Proton–Electron Cosmology

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Mathematical theory and formulation by the author; manuscript developed in collaboration with Claude (Anthropic). See Section 13.

Abstract

We sketch an exploratory cosmology built from the RealQM / RealNucleus program, in which all structure is Coulombic (no strong force, no elementary neutron). The arena is a **given 3D Euclidean space** (in the spirit of Many-Minds Relativity) — no physical medium, only the coordinate system and the Laplacian. On it live **two fluctuating potentials**, a gravitational φ_g and an electric φ_E. Mass and charge are not postulated but read off as the curvature of the potentials, $\rho = \nabla^2\varphi$, which makes both *variable in sign* and *net-zero* ($\int \nabla^2\varphi\, dV = 0$): the universe carries no net mass and no net charge, the latter giving equal numbers of protons and electrons with no baryogenesis. The Laplacian amplifies small scales ($\rho_k \propto k^2\varphi_k$); the seed itself is a *small fluctuation.* From this one seed the universe develops in **two tiers**: **large-scale gravitation** — positive mass aggregating into the **cosmic web**, negative mass repelling as **dark energy** — and **small-scale electromagnetics** — the co-seeded ±charge, with + tied to the **large mass (protons)** and − to the **small (electrons)**, forming nuclei and atoms. As **gravitational contraction** makes the positive mass hot and dense, **deuterons and nuclei** form (∼MeV, RealNucleus) — the step required for everything beyond hydrogen — and, on cooling, **atoms** (∼eV, RealQM); the electromagnetic **binding energy is released as radiation** — the origin of **light** — the mass defect feeding back to gravity via $E = mc^2$. The electron is taken to have **two temperature-selected size-phases** — compact (inside nuclei, ∼MeV) and expanded (atomic, ∼eV) — so a single cooling curve orders nuclei then atoms, with neutron = proton + compact electron, the weak interaction as the size-transition, neutron stars as forced compactification, and the primordial helium fraction set by a transition temperature T_*, with **no strong force, no elementary neutron, no matter–antimatter asymmetry, and no rebounce or singularity** (a finite-fluctuation origin). We state the picture, its one quantitative handle (T_*), and its load-bearing open problems — chiefly *what sets the nuclear scale*, and whether the $\nabla^2\varphi$ *fluctuation spectrum* matches large-scale structure.

Status. This is an exploratory proposal, not established cosmology. It departs sharply from the Standard Model and ΛCDM and must eventually be reconciled with them; the open problems in Section 10 are load-bearing. Read it as "what follows *if*."

Keywords: cosmology; two-tier cosmology; induced gravity; proton–electron model of the nucleus; dark energy; primordial nucleosynthesis; RealQM; multiphase Coulomb continuum mechanics.

1 Introduction

The RealQM program formulates quantum mechanics as multiphase 3D continuum mechanics — unit-charge densities on non-overlapping domains separated by Bernoulli free boundaries, minimising the Coulomb energy [1]. Its nuclear extension, RealNucleus, revives the pre-1932 proton–electron picture (neutron = proton + electron) and reproduces nuclear binding from pure Coulomb interactions with no strong-force postulate [2]. This note asks what cosmology results if the *same* ingredients — Coulomb attraction, a multiphase free-boundary vacuum, and particles built from charge — are taken as the starting point of the universe. The result is a **two-tier** cosmology — large-scale gravitation and small-scale electromagnetics from one seed fluctuation — with dark energy and a unified treatment of nuclear and atomic structure built in, and with no large-scale rebounce or singularity. We develop it as a chain of postulates and consequences, and we keep the open problems explicit.

2 The arena: a given 3D Euclidean space

Following *Many-Minds Relativity* [3], we take the arena to be a plain **3D Euclidean coordinate system** — absolute space, simply *given*: not Einstein's relative spacetime, and *not* a physical elastic medium. On it live scalar potentials (a gravitational φ_g and an electric φ_E), and the only operator needed is the **Laplacian** ∇^2. Mass and charge are not separate ingredients — they are the Laplacian (curvature) of the potentials,

$$\rho_{\text{mass}} = \frac{1}{4\pi G}\,\nabla^2\varphi_g, \qquad \rho_{\text{charge}} = -\varepsilon_0\,\nabla^2\varphi_E.$$

Nothing is presupposed but the coordinate space and the operator — no pre-stressed medium, no tension to justify. (This replaces the earlier tensioned-vacuum picture with a smaller, cleaner given.)

