The Metrics of the Living Spaces: One Law from Hubble to Planck, and Where α Lives in the Geometry

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Abstract. Every world of this series' ladder — from the whole visible universe down to the weak bubble inside a particle — is characterized by one number, its curvature radius R, and one law binds them all: the product of a world's size and its temperature is the same constant, 0.3644 millimetre·kelvin. This note computes the metric of each world explicitly and in plain language; explains why nature winds its curvature into small rolled-up directions (the answer is a price ratio of 10^{43}); shows that a particle's boundary and the cosmic horizon are the same exponential wall at opposite ends of the ladder; locates the crack in the chemistry rung where life lives; and states honestly where the fine-structure constant α does — and does not yet — come out of the geometry. Every symbol is introduced before it is used.

1. The Family Law

Each living space of the ladder has a radius R (in metres) and, for anyone dwelling in it, an acceleration $a = c^2/R$ — the same formula, walked symbol by symbol, in the Postulates paper, Section 3. There it is also shown that acceleration carries temperature (Unruh; Gibbons and Hawking), and that chaining the two gives the family law:

$T \cdot R = \hbar c / (2\pi \cdot k_B) = 0.3644$ mm·K

T is the world's temperature in kelvin; R its radius in metres; ħ is Planck's constant divided by 2π (1.055×10^{-34} joule·seconds, the exchange rate between energy and frequency); c is the speed of light; k_B is Boltzmann's constant (1.381×10^{-23} joules per kelvin, the exchange rate between temperature and energy). One constant governs every scale in nature — a cousin, incidentally, of Wien's displacement constant from the physics of glowing bodies.

Three middle rungs pass a physical audit, not just an arithmetic one. The chemistry rung's temperature (around 300–400 K) is where chemistry actually operates. The electron's Compton rung sits at about 10^9 K — precisely where matter boils into electron–positron pairs, the birth-and-death door of the Matter Meets Space paper, now with its own thermometer. The weak rung sits at 1.5×10^{14} K — the electroweak transition, within an order. And since this note's first edition, a fourth: the colour cage at 0.2 femtometres sits at 1.8×10^{12} K — the measured melting point of nuclear matter (Paper 4, Section 9.5). One point in all of nature sits *off* the line: the 2.725 K bath at the Hubble rung, displaced by the famous factor of 10^{30} — the anchor problem, treated at length in the Four Calculations note. The microscopic rungs have no anchor problem; their curvature temperature *is* their physical temperature.

