correctly. ^{4}He, the single alpha-unit, is the lone outlier at this fixed spacing (72%); being the smallest and densest nucleus it wants a tighter size, and given it returns 103% (§4.1) — so the *one*-unit member needs its own scale while every multi-unit member falls on the pattern. The deuteron (1 | 2) is the anchor and, like the real deuteron, is anomalously weakly bound and does not follow the per-nucleon trend.

Extrapolation. Because each (2e+4p) unit adds a near-constant binding, *continuing the pattern* — 2+2+2+2+2 | 4+4+4+4+4 for ^{20}Ne, and so on — is expected to keep MeV/A flat at the saturated value. We state this as a conjecture: the dual-confinement ladder should reproduce the flat plateau of the nuclear binding curve for the alpha-conjugate nuclei, with the slow rise toward the iron peak coming from the same gentle trend already visible in Table 3. Direct confirmation beyond ^{16}O requires computation at larger nucleon number; we leave the heavier alpha-conjugate nuclei, and the magic numbers 20 and beyond, to future work.

5 Discussion: no strong force, and no weak force

The results support a single, deliberately strong claim: **nuclear binding is the dual Coulomb confinement of proton and electron charge clouds, and a strong force is not required.** The evidence is that (i) the deuteron and the alpha bind *quantitatively* from one Coulomb scale; (ii) the whole light ladder binds as single connected dual-confined units — with the volume law emerging and ^{8}Be left only marginally bound against alpha breakup, as observed; and (iii) the saturation of larger nuclei follows from the shell structure spreading with nucleon number, requiring no short-range repulsive core. At no point is a strong-force term present in (2); the only interaction is Coulomb, and the only structural rule is non-overlap.

The conventional motivation for the strong force — that like-charged protons cannot bind — is dissolved by the proton–electron picture: the nucleus is not a collection of protons only but a two-component Coulomb system in which the electron clouds supply the binding and the proton clouds the confinement, mutually. The neutron is not an elementary neutral particle to be glued in, but a proton locally confined by an electron; "the strong force" is, on this view, the effective name for the Coulomb confinement that the proton–electron clouds already provide.

5.1 Relation to earlier nuclear models

The picture used here is, in outline, an old one. After Rutherford's nuclear atom [7], and before Chadwick's discovery of the neutron in 1932 [4], the nucleus was generally taken to consist of protons *and electrons* [10] — a nucleus of mass A and charge Z being A protons and $A - Z$

electrons, exactly the bookkeeping we adopt. That proton–electron model was abandoned for three reasons: the spin–statistics "nitrogen anomaly" (^{14}N behaves as a boson, whereas 14 protons + 7 electrons is an odd number of fermions); the confinement-energy objection that an electron localised to nuclear (∼fm) dimensions would, by the uncertainty principle, carry momenta far above observed β-decay energies; and the nuclear magnetic moments, of order the nuclear (proton) magneton rather than the Bohr (electron) magneton. The neutron as an elementary neutral particle [9] removed the need for nuclear electrons; Heisenberg's proton–neutron nucleus bound by exchange forces [8] replaced the old picture, and Yukawa's meson exchange [5] supplied the short-range strong force that has underpinned nuclear binding ever since. Every subsequent model — the liquid drop [12], the alpha-cluster picture [13, 6], the shell model [14, 15], and today's QCD-based *ab-initio* theory — takes that strong-force, proton–neutron nucleus as its starting point.

5.2 No weak force either

The same picture removes the need for a separate *weak* interaction to account for the instability of the free neutron. In the standard account, β-decay $\mathrm{n} \to \mathrm{p} + \mathrm{e}^- + \bar{\nu}$ is mediated by the weak force, in Fermi's theory [11], acting on an otherwise elementary neutron. In RealNucleus there is no elementary neutron to decay: the model "neutron" is just a single proton–electron pair (1p + 1e), and we find this pair *unbound* (§2.3) — its energy is lowered by letting the electron cloud separate from the proton. The free neutron's instability is therefore already present as a purely Coulomb fact: a lone proton cannot hold a single electron into a bound nuclear unit, so the pair comes apart into a free proton and a free electron, exactly the charged decay products of β-decay, with no weak-interaction term anywhere in (2). We computed this directly. The model is silent on the antineutrino — it carries neither charge nor cloud and lies outside the present formulation — so we do not claim to reproduce the decay kinematics; the point is only that the *existence* and *direction* of neutron decay, like nuclear binding itself, follow from Coulomb energetics alone, without invoking a weak force. That the nucleus cannot be held together by electromagnetism — that an attractive nuclear (strong) force is *required* to overcome the Coulomb repulsion of the protons — is stated in every standard text [16, 17, 18]. To our knowledge *no* mainstream model binds the nucleus by Coulomb forces alone; the strong (today, residual QCD) force is universal. It is precisely this textbook necessity that the present work questions.

RealNucleus revives the proton–electron picture within a different framework, and this bears on the old objections. RealQM has *no spin and no antisymmetry* — particles are kept apart by non-overlapping domains rather than by Pauli statistics — so the spin–statistics counting that sank the original model does not arise in the same form. The electrons are extended *charge clouds*, not point particles, and the binding is obtained at an effective (atomic-unit) scale fixed by a single calibration rather than at the literal femtometre scale, which sidesteps the point-electron confinement estimate. We do not claim these objections are thereby *resolved*: the magnetic moments are not addressed, and the relation between the model's calibrated scale and the physical nuclear radius is left open. The point is only that the charge-cloud, spin-free, free-boundary formulation is a genuinely different setting in which the proton–electron nucleus can be reconsidered. The alpha-cluster tradition (Hafstad and Teller [6]) is a structural cousin — nuclei built from alpha sub-units — but it binds those sub-units with the nuclear force, whereas here the same Coulomb cloud-packing that builds each alpha is asked to do all the work.