The Laplacian's large multiplicative effect. ∇^2 multiplies each Fourier mode by k^2 ($\rho_k \propto k^2\varphi_k$), so a gentle, small-scale ripple in a potential becomes a *large* density contrast — a strong multiplicative amplification at short wavelengths (the "inflation" of the density field). A tiny fluctuation of φ thus seeds strongly-varying mass and charge on small scales.

Mass is not electromagnetic. The electromagnetic sector carries *charge*; *mass is inertia* — the localization, i.e. the frequency / inverse size of the matter wave, the dispersion gap $\omega_0 = mc^2/\hbar$ — a separate, gravitational quantity (signed, hence not the positive-definite EM field energy). Electromagnetism and gravitation meet *only through energy* ($E = mc^2$), embodied in matter (a charge welded to an inertia). MMR also gives $E = mc^2$ from a wave momentum $P = mc$ ([3], ch. 16), mass–energy equivalence without Lorentz kinematics; the present construction needs only the Euclidean arena and the Laplacian, and is otherwise *non-relativistic — no c enters* the electrostatic/gravitational structure.

How the Coulomb sector couples to gravitation — only through energy. Gravity never sees electric charge directly; it sees only *energy*, and $E = mc^2$ turns the Coulomb sector's energy (binding, kinetic, radiation) into *mass*, the gravitational charge — realised in matter (each cloud carries both a charge and a mass) and manifested in the *mass defect* (binding lowers the energy, hence the mass; the difference radiates). $E = mc^2$ is itself neither from RealQM nor from Newton but a bridge imported from the wave/radiation side ($P = mc$, largely a convention) — the one place c enters; see the foundations note *Where $E = mc^2$ comes from.*

The irreducible given is then only a Euclidean coordinate space and the potentials on it — a far smaller assumption than a pre-stressed elastic solid. Why there is a space with potentials at all is the boundary where physics hands off to metaphysics; we state it plainly rather than smuggle it in.

3 Two fluctuating potentials: mass and charge as curvature

The fundamental objects are two potentials on the substrate of Section 2 — a gravitational φ_g and an electric φ_E — each carrying a small-scale fluctuation. Density is not assumed; it is the

Laplacian of the potential (Poisson, run backwards):

$$\rho_{\text{mass}} = \frac{1}{4\pi G}\,\nabla^2\varphi_g, \qquad \rho_{\text{charge}} = -\varepsilon_0\,\nabla^2\varphi_E. \tag{1}$$

Three consequences follow at once.

1. **Variable sign.** ρ is positive where φ is concave and negative where convex. Gravity thus has ±mass and electromagnetism ±charge, both *derived* from one potential each, not postulated as separate ingredients.

2. **Net zero.** For any localised fluctuation, $\int \nabla^2\varphi\, dV$ is a surface term that vanishes, so $\int \rho\, dV = 0$. The universe carries **zero net mass and zero net charge** automatically. Charge neutrality means equal numbers of protons and electrons — $\#p = \#e$ — with *no baryogenesis required*; mass neutrality means the ±mass regions balance.

3. **Small-scale amplification.** For a Fourier mode, $\rho_k \propto k^2\varphi_k$: the Laplacian amplifies short wavelengths by k^2, so a gentle potential ripple becomes a large density contrast. We refer to this as the "inflation" of the density field; it is amplification, not the exponential spatial expansion of standard inflation (Section 10).

The Laplacian's k^2 amplification first makes many *small* ±mass regions, already spanning a range of magnitudes (deep wells = larger positive mass, shallow = smaller). **Charge is co-seeded at this same small scale, not added later**: one correlated fluctuation sources both potentials, so the co-aligned electric potential — nonzero only on the positive-mass regions — assigns + charge to the **larger** positive mass (protons) and, by *local neutrality*, − charge to the **smaller** positive-mass remainder (electrons), leaving negative mass **chargeless**. Net charge is zero already at the small scale, and strong electromagnetism makes this *fast*, quantizing it to ±1 (Section 5). Only *then* does the weak, *slow* gravitational aggregation act: same-sign mass attracts and opposite repels, so the small-scale ±mass accumulates into a **large-scale web** — positive-mass filaments and nodes (carrying their already-neutral proton–electron charge) and negative-mass regions, separated by voids from the repulsion. So the genuine order is **fast local seeding, then slow aggregation**; mass and charge themselves are simultaneous (correlated), not sequential (Sections 4, 5).

