# Matter Meets Space: The Weak Interaction as Curvature of Spacetime

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**Abstract**

Gravitation is not a force but the curvature of spacetime near masses. We extend the same reading downward: the binding of atoms and molecules, and beneath it the weak interaction, are read as curvature — not of the metric scale (Weyl's 1918 road, closed by Einstein) but of the quaternion phase, the i in W = iτ that this series placed at the foundation of spacetime. The framework stays strictly quaternionic: no octonions are invoked, because none are needed until the nucleon door — the colour sector deferred at the threshold p = 2πħc/r_p = 1474 MeV/c established in the state-quaternion paper. Three results organize the paper. First, a ladder of visibility thresholds: each "living space" of matter opens only to probes whose wavelength fits inside it — 23.4 keV opens the atom, 1.022 MeV opens birth and death itself (pair creation: below it electrons are eternal, above it they are mortal), 1474 MeV opens the nucleon (deferred), and 80.4 GeV resolves the weak bubble, below which the weak interaction masquerades as a zero-range contact force. Second, a running consistency check of the curvature–temperature identity of this series: the Unruh temperature of atomic-binding curvature is 364 K — chemistry runs at the temperature of its own curvature — and the Unruh temperature of weak-scale curvature is $1.5 \times 10^{14}$ K, within an order of magnitude of the electroweak transition temperature, across fourteen orders of magnitude of scale. Third, the weak interaction itself: its gauge group SU(2) is exactly the group of unit quaternions (Sp(1) ≅ SU(2)), so a weak transition is left multiplication by a unit quaternion; the interaction's fixed chirality is the algebra's fixed handedness (ij = k); and the death and birth of state quaternions — beta decay as the canonical case — is a per-axis ledger that closes exactly. The neutron lifetime anomaly (878 s in bottles against 888 s in beams) is identified as the framework's empirical prize. What remains open is stated plainly: the stiffness (mass) of the weak curvature, and the microscopic line element.

## 1. Matter Meets Space

The cosmological papers of this series read the largest structure in nature — the redshift, the background radiation, the horizon — as one gentle curvature, with radius c/H and acceleration cH. This paper dives to the other end of the ladder and makes the complementary postulate: **matter is extreme curvature of the same space**, and what we call the binding forces of atoms, molecules, and — the subject here — the weak interaction, are not forces acting *in* spacetime but compressions *of* it. A particle is not an object placed on the stage; it is a place where the stage is insanely tightly rolled.

One historical trap must be named at the door, because this postulate has been tried. Weyl (1918) geometrized electromagnetism as a stretching of the metric scale; Einstein refuted it in a famous objection — if rulers depended on their path history, atomic spectral lines would smear, and they do not. Kaluza and Klein made electromagnetism the curvature of a compact fifth dimension, and as mathematics this succeeded: in their picture the electromagnetic field literally is curvature. Weyl's own repair of 1929 became modern physics: the compression lives not in the metric scale but in the *phase* of the matter field — gauge theory. This series is unusually well placed to inherit that lesson, because it owns the phase by construction: the complex unit i in W = iτ, the axis around which the state quaternion of the fermion papers already turns. Throughout this paper, "compressed spacetime" therefore means **curvature of the quaternion phase connection**, Kaluza–Klein's success in Hamilton's algebra, and not Weyl's dead end.

## 2. The Ladder of Living Spaces: Visibility Thresholds

The state-quaternion paper established one threshold as a matter of principle (its eq. 18): the interior of the proton — the colour quaternion $Q_2$ — becomes visible only to probes with $p \geq 2\pi\hbar c/r\_p$ = 1474 MeV/c, because no probe can resolve a room its wavelength does not fit inside. The principle generalizes into a ladder, and the ladder is this paper's skeleton (Figure 1):

| Living space | Size | Threshold ($E \approx hc$/size) | What becomes visible |
|---|---|---|---|
| the atom | $a_0$ = 0.529 Å | **23.4 keV** | the electron shells (X-ray diffraction lives here) |
| the electron's own room | λ_C = h/m_e c = 2.43 pm | **0.511 MeV** (pairs at 1.022 MeV) | **birth and death**: below this door electrons are eternal; above it they can be created and annihilated |
| the nucleon | r_p = 0.841 fm | **1474 MeV** | $Q_2$, colour, confinement — the octonion sector, **deferred** |
| the weak bubble | ħ/m_W c = $2.46\times10^{-18}$ m | **80.4 GeV** | the weak curvature itself: real W bosons (CERN, 1983) |
| the stiffness scale | — | 246 GeV | the electroweak vacuum value — the open problem of Section 6 |

(Conventions: the nucleon row uses the 2π convention of eq. 18; the weak row uses the reduced convention whose anchor is the measured W mass. The bookkeeping differs by 2π; the doors are where nature put them.)

