Four Calculations Toward a Conclusive Background

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Abstract. The cosmic microwave background — the 2.725-kelvin glow that fills the sky in every direction — is the sternest examiner of any cosmology. This note reports four calculations that confront the static cosmology of Paper 2 with that examiner. Two produce genuine passes, one is conditionally positive, and one remains an honest failure and the decisive open test. Along the way the note explains, in plain language, why temperature and geometry are two readings of one field, what the mysterious factor of 10^{30} between the sky's warmth and the horizon's whisper might mean, and which upcoming measurements can kill or crown the model. Every number is reproducible and every symbol is introduced before it is used.

1. First Calculation: The Line Element — a Pass

The requirement. Astronomers use two different notions of distance, and any honest cosmology must relate them correctly. The *luminosity distance*, written d_L, is the distance you infer from dimming: if a lamp of known power looks faint, d_L says how far it must be. The *angular-diameter distance*, written d_A, is the distance you infer from apparent size: if a ruler of known length spans a small angle on the sky, d_A says how far it must be. In 1933 Etherington proved a theorem that holds in *any* curved spacetime whatsoever, provided only that light travels on its natural paths and photons are not destroyed en route:

$$d\_L = (1 + z)^2 \times d\_A$$

where z is the redshift — the fractional stretching of the light's wavelength, so that 1 + z is the factor by which each received wave is longer than when it was sent. Paper 2's flux law states d_L = d·(1+z), with d the proper distance (the odometer reading along the way). Etherington then *forces* d_A = d/(1+z): transverse rulers must appear shrunk by exactly one factor of (1+z). What Paper 2 once assumed ("meters shrink") is now demanded by a theorem.

The result. Candidate geometries were tested symbolically, computing for each the full Einstein tensor — the mathematical object that says what source a geometry requires. One geometry, called metric D throughout this series, delivers everything at once and exactly: the redshift law 1 + z = e^(H·r/c) (H is the Hubble rate, about 2.2×10^{-18} per second — the universe's one curvature constant; r is proper distance; c is the speed of light; e is the exponential number 2.718…); the required d_A = r/(1+z) and hence d_L = r·(1+z), so the supernova fit of Paper 2 is inherited intact; the temperature law of Section 2 below; and a universal acceleration c·H ≈ 6.8×10^{-10} metres per second squared — the tiny, everywhere-the-same pull that Paper 2's dark-matter companion recognized in galaxy rotation.

The price, stated plainly. The geometry has a genuine center, so the Copernican principle — the assumption that no place is special — is abandoned rather than approximated. The source that curves the space must be a tension medium: everywhere its density ρ (rho, mass per volume) is positive, but along the radial direction it pulls rather than pushes, with tension $p_r \approx -\rho c^2$ — spacetime taut along the fall. The medium passes the null energy condition (the standard lawfulness test for exotic sources) at every radius. But near the observer its required density exceeds the observed inventory of matter by large factors, and near the origin it needs a core repair — this is the model's most exposed flank, recorded here as owed, not hidden.

1.1 Distances and Fluxes: Two More Passes, Free of Charge

The flux law, derived long-hand. Received brightness is degraded three ways. The light spreads over a sphere of area A. Each photon arrives with its energy reduced by one factor of (1+z), because energy rides on frequency and frequency is stretched. And the photons arrive less often, by another factor of (1+z), because the arrival clock is stretched too. So the received flux is

$$F = L / [A \times (1+z) \times (1+z)]$$

with L the lamp's power. In metric D the sphere's area works out to exactly $4\pi r^2$ in the observer's own meters, and the flux law $d_L = r(1+z)$ follows — derived now, not assumed.

Tolman surface-brightness dimming: passed. The surface brightness of an extended object (brightness per patch of sky) goes as $(d_A/d_L)^2$, which by Etherington is $1/(1+z)^4$ — the famous "Tolman dimming," measured by Lubin and Sandage. Naive static models predict only $1/(1+z)^2$ and die there. Metric D, with its shrinking transverse rulers, passes automatically — identically to the expanding model, so this classic test cannot distinguish the two, and cannot threaten us.

The angular-size turnaround: a parameter-free prediction. In metric D, $d_A = r \cdot e^{-kr}$ (with $k = H/c$, the curvature per meter). This quantity first grows with distance, then — strange but true — shrinks: beyond a certain depth, objects of fixed size start looking *bigger* again, because the geometry magnifies the deep sky. The turnaround sits where $k \cdot r = 1$, i.e. at redshift $z = e - 1 \approx 1.72$, with maximum $d_A \approx 1576$ megaparsecs. The standard model predicts the same turnaround near $z \approx 1.6$. One of the strangest confirmed features of modern cosmology comes out of metric D with no adjustable anything — the location is the pure number $e - 1$.