4 Contraction, nucleosynthesis, and dark energy

The sequence needs no large-scale collapse-and-rebounce; ordinary gravitational contraction supplies the one hot dense epoch, and the released energy leaves as light:

1. **Gravitational contraction → hot dense.** The positive-mass seed — a *small fluctuation* — **contracts gravitationally** into a hot dense state. The hot dense comes from the contraction, not from the seed.

2. **Deuterons and nuclei, and light.** The contracting matter is already a proton–electron mix (charged at the seed, Section 3); the mass difference is gravitational, distinct from the electrostatic kinetic coefficient κ, which treats both as charge clouds for atomic/nuclear structure. The hot dense state builds **deuterons and nuclei** (∼MeV, RealNucleus) — required for everything beyond hydrogen — and the electromagnetic **binding energy is released as radiation (light)**, the mass defect feeding back to gravity via $E = mc^2$. No rebounce is invoked: the energy leaves as light, not as a mechanical bounce.

3. **Cooling → atoms.** As it cools, nuclei capture expanded electrons to form **atoms** (∼eV, RealQM), releasing radiation. Hydrogen needs no nucleosynthesis; heavier atoms need the nuclei above.

4. **Slow large-scale aggregation, and dark energy.** Much later, weak gravity aggregates the positive mass into the **cosmic web**; the negative-mass regions are *chargeless* — no electromagnetics, no light, hence literally **dark** — acting only by gravity and repelling as **dark energy**. Electric structure and light live only in the visible (positive-mass) region.

Two features stand out: the picture has *no singularity* (a finite-fluctuation origin, in the spirit of bounce cosmologies [5]) and is *two-tier* — small-scale electromagnetics (charge, nuclei, atoms, light; early) and large-scale gravitation (contraction to the hot dense state, then the cosmic web; late). It keeps ordinary gravitational contraction but needs **no rebounce and no bounce energy budget**: the released energy radiates as light rather than reversing a collapse. **Cosmic expansion has two drivers**: an **initial expansion from the seed** itself, and the **ongoing acceleration from dark negative-mass repulsion**.

A 2D test: cosmic-web morphology, and voids from negative-mass repulsion. A mass-conserving 2D simulation of the mass seed and its aggregation — generate mass $\rho = \nabla^2\varphi$ from a random potential fluctuation, then evolve compressible self-gravitating flow with same-sign attraction and opposite-sign repulsion — develops the **morphology of observed large-scale structure** (Figure 1): two **intermixed filamentary webs** (positive- and negative-mass), mass **concentrated at nodes** where filaments meet, separated by **large voids**. Filaments and nodes arise from same-sign gravitational aggregation; crucially, the **voids are actively driven by the negative-mass repulsion** (the dark-energy sector), rather than being merely under-dense regions evacuated by gravity as in ΛCDM. This is a *qualitative* morphological match (a 2D toy); a quantitative test (void-size distribution, filament statistics, the two-point correlation function against surveys and ΛCDM) remains to be done.

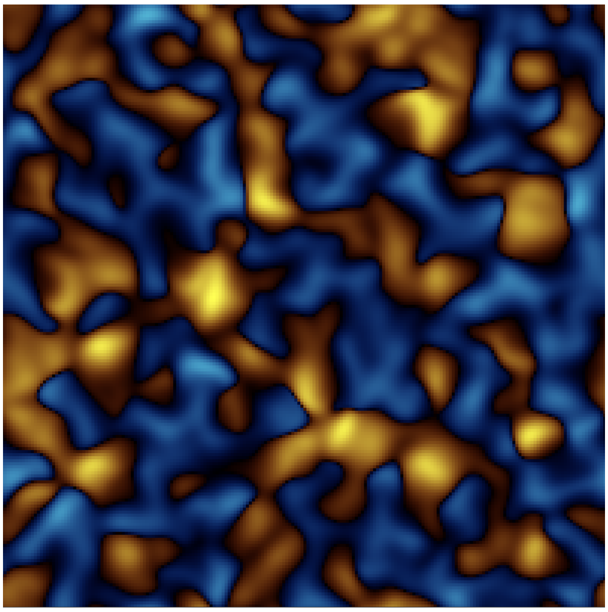

Figure 1: 2D self-gravitating ±mass from $\rho = \nabla^2\varphi$: intermixed positive- (warm) and negative- (cool) mass webs with concentrated nodes and large voids — the cosmic-web morphology, with voids driven by negative-mass repulsion. Mass-conserving; periodic box.