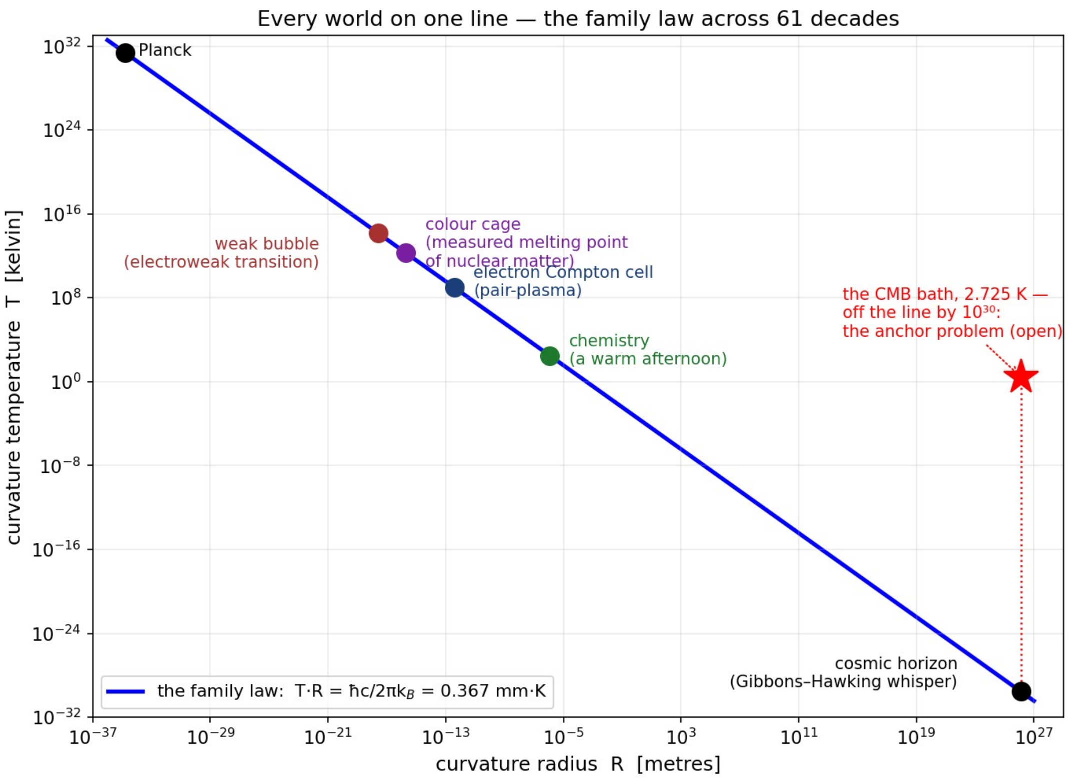

Figure 1. The R–T diagram of the living spaces. Every rung sits on the one-constant line; only the cosmic bath (red star) is displaced — by 10^{30}.

2. One Curvature, Two Prices — Why Nature Winds

Could the atom's binding be curvature of ordinary space, the way the cosmos's redshift is? Price it out, long-hand. To bend the *open* directions of space at radius R requires an energy density of roughly $\rho = 3c^2/(8\pi G \cdot R^2)$, where G is Newton's constant. At the chemistry rung this demands about 1.6×10^{38} kilograms per cubic metre — thirty-five orders of magnitude beyond anything present in an atom. But read that number correctly: it is not an argument that the atom's binding is something *other* than gravity. It is the argument that the curvature cannot live in the open directions. In the seven-dimensional metric of Section 3 there is only one geometric object, and what we call the weak force is the gravity of the *wound* directions — the lesson of Kaluza and Klein, adopted here without reservation: **there is no extra force in addition to the weak force.** The same curvature that would cost 10^{38} kg/m^3 in open space costs, when carried by the wound quaternion fiber, only the field energy actually measured in the atom — about 10^{12} joules per cubic metre, a mass-equivalent of 10^{-5} kg/m^3. Winding makes curvature roughly 10^{43} times cheaper. That is why nature winds. Gravity is not negligible in the atom; it has moved into the small directions, where it can afford to be enormous.

3. The Metrics, Explicitly

The cosmological member. The line element of metric D, derived and defended in the cosmology papers:

$ds^2 = -e^{(-2r/R_0)} \cdot c^2 dt^2 + dr^2 + e^{(-2r/R_0)} \cdot r^2 d\Omega^2$, with $R_0 = c/H$

Read it slowly: ds is the spacetime interval; t is time and r is proper distance from the observer; $d\Omega^2$ is shorthand for the angular part (sideways displacements); and the factor $e^{(-2r/R_0)}$ — the exponential seal — is the whole story: clocks and transverse rulers shrink by one factor of e per curvature radius of depth.

The microscopic member — spacetime with a quaternion fiber. Here is an old idea, used precisely. Kaluza (1921) and Klein (1926) discovered that if every point of spacetime carries a small rolled-up circle, the geometry of that circle *is* electromagnetism. This series' version rolls up something richer: the unit quaternions, which form the three-dimensional sphere S^3 — and S^3 is, as a group, exactly the weak force's SU(2). So the ansatz is a seven-dimensional line element: the large metric above, carrying at every point a small S^3 of radius R_f, with the weak field living in the tilt between the large and small directions. In this picture the statements of Matter Meets Space become geometry: the weak interaction is the curvature of the quaternion sphere; the W boson's mass is the fiber's inverse size, $m_W = \hbar/(c \cdot R_f)$, which gives $R_f = 2.46\times10^{-18}$ metres — two and a half attometres, **the measured radius of the quaternion sphere.** The 80.4 GeV door of the ladder is the energy at which a probe's wavelength first fits inside it.