Global structure. Adding up all the volume, the space is finite: π/k^3, roughly three-quarters of a Hubble volume — infinitely deep in redshift, finitely big in meters. The infinite-redshift surface surrounds the observer at the bottom of every line of sight, with temperature rising toward it: the furnace at the bottom of the world, in every direction.

2. Second Calculation: The Temperature History — the Strongest Pass

In a static gravitational field, thermal equilibrium does not mean uniform temperature. Tolman and Ehrenfest proved in 1930 that a bath in equilibrium must be *hotter where the field is deeper*, according to $T \times \sqrt{(-g_{tt})}$ = constant, where $\sqrt{(-g_{tt})}$ is the lapse — the local rate of clocks compared to far-away clocks. Slow clocks, hot bath. In metric D the lapse is $e^{(-Hr/c)}$, so equilibrium demands

$$T(r) = T_0 \times e^{(H \cdot r/c)} = T_0 \times (1 + z)$$

— the temperature of the bath, seen at depth r, is today's temperature times exactly (1+z). And this is the *measured* law: excitation temperatures in gas clouds at high redshift (9.15 K measured at z = 2.418, against the law's 9.31 K) and scattering measurements toward galaxy clusters follow $T = T_0(1+z)$. A test the model once failed under a naive reading is passed by its equilibrium state (Figure 1).

The structural consequence: **in equilibrium, no furnace is needed.** The bath is not powered; it is maintained, like radiation inside a closed oven that no one is stoking. The visible wall of the bath — the photosphere — sits where the temperature profile crosses 3,000 kelvin, the temperature at which hydrogen becomes opaque; by atomic physics that is z ≈ 1100, and by the metric that is a radius of about 30,000 megaparsecs. Paper 2's energy budget is thereby demoted from engine to safety margin.

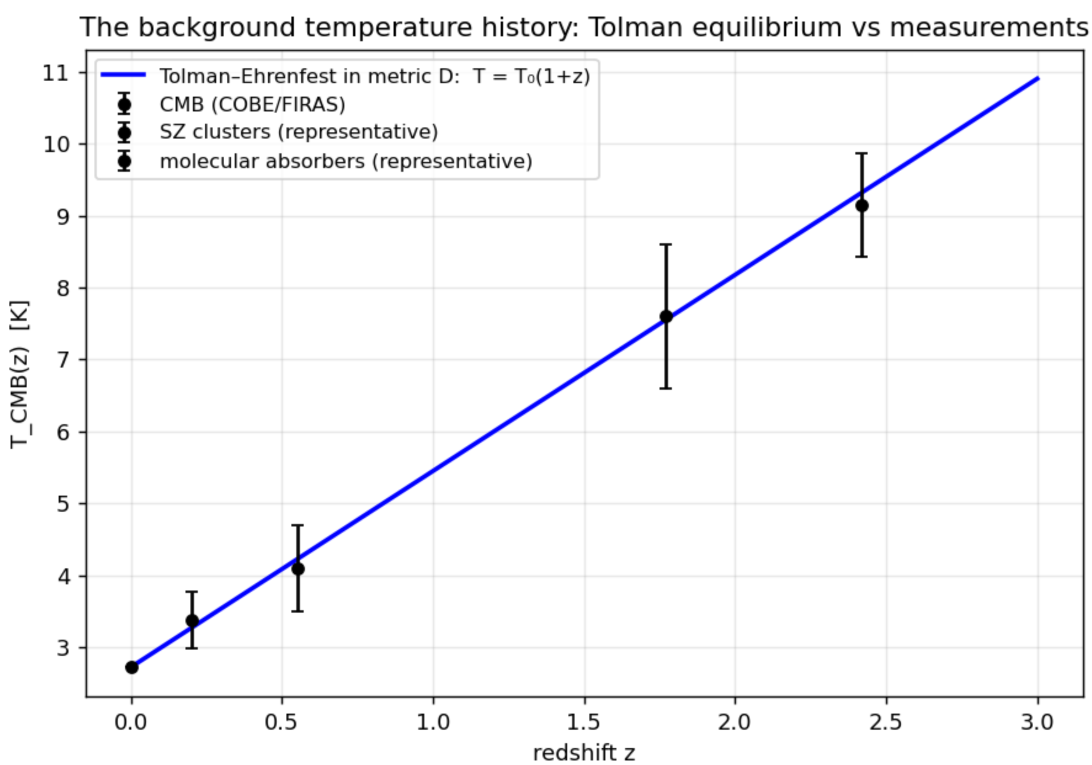

Figure 1. The Tolman–Ehrenfest temperature profile of metric D against representative published measurements.