5 Why charge is quantised and mass is not

In one line: the large positive mass gets the + charge; the − charge is the **neutrality-mandated remainder**, carried by the small positive mass — **that is the basic asymmetry** (charge is co-seeded with mass, so charge sign tracks mass size; which sign we call + is the matter/antimatter convention).

The construction places charge *onto* the mass, not independently of it. Mass sets the template — the gravitational fluctuation makes **deep wells** (large, concentrated mass) separated by **shallow regions** (small, diffuse mass) — and the electric fluctuation is *co-aligned* with it (one correlated primordial fluctuation sourcing both potentials, not two independent ones). The + charge then lands on the deep wells (the **heavy protons**), and charge neutrality forces the − charge into the shallow complement (the **light electrons**). The electron is thus the *neutrality-mandated leftover*, and it is necessarily small and diffuse — both because the big-mass sites were already claimed by the + charge, and because, being spread out, it has large size and hence (mass ∼ inverse size) small mass. The correlation **big ↔ +, small ↔ −** is a consequence, not a separate assumption; which sign we call + is the matter/antimatter convention. (This is correlated *seeding*, not a time sequence: since electromagnetism is $\sim 10^{39}$ times stronger than gravity, charge cannot wait for mass to finish segregating — the two must be laid down already correlated. Neutrality then keeps the newly charged scaffold bound: protons plus electron clouds carry no net long-range force, so charging does not blow the structure apart.)

This same strong/weak asymmetry explains a fact usually taken as given — **charge is quantised in exact units, mass is not**:

	charge	mass
force	strong (EM)	weak (gravity, $\sim 10^{39}\times$ weaker)
dynamics	fast	slow
outcome	discrete ±1 units	continuous gradation
symmetry	exactly equal and opposite	grossly unequal (1836:1), top-heavy

Fast ⇒ quantised. Strong electromagnetism drives opposite charges together fast (the Coulomb collapse of Section 7); stabilised by the electron's kinetic energy, they lock onto the one *stable bound unit*, the proton–electron pair, which carries **integer charge** (+1 core, −1 cloud). All charge therefore relaxes onto multiples of a single elementary unit, and $+e$ and $-e$ come out *exactly* equal and opposite because they are the *same* unit — quantisation as fast relaxation onto the stable charged state. **Slow ⇒ gradation.** Gravity is weak, slow, and — crucially — has *no stable elementary unit to snap onto*: same-sign mass simply keeps accreting, nothing halting it at a preferred size. Mass therefore never quantises; it accumulates by gradation into a **continuous spectrum weighted toward the big wells** (most of the mass in nuclei, and upward to stars). The two 2D simulations embody the contrast directly: the charge run (fast collapse onto discrete bound ±1 pairs) versus the mass run (slow segregation into a continuous graded web).

Two honest limits remain. The fast dynamics explains why charge appears in *integer multiples* of a unit, but not why the unit e exists (a stable $\pm e$ soliton is still an input); and at the elementary level protons and electrons do have definite masses, so the "continuum" is really the *aggregate* mass spectrum — the 1836 ratio itself stays the open number of Section 10.

6 Proton–electron charges and the two electron sizes

We take protons (+1) and electrons (−1) to be **equal in mass** at the level of the charge fluctuation. In the proton–electron picture a neutron is $p+e$, so any neutral atom (A, Z) contains A protons and A electrons: $A - Z$ compact inside the nucleus (one per neutron) and Z expanded in orbitals. Equal numbers of protons and electrons everywhere is consistent with the net-zero charge of Section 3.

The electron is taken to occupy **two size-phases**, its extent adapting to the Coulomb well: *compact* in a deep well (inside a nucleus, ∼fm, ∼MeV) and *expanded* in a shallow one (atomic, ∼Å, ∼eV). The same particle then spans the nuclear and atomic energy scales, a ratio $\sim 10^5$–10^6.