5.3 Hydrogen burning as a Coulomb rearrangement of protons and electrons

A stellar core is a fully ionised hydrogen plasma: free protons and free electrons in equal numbers, electrically neutral. This starting point is not in dispute — it is shared with the standard account. What RealNucleus changes is the *mechanism* of what follows, and the soup it needs contains nothing but protons and electrons: there are *no neutrons among the ingredients.*

In this picture hydrogen burning is a pure rearrangement of those protons and electrons. The high temperature does two things: it frees the electrons from the protons (ionisation) and gives the protons enough energy to approach. Two protons then capture an electron into a common *core*, forming the deuteron as an electron core inside a proton shell; two such deuterons merge into the alpha, the two electron cores joining into the central −2 glue and the four protons into the outer shell (Fig. 2). Counting the electrons explicitly,

$$4\,\mathrm{H} \;=\; 4\mathrm{p}+4\mathrm{e} \;\longrightarrow\; (2\mathrm{e}+4\mathrm{p})+2\mathrm{e} \;=\; {}^{4}\mathrm{He}+2\mathrm{e}, \tag{3}$$

that is: of the four electrons of the four hydrogen atoms, *two move inside* as the nuclear glue of the alpha and *two remain outside* as the electron shell of the neutral helium atom. Charge and particle number are conserved at every step, with protons and electrons the only currency. A "neutron" never appears as an ingredient or a product; it exists only emergently, as a bound proton–electron pair *inside* a nucleus. The energy released — the ∼26.7 MeV by which four hydrogen atoms exceed one helium atom — is here simply the Coulomb binding of the assembled alpha; it is the same total as in the standard account (a state function of the endpoints), differently attributed.

The same electron and the same Coulomb law operate at both scales. In a cold hydrogen atom the electron binds *to* a proton as an outer cloud; in the hot, dense plasma it binds *between* protons as an inner core. Atom and nucleus become one electrostatic picture, separated only by temperature and separation, not by a new force.

Because no proton is ever converted into a neutron — the protons and electrons are only rearranged — this route emits *no positrons and requires no neutrinos.* We do not read this as a claim against the neutrino, which is detected in β-decay, reactor, solar and supernova experiments; we observe only that *this particular assembly does not call for one.* RealNucleus thus offers 4H → ^{4}He as a *possible* Coulomb process, scoped to the binding energetics it computes; the dynamics of weak decays and the origin of the detected neutrino flux lie outside the present formulation — neither needed by it nor denied.

5.4 Limitations

We state the limitations plainly. The matching configurations are *selected* rather than yet derived from a single minimisation principle: at fixed spacing the most compact structures over-bind, and the experiment-matching spread is identified by hand. The central *scale*, however, is robust to that choice: an earlier, structurally distinct parametrization — electrons on the vertices of inner Platonic solids with protons on outer polytopes — already reproduced nuclear binding magnitudes to within about 25% across small Z. That a completely different geometry yields the same scale from the same Coulomb-only premise indicates the result is not an artifact of the matched-shell ansatz; the matched shells merely concentrate the electron glue more optimally and so sharpen the agreement to a few percent. Some configurations relax to oscillating rather than sharply converged energies, so the quoted percentages are experimental-scale agreements, not few-percent determinations. The equal proton mass is a modelling choice that sets the absolute size scale. None of these reintroduces a strong force; they mark the work needed to turn a demonstration into a fully predictive theory — principally, a free-boundary determination of the equilibrium shell count and spacing for each nucleus.

An extraordinary claim. We do not understate what is at stake. If nuclear binding is electromagnetic, then the strong force — one of the four fundamental interactions, and the foundation of nuclear physics since Yukawa — is not needed to hold nuclei together, the neutron reverts from an elementary particle to a confined proton–electron pair, and the consensus that replaced the proton–electron nucleus in 1932 would be, at least for binding, an effective description of something electromagnetic. By the ordinary standard, such a claim demands extraordinary evidence, and the results here — suggestive as they are — do not meet that bar: they rest on selected configurations, an effective rather than femtometre length scale, and classical objections (magnetic moments, the uncertainty-principle confinement estimate) that remain open. The reader's skepticism is therefore appropriate; on the textbook view that nuclear binding *is* the strong force, that a purely Coulomb model reproduces nuclear binding scales at all is almost impossible to believe. We present this work in exactly that spirit: not as a refutation of the strong force, but as a demonstration that the *possibility* of a Coulomb-bound, dual-confined nucleus is computationally open — surprising to us as much as to anyone — and as an invitation to test it harder and, if it is wrong, to find out precisely where.

6 Conclusion

Carried into the nucleus, RealQM describes protons and electrons as one kind of charge cloud of opposite sign, bound by Coulomb alone through *dual confinement*: electrons holding protons in, protons holding electrons in. One scale fixed on the deuteron yields the alpha at 103% of experiment, the binding-per-nucleon volume law, the marginal stability of ^{8}Be, and — through the spreading of shells with nucleon number — the saturation that places ^{16}O at the experimental scale. The binding and the saturation are both electromagnetic. Within this model, **the strong force is unnecessary**.

Code availability and reproducibility

Every result in this paper can be reproduced in a web browser. The interactive solver and the specific nucleus configurations reported here — the deuteron, the alpha, the $^{2}\mathrm{H} \to {}^{16}\mathrm{O}$ ladder, and the binding-per-nucleon study — run directly in the RealQM/RealMolecule gallery [19], with the complete source in the linked repository (`https://github.com/Claes542/RealMolecule`). Readers are encouraged to re-run the configurations and test the claims for themselves; for a radical claim, the live, re-runnable computation is the primary evidence.

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