Two remarks the table forces. First, the answer to why the weak force is invisible in daily life is the same as why the proton's interior is: **its living space is below every ordinary probe's resolution**. Below 80 GeV the weak interaction has no visible interior at all — it acts as a zero-range contact, which is precisely Fermi's 1934 description (coupling $G_F = 1.166\times10^{-5}\ \text{GeV}^{-2}$, dimensionally the confession that a scale is hidden: $G_F \propto 1/m_W^2$). The weak force was a contact stain on the ledger for fifty years until accelerators knocked on the 80 GeV door and the curvature answered in person. Second, the ladder is *inverted* relative to naive size ordering in one telling place: the weak bubble ($10^{-18}$ m) is smaller than the nucleon ($10^{-15}$ m). One passes the octonion door on the way to the weak one. But colour is a different algebra, not a deeper version of this one — the weak sector is quaternionic all the way down, which is why this paper needs no octonions and uses none.

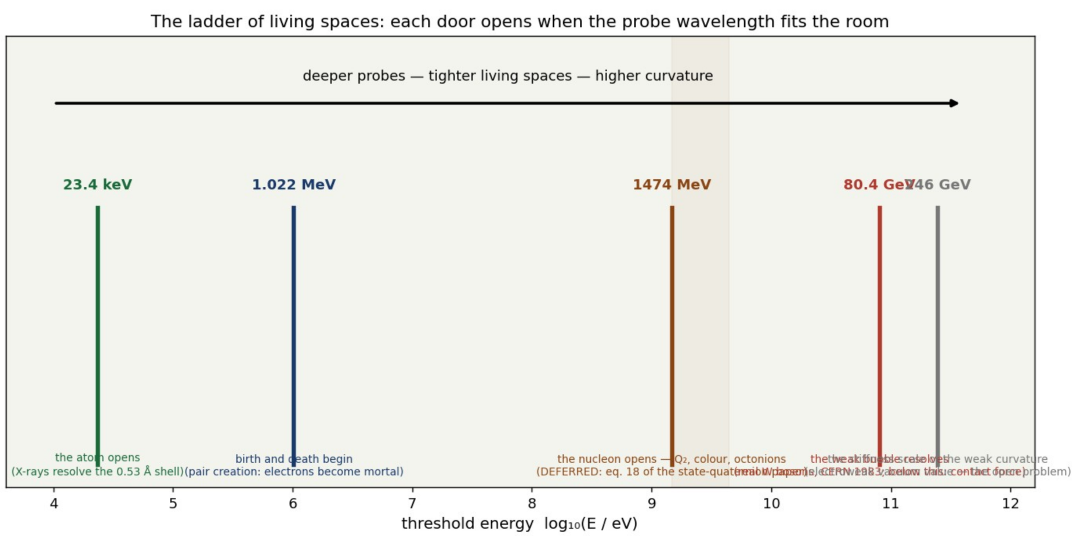


*Figure 1. The ladder of living spaces. Each door opens when the probe's wavelength fits the room. The nucleon door (1474 MeV, brown) leads to the colour/octonion sector and stays shut in this paper.*

## 3. The Curvature Ladder, and Two Temperature Coincidences

If binding is curvature, each rung has a curvature radius $r_c = c^2/a$ and — by the temperature–geometry identity of the cosmology paper (Tolman; Gibbons–Hawking; the W-circle) — an Unruh temperature $T = \hbar a/2\pi c k_B$. Computed:

| System |
|---|
| Earth's surface gravity |
| electron in hydrogen |
| weak scale ($r_c = \hbar/m_W c$) |

The middle row says: chemistry bends space twenty-two orders of magnitude harder than a planet does, and the Unruh temperature of that bending is 364 K — **chemistry, and life, run at roughly the temperature of their own curvature**. The bottom row says: the Unruh temperature of the weak curvature is within an order of magnitude of the electroweak transition temperature (~160 GeV/k_B ≈ $2×10^{15}$ K) — the temperature at which, in the standard account, the weak sector melts back into symmetry. Fourteen orders of magnitude apart, the same identity keeps returning the physically right temperature. In this series' language: each living space is a Tolman cell, hotter the tighter it is rolled — the same law that made the deep cosmological well glow at 3,000 K makes the weak bubble "glow" at the electroweak scale.