Chemistry and nuclear physics become one Coulomb free-boundary mechanism at two scales: a molecule is nuclei glued by *expanded* (valence) electrons; a nucleus is protons glued by *compact* electrons. What physically sets the separation is the central open problem (Section 10).

Why the gap is α^2. The electron has three characteristic lengths — the three ways to build a length from $(\hbar, m, c, e)$, each differing by one factor of $\alpha = e^2/\hbar c$:

$$\underbrace{a_0 = \tfrac{\hbar^2}{me^2} \approx 0.5\,\text{Å}}_{\text{atomic }(\hbar,e)} \xrightarrow{\times\alpha} \underbrace{\bar\lambda_C = \tfrac{\hbar}{mc} \approx 386\,\text{fm}}_{\text{Compton }(\hbar,c)} \xrightarrow{\times\alpha} \underbrace{r_e = \tfrac{e^2}{mc^2} \approx 2.8\,\text{fm}}_{\text{classical / nuclear }(e,c)}, \qquad a_0 : \bar\lambda_C : r_e = 1 : \alpha : \alpha^2. \tag{2}$$

The two electron *phases* are the ends — expanded (atomic, a_0; non-relativistic Coulomb) and compact (nuclear, r_e; electromagnetic mass). The middle length, the *Compton wavelength* ($\hbar, c$; the quantum-relativistic scale where confinement costs $\sim mc^2$), is the quantum rung between them, which is why the nuclear/atomic gap is α^2 (two steps of α). Dropping $\hbar$ carries one from the atomic to the classical scale; α is the price of each step. (The value of α itself is an input, Section 10.)

The two sizes, set by charge and proton size — without mass. Described by charge and a kinetic coefficient κ alone (the electrostatic structure needs *no mass*), the *same* electron takes two forms. **Outside (atomic):** attracted to one proton, its density must taper to zero in vacuum; a varying profile carries kinetic energy κ/L^2, forcing a large cloud — size set by the proton's *charge*, $L = a_0$. **Inside (nuclear):** caged by protons with a multiphase *free boundary* — its density does *not* drop to zero but hands off to the proton density. A flat caged density then has $\nabla\psi = 0$, hence *zero kinetic energy*: no kinetic penalty for being small. Its size is set by the proton's *finite size* R_p (the cage floor that stops collapse), its binding Coulomb at that size ($\sim$MeV at fm). So the crucial factor is **proton charge vs proton size**: the ratio is $a_0/R_p \approx 1/\alpha^2$ (since $R_p \approx$ the classical radius $\approx$ a few fm). **The nuclear scale follows from Coulomb plus the proton's finite size, via a zero-kinetic-energy flat caged electron — no relativistic effect required.** (The kinetic obstacle κ/L^2 applies only to a *vacuum* electron forced to taper to zero, not to a caged one whose density stays finite at the free boundary.) Mass plays no part: it is a separate, *gravitational* quantity (the matter-wave's inverse size / dispersion gap).

Inputs of the electrostatic model. The whole atom/nucleus structure needs just three: **(i)** the charge / Coulomb potential e^2, **(ii)** the electron kinetic coefficient κ, and **(iii)** the proton's finite size R_p. From them: the atomic scale $a_0 = 2\kappa/e^2$ (from κ, e^2), and the nuclear scale R_p with binding $\sim e^2/R_p$ (from R_p, e^2), ratio a_0/R_p. *No mass, no c, no strong force, and α is not fundamental* — the nuclear/atomic ratio is a_0/R_p, which equals $1/\alpha^2$ only because R_p happens to be the classical radius. Mass (inertia) and gravity form a separate sector, coupling in only through energy ($E = mc^2$).

What α signifies. The fine-structure constant then emerges as a pure *geometric ratio* of the two scales,

$$\alpha^2 = \frac{R_p}{a_0} = \frac{\text{proton (nuclear) size}}{\text{atomic size}}, \qquad \alpha = \sqrt{R_p/a_0},$$

— how much smaller the nucleus is than the atom. *Not a coupling constant, and no c required.* It equals the textbook $\alpha = e^2/\hbar c$ only because the proton sits at the classical-radius scale ($R_p \approx \alpha^2 a_0 \approx$ a few fm). So the model reframes "why $\alpha \approx 1/137$" as "why is the proton $\sim$fm while the atom is $\sim$Å" — relocating the question to the proton size (an input), and interpreting α itself as the proton-to-atom size ratio.