The electron's nested cells. Inside the atom the geometry contracts in exact, measured steps. The Bohr radius a_0 (the atom's size, 5.3×10^{-11} m); the reduced Compton wavelength $\bar{\lambda}_C = \alpha \cdot a_0$ (the electron's own cell); the classical electron radius $r_e = \alpha \cdot \bar{\lambda}_C = \alpha^2 \cdot a_0$. Each room is α times tighter than the last, where $\alpha \approx 1/137.036$ is the fine-structure constant — electromagnetism's dimensionless strength. The ground-state speed of the electron is $\alpha \cdot c$; the Rydberg energy (hydrogen's binding, 13.6 electron-volts) is $\frac{1}{2} \cdot \alpha^2 \cdot m_e c^2$. These are exact identities of standard physics, restated here as the *gear ratio* of the electron's ladder: α is the compression factor between successive rooms.

4. The Event Horizon of a Particle

Each living space is horizon-bounded from within at the same radius at which it is opaque from without: the energy at which an outside probe first fits through the door is the energy at which anything inside could first signal out. We cannot see into the weak bubble below 80 GeV; nothing weak inside it can see out.

The formal identity that seals this is the best single line of this note. The weak force dies off with distance as $e^{(-r/R_f)}$ — the Yukawa suppression, measured in every weak process. The cosmological metric's lapse is $e^{(-r/R_0)}$. **The same exponential, at opposite ends of the ladder.** The weak force dies beyond 2.5 attometres for exactly the reason distant galaxies redshift away from us: one factor of e lost per curvature radius of an exponentially wound space. Our situation inside the Hubble horizon and a particle's situation inside its bubble are the same situation at different rungs, sealed by the same function. With the atomic rung included, the seal appears three times — the cosmic lapse, the hydrogen wavefunction's $e^{(-r/a_0)}$, the weak Yukawa factor — and every seal leaks, each leak bearing its own historical name: the Flimmer, quantum tunneling, the virtual W. Tunneling is the atom's Flimmer: the slow luminous leak through a soft exponential wall.

Three corollaries. *(i)* Confinement takes its place on the ladder as the one wall of a different character: no coloured signal escapes the 1474 MeV door at any distance — yet even that wall melts, above 1.8×10^{12} K, and its melting point sits on the family line at exactly the size of the room it guards (0.2 fm). *(ii)* The photon has no horizon: massless, no Yukawa factor, its wall at infinity. Electromagnetism is the one force whose living space is unbounded — which is why seeing is possible at all, why astronomy exists, and why the rungs of the ladder can know of one another. *(iii)* Conjecture, labeled: a particle in superposition is a bubble whose horizon nothing has crossed; a measurement is a breach — an interaction resolving enough to fit through the door. This belongs to a future paper, as conjecture and no more.

5. The Chemistry Rung: Two Doors, and the Crack Where Life Lives

Chemistry has two entry energies, both derivable long-hand. To *see* the atom: $\hbar c/a_0 = \alpha\cdot m_ec^2$ = 3.73 keV — X-rays, exactly where crystallography lives. (The elegance generalizes: the electron's three nested rooms have doors at $\alpha\cdot m_ec^2$, m_ec^2, and m_ec^2/α — 3.73 keV, 511 keV, 70 MeV — the gear ratio α expressed in energy.) To *operate* chemistry — make and break bonds — the scale is the Rydberg family, $\tfrac{1}{2}\cdot\alpha^2\cdot m_ec^2$ = 13.6 eV, with real bonds at 1–5 eV.

Now set those against the rung's own curvature temperature, about 364 K, which in energy units is $k_B\cdot T \approx 0.031$ eV. Covalent bonds are about a hundred times $k_B\cdot T$: sealed — this is why molecules persist. Hydrogen bonds are 0.1–0.3 eV — only three to ten times $k_B\cdot T$: they open and close at the rung's own temperature. **Biology lives in exactly that crack**: warm enough for its weakest doors — base pairing, protein folding — to breathe, cold enough for its covalent skeleton to hold. Life operates at the temperature of its own curvature because that is the temperature at which its information can be both written and rewritten. The most human number in this series is the ratio of the hydrogen bond to the rung temperature: three to ten.