## 4. Equation (1): The Weak Group Is the Unit Quaternions

The first equation of this paper is a theorem of algebra, not a proposal:

**Sp(1)** ≅ **SU(2)** (1)

The group of unit quaternions and the gauge group of the weak interaction are the same object — exactly, not analogously. Consequences, in order of weight. A weak transition (d → u; n → p; ν ↔ e in the doublet) **is left multiplication by a unit quaternion**: a rotation in isospin space, performed by the very algebra this series placed under spacetime. The weak interaction is the only force in nature whose charge space is Hamilton's; the others borrow the algebra, the weak force *is* it, gauged. And its defining scandal — that it couples only to left-handed fermions, the unique parity-violating interaction (Lee and Yang 1956; Wu 1957) — is the algebra's fixed handedness ij = k, the same screw that the galaxy-rotation paper put in the sky. One handedness, from beta decay to the spin of galaxies: that is the series' single strongest cross-scale claim, and both ends of it are stated in refereeable form (the Wu experiment at one end; the spin-handedness dipole at the other).

## 5. Life and Death of State Quaternions

Three pieces built earlier in this series now assemble themselves.

**The moment of death.** The quantum-leap paper identified the transition instant as the *transfiguration point*: the real part of the state quaternion passing through zero — the state momentarily neither old nor new, purely imaginary, unobservable. Death and birth of a state are one event seen from two sides of the zero.

**The executioner and the midwife.** Gravity curves a quaternion's path; electromagnetism binds it; only the weak interaction — only equation (1) — **changes its identity**. Flavor change is quaternion multiplication. The weak force is the sole interaction authorized to move a state quaternion from one identity to another; it is the undertaker and the midwife in a single operator.

**The books.** The state-quaternion paper's per-axis accounting, applied to the canonical death — the free neutron, n → p + $e^-$ + $\bar{\nu}$:

| axis |
|---|
| $e_0$ (energy, MeV) |
| $e_1$ (charge) |
| $e_2$ (spin) |
| $e_3$ (orbital) |

Every axis clears. The ledger discipline of the cosmological bookkeeping paper continues without modification into the femtometre world: the weak force may move entries between accounts — it is the only teller with that authority — but it cannot touch the totals. (The addition machinery behind the $e_2$ row is the operator triangle rule, per the honesty corrections already adopted in the state-quaternion paper: the axes organize the bookkeeping; they do not replace the operator algebra.)

## 6. The Prize and the Debts

**The prize.** The neutron lifetime anomaly is the standing empirical puzzle of exactly this territory: bottle experiments, which count surviving neutrons, give $\tau \approx 878$ s; beam experiments, which count the decay protons, give ≈ 888 s — a ~1 percent, ~4σ discrepancy, stable for a decade. Counted deaths disagree with counted survivors. A framework that books the death of the neutron axis-by-axis is obligated to ask its natural question: **is there a death that produces no proton to count** — a transfiguration path whose $e_1$ ledger clears by a different route? We state the question rather than an answer; it is the right-sized target for the next paper of this thread, and any resolution — including the mundane systematic one — is a test passed or failed in public.

**The debts, plainly.** (i) The W and Z are massive: the weak curvature is *stiff*, its range cut to 2.5 attometres, and nothing in the bare algebra yet says why — the standard account buys the stiffness with the Higgs field at 246 GeV, and this framework must either derive an equivalent (a natural candidate: the tension medium of the cosmological papers, evaluated at its ultraviolet end) or admit the scale as input. (ii) The microscopic line element — the insanely-tight sibling of the cosmological metric D, with curvature radius $2.5\times10^{-18}$ m — is not yet written; Section 3's dictionary (a, r_c, T) constrains it but does not determine it. (iii) Neutrino mass, the weak sector's other riddle, is untouched here. No octonions were used in this paper, and none will be needed until the 1474 MeV door is deliberately opened.

## References

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