Empirical check. Observed sizes: the H atom $\approx a_0 = 0.53$ Å $\approx$ 53,000 fm; the deuteron nucleus $\approx$ 2.1 fm (rms). Their ratio $\approx 4 \times 10^{-5} \approx 1/25{,}000$ matches $\alpha^2 \approx 5 \times 10^{-5} \approx 1/18{,}800$ to within ~30%, with the deuteron (~2.1 fm) sitting essentially at the classical electron radius ($r_e = \alpha^2 a_0 = 2.8$ fm). So the α^2 nuclear/atomic size relation is confirmed to order of magnitude — the H-atom/deuteron-nucleus size ratio comes out as $1/\alpha^2$, from charge, $\hbar$ and c alone, with no strong force. (The deuteron is unusually loosely bound, so this is the scale/ratio being right, not a precise fit.)

7 Temperature, the cosmic sequence, and the weak interaction

A bound state survives once the bath can no longer ionise it ($kT <$ binding). The two electron phases therefore switch on at two temperatures set by their two binding energies, forcing the order plasma → nuclei → atoms (Table 1). The temperature ratio between the two epochs ($\sim 10^6$) equals the energy-scale ratio — one fact, not two.

epoch	process	temperature
plasma	free ± charges	$> 10^{10}$ K
nuclear condensation	compact e captured → nuclei	$\sim 10^{10}$ K ($kT \sim$MeV)
atom formation	expanded e captured → atoms; radiation	$\sim$3000 K ($kT \sim$eV)

Table 1: The two condensation epochs, separated by $\sim 10^6$ in temperature.

The compact electron is precisely the electron inside a neutron: neutron $= p +$ compact e. The two weak processes are then the two directions of the size-transition, driven by temperature/density: *compactify* ($p + e \to n$, electron capture) and *expand* ($n \to p + e$, β-decay). This lands on real astrophysics: crushing matter forces electrons compact → wholesale $p \to n \to$ a neutron star (neutronisation in core collapse). The cosmic neutron/proton ratio at freeze-out is the compact/free electron ratio at T_*.

8 The quantitative handle: T_* and the helium fraction

The postulate predicts a transition temperature T_* at the compactification energy. The fraction of electrons that compactify by freeze-out fixes the cosmic neutron/proton ratio and hence the **primordial helium fraction**; matching the observed ~25% He ($n/p \approx 1/7$) is the decisive quantitative test. In standard physics freeze-out is at $kT \approx 0.8$ MeV ($T \approx 10^{10}$ K), tied to the n–p mass difference 1.29 MeV, so the prediction is $T_* \sim$ MeV $\sim 10^{10}$ K. Equivalently, the universe's small:big (compact:expanded) electron ratio equals the N:Z of primordial matter, ≈1:7, dominated by hydrogen (which has no compact electron).

A neutron is a proton with a compact electron, so the neutron/proton ratio is the compact/free electron ratio at freeze-out, $(n/p)_f = e^{-E_*/kT_f}$, with the compactification gap E_* playing the role of the n–p mass difference; free neutrons partly expand back (β-decay, factor d) before nucleosynthesis, and essentially all survivors end in He-4:

$$(n/p)_{\mathrm{nuc}} = \frac{(n/p)_f\, d}{1 + (n/p)_f\,(1-d)}, \qquad Y = \frac{2\,(n/p)_{\mathrm{nuc}}}{1 + (n/p)_{\mathrm{nuc}}}. \tag{3}$$

With the model's single MeV-scale handle ($E_* \approx 1.29$ MeV, $T_f \approx 0.8$ MeV so $T_* \sim 10^{10}$ K, $d \approx 0.74$): $(n/p)_f = 0.199 \to (n/p)_{\mathrm{nuc}} = 0.140 \to \boxed{Y = 0.245}$, the observed primordial helium. A single compactification energy thus reproduces the ~25% helium — the model's *first falsifiable quantitative success*. (Caveat: T_f is, in standard BBN, derived from the weak-rate-vs-expansion balance; here it is a second input, so the genuine prediction is the ratio $E_*/kT_f \approx 1.6$ with $E_* \sim 1.3$ MeV.)