6. Capture: How the Rungs Hand Off

Does a free particle fall into a well? Yes — under two conditions that are the same at every rung. First, the books must clear: the falling particle's energy and angular momentum must go somewhere, so every descent is paid in light — the captured electron lands on the discrete winding levels of the quantization note, cascading down and emitting each gap as a photon, exactly as infalling matter at the top of the ladder pays in quasar glow. Descent pays in glow, at every rung. Second, the surrounding bath must be colder than the well's grip: capture wins when the bath's $k_B\cdot T$ falls below the binding energy — the balance chemists call the Saha equation, which is simply the bookkeeping of whether the bath can afford to keep re-evicting the tenant.

And here the ladder closes a loop on this series' own cosmology. Recombination — the 3,000 K photosphere at $z = 1100$ — is precisely the moment the cosmic rung's Tolman bath drops below the atomic rung's grip, and every free electron in the universe falls into its well, radiating as it lands. The microwave background is the receipt of the greatest capture event the universe contains. The rungs of the ladder are not merely stacked: they hand off to one another, and each handoff is luminous.

7. Where α Lives in the Geometry — and Where It Does Not Yet

Exact: α is the compression ratio between successive electron living spaces (Section 3). The electromagnetic curvature steps space down by one factor of α per level. That is where α lives.

Structural, with an honest collision: in Kaluza–Klein theory the coupling strength is set by the fiber's size against the Planck length: $\alpha \sim (\ell\_P/R\_\text{fiber})^2$. Inverting with the measured α gives a fiber of about 11.7 Planck lengths. But Section 3's *mass* identification wants the fiber at 2.46×10^{-18} metres — sixteen orders larger. Naive Kaluza–Klein cannot have both. This tension is nothing less than the hierarchy problem wearing geometric clothes, and we name it rather than paper over it.

Precedent, not derivation: Wyler (1971) produced 1/137.036 from the volumes of certain symmetric geometric domains — numerically astonishing, physically unanchored, and the standing warning (with Eddington's 137 before it) against numerology. Recorded for one reason: Wyler's domains have quaternionic structure, and a series built on quaternionic geometry is entitled to re-derive or refute him properly someday. Someday is not today.

The requirement any geometric account must meet: α is not a constant. It runs: 1/137.04 measured at atomic scales, 1/127.9 at the weak rung. A static derivation of "the" value answers a malformed question. But in this framework the running has a natural reading: the gear ratio depends on the curvature of the rung at which it is measured — coupling as a function of depth in the ladder, exactly as temperature is. Deriving α(R), even its direction of change, is the well-posed problem, and the measured pair is its two-point test.

8. A Curiosity, Labeled as Such

The ladder from Planck to Hubble spans 140 factors of e in radius — which is 28.5 steps of α (each step of the gear ratio is $\ln(1/\alpha) = 4.92$ factors of e). The universe is twenty-eight and a half α-compressions deep. Whether that means anything, nobody knows; it is recorded in the spirit of the series — numbers first, meaning when earned.

9. Open Problems

(i) Derive R_f — why the quaternion sphere has radius 2.5 attometres; the Higgs problem restated geometrically. (ii) Resolve the two-fiber collision of Section 7 — the hierarchy problem in this framework's own terms. (iii) $\alpha(R)$: the running of the gear ratio from the compression geometry. (iv) The Compton rung's 10^9 K thermometer suggests a Tolman-style reading of pair plasmas; unexplored. (v) The one off-line point — the cosmic bath — remains the anchor problem; the microscopic rungs' perfect obedience to the family law sharpens how anomalous the top rung's displacement is.

References

W. G. Unruh, Phys. Rev. D 14, 870 (1976); R. C. Tolman and P. Ehrenfest, Phys. Rev. 36, 1791 (1930); G. W. Gibbons and S. W. Hawking, Phys. Rev. D 15, 2738 (1977); T. Kaluza (1921); O. Klein (1926); H. Weyl, Z. Phys. 56, 330 (1929); A. Wyler, C. R. Acad. Sci. A 271, 186 (1971); CODATA values of α, a_0, $\bar{\lambda}_C$, r_e; and the papers and notes of this series. *(Citations from memory; the literature-verification pass applies.)*