9 Energetics: where the binding energy goes

Forming a deuteron releases its binding (∼MeV). Because the binding is Coulombic — an electron dropping from the expanded into the compact phase — the energy is released as photons, exactly as an atomic electron radiates when it falls to a lower level, scaled up $\sim 10^5$ to ∼MeV gammas. Equivalently it appears as the deuteron's mass defect ($E = mc^2$): the deuteron is lighter than its constituents by binding/c^2. Cosmologically it is dumped into a photon bath with $\sim 10^9$ photons per baryon, a $\sim 10^{-8}$ perturbation that redshifts to insignificance — the universe is not noticeably reheated.

The process is **not self-sustaining**: the released gammas feed the same bath that re-dissociates fresh deuterons while $kT \gtrsim$ binding, so net formation proceeds only as the universe *cools* below T_* (the deuterium bottleneck). This is the opposite of barrier-limited stellar fusion (favoured by heating, energy release sustaining the high T it needs); deuteron *formation* is exothermic capture (favoured by cooling) and self-quenches at high T. Proton density sets the *yields* (as the baryon density does in standard nucleosynthesis), not ignition. The one self-sustaining channel is *gravitational*: in a collapsing dense region, rising density forces electron capture in a runaway sustained by gravity — neutron-star neutronisation.

Radiation (deterministic, no photons). The light of this cosmology — the thermal radiation of the hot dense state — is handled within RealQM *deterministically*, without photons or statistics, by the *interaction matter–radiation* developed in [1]. Matter and radiation share one wave-equation structure: each electron density and the radiation field obey a wave equation augmented by an Abraham–Lorentz radiation-reaction term (energy radiated by accelerating charge) and a viscous term (coherent energy converted to heat at small scales). This yields the Rayleigh–Jeans law at low frequency and a temperature-dependent high-frequency cutoff — Wien's displacement law, and the Planck spectrum — with the ultraviolet catastrophe removed by a finite resolution scale rather than by quantisation, and the second law of radiation (heat flows hot → cold) following directly from the PDE. So the cosmic thermal radiation belongs to the same deterministic continuum program, not a separate quantised sector.

10 Open problems

1. **The nuclear scale.** What sets the $\sim 10^4$–10^5 nuclear/atomic separation? *Candidate (preferred):* take the **proton's finite size R_p (∼fm) as the input nuclear length**. An electron caged by protons with a multiphase *free boundary* (density finite, not dropping to zero) can be *flat* ⇒ *zero kinetic energy*, so it sits at the cage (proton) size with no kinetic penalty; binding is Coulomb (∼MeV at fm). The size ratio to the atomic (charge-set) electron is $a_0/R_p \approx 1/\alpha^2$ — no relativity needed. *Alternative:* the relativistic *classical radius* $r = \alpha^2 a_0 \approx 2.8$ fm (Coulomb self-energy = rest energy, in the sense of Many-Minds Relativity [3]), giving the same ratio. Open which primitive (proton size vs. relativistic), and whether the solver realises the flat zero-KE cage — direct runs so far were inconclusive (non-convergence at small cage size). The kinetic obstacle κ/L^2 applies only to a *vacuum* electron, not a caged one.

2. **The fluctuation spectrum and φ dynamics.** $\rho = \nabla^2\varphi$ gives a blue (k^2-amplified) density spectrum, whereas large-scale structure fits a near scale-invariant one ($n_s \approx 0.96$); the potential must carry a compensating red spectrum. Moreover $\rho = \nabla^2\varphi$ is a definition, not yet a law of motion — φ needs its own field equation.

3. **The mass ratio $m_p/m_e = 1836$.** The origin's mass-split makes the proton heavier than the electron (gravitationally), so the mass difference is now *built in* — but its *value* (1836) is not derived (nor is it in the Standard Model: proton mass ∼99% QCD binding, electron mass

from the Higgs). A subtlety to reconcile: the quantitative nuclear binding (He-4/deuteron 13.1 vs. 12.7) treats protons as *charge clouds* with an electron-like kinetic coefficient, so the *gravitational* mass (heavier proton) is distinct from the *electrostatic* kinetic coefficient κ (both charge clouds) — the relation between the two is open. Numerological aside: $m_p/m_e \approx 6\pi^5 = 1836.1$.

4. **The neutrino.** β-decay has a continuous spectrum — the 1930 objection that sank the proton–electron neutron and forced Pauli's neutrino [6]. The "electron expands" step needs a home for that energy and spin.

5. **Precision data and the rest.** BBN abundances are percent-level successes the sequence must reproduce; antimatter and proton substructure must be accounted for in a two-ingredient ontology.

11 Computational status

What the RealQM/RealNucleus engine has shown, versus what remains. **Done:** p-e-p binds as a stable configuration; the He-4/deuteron binding *ratio* comes out 13.1 vs. experiment 12.7 [2]; the lepton-mass scaling law $R \propto 1/m_{\text{glue}}$ is reproduced, with muon-catalysed fusion (the muonic molecular ion $dd\mu$ at ∼512 fm) as the observed proof that a heavy negative glue binds two protons; and the helium-fraction calculation of Section 8 gives $Y = 0.245$ from a single MeV-scale handle, matching the observed primordial helium. **Open:** the two-scale test (does one engine give MeV *and* eV in the same units? equal-mass Coulomb returns ∼1, confirming a scale ingredient is needed); and a cooling-quench using the engine's temperature and Brownian-dynamics machinery to enact the two condensation epochs.

12 Complexity from the proton–electron size asymmetry

The world is built not on a *charge* imbalance (charge is exactly balanced, $\pm e$) but on a *size* imbalance: the proton has a **fixed, small size** (a rigid anchor) while the electron's size is **variable** — it adapts to its well, spreading to ∼Å in an atom and compacting to ∼fm in a cage. The fixed proton supplies the anchors; the variable electron *spans scales* — spreading to bind atoms and molecules, compacting to bind nuclei — producing the nested multi-scale hierarchy that *is* complexity. With a fixed size for both, only one scale exists and nothing complex is built (both small → only nuclei; both large → only atoms). And α measures exactly this asymmetry: $\alpha^2 = R_p/a_0$ is the *inverse dynamic range* of the electron — a factor $1/\alpha^2 \approx 18{,}800$ between its nuclear and atomic phases — so **the smallness of α is the engine of complexity**. Equal fixed sizes would build nothing.

13 Collaboration

The mathematical theory and the cosmological proposal are the author's. The manuscript was developed in dialogue with Claude (Anthropic), which also assisted in articulating the argument, surfacing the quantitative constraints and open problems, and preparing the supporting interactive simulations of the RealQM/RealNucleus program. We present the human–AI collaboration transparently as part of the working method.

One-sentence summary. On a given 3D Euclidean space, if mass is built first from a gravitational-potential fluctuation (protons heavier, electrons lighter) and charge is then added by an electric-potential fluctuation in the positive-mass region — the negative-mass regions left chargeless and dark — and the electron has two temperature-selected sizes, then nuclei, atoms, the weak interaction, neutron stars, dark energy, and the primordial helium fraction follow from one cooling curve — a unifying picture whose survival hinges on a single hard question: what sets the nuclear scale, if not the strong force.

Three questions to close. Why bring in the strong force at all, when RealNucleus binds nuclei by Coulomb alone (neutron = p+e), using and needing no strong interaction? How crucial is the *exact* value of the nuclear/atomic scale difference $\alpha^2 \approx 1/18{,}800$? And would the world look essentially the same with a scale difference ten times smaller — nuclei ten times larger relative to atoms — still hierarchical, still complex? The picture suggests that what matters for a structured universe is that a *size asymmetry exists at all* (a rigid small proton, a fluid variable electron), more than its precise magnitude. The standard view is that α must lie in a **two-sided window** — neither **too large** (else the electromagnetic self-energy makes the proton outweigh the neutron and hydrogen decays, and heavy atoms destabilise at $Z\alpha \to 1$) nor **too small** (feeble chemistry, unviable stars) — a few percent wide for the strict carbon/oxygen (Hoyle) resonance, a factor of a few for the looser atom/star criteria. Two remarks. First, the *existence* of the nuclear/atomic hierarchy is far more robust to α than the detailed universe (which elements form, how stars burn). Second, **one side of that window dissolves here**: since neutron = p + e, the neutron is *structurally* heavier than the proton — by construction, independent of α — so proton and hydrogen stability is **automatic, not tuned**, and the mainstream "α must not be too large or the proton decays" bound simply does not arise.

References

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