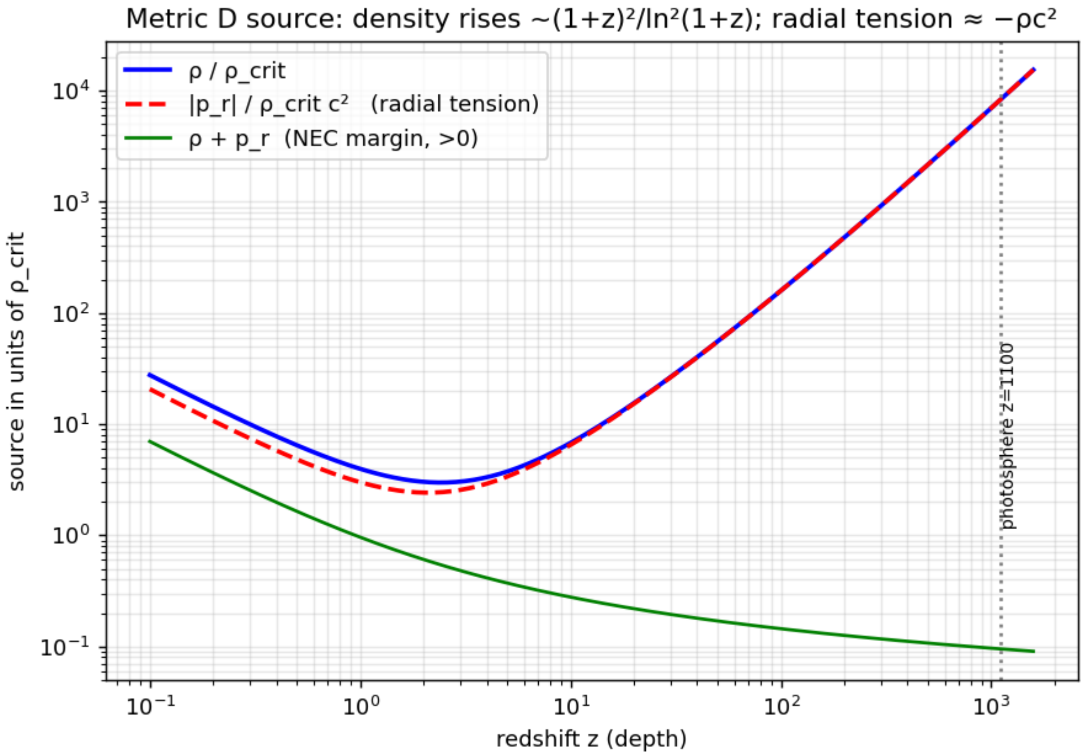

Figure 2. The source metric D requires, in units of the critical density. Density rises toward the shell; the lawfulness margin (green) stays positive everywhere.

3. Third Calculation: Thermalization and the Perfect Spectrum — Conditionally Positive

The background's spectrum is the most perfect blackbody ever measured (the FIRAS instrument aboard COBE: deviations below 50 parts per million). Can the shell deliver that?

Two different questions hide here, and they must be separated. The first: does the sky become an opaque wall at the right depth? Yes — with the metric's density profile and a 5% share of ordinary matter, free electrons at the shell scatter light (Thomson scattering — photons bouncing off electrons like balls off posts) with optical depth $\tau \approx 2$ just past the 3,000 K radius. Optical depth counts opacity in factors of e: $\tau = 2$ means only $e^{-2} \approx 14\%$ of light passes unscattered. The wall lands at $z \approx 1100$ from the metric plus atomic physics alone.

The second question is harder: bouncing does not *mint* new thermal photons; only true absorption and re-emission does. Free-free absorption (light absorbed by electrons braking near ions) reaches full strength only very deep — around $z \sim 10^7$ on the long-wavelength side, deeper still at the spectral peak. In an eternal static space that depth exists — the cavity is bottomless, so a perfect furnace exists somewhere below, and light carried upward by mere bouncing keeps its perfect spectrum while the Tolman law rescales it. Crucially, equilibrium protects the spectrum: distortions arise when electrons and photons have *different* temperatures, and Tolman equilibrium sets them equal at every depth. What remains owed: a full radiative-transfer computation with realistic ingredients (molecular ions, dust — all far stronger absorbers than free-free) and a forecast of the tiny residual distortions. Verdict: plausible, not yet proven.

4. Fourth Calculation: The Spots on the Sky — the Standing Obstacle

The background is not perfectly smooth: it carries a pattern of warm and cool spots, and the *sizes* of those spots follow a drumbeat — strong preference for spots about one degree across (in the trade: a peak at multipole $\ell \approx 220$, where ℓ is roughly 180° divided by the spot's angular size), then again at $\ell \approx 537$ and $\ell \approx 810$: a harmonic series, like a plucked string's overtones.

The calculation: take the standard statistical description of cosmic clumpiness, place it on the shell at 30,000 Mpc, and project it onto the sky (the Limber projection — the bookkeeping of how three-dimensional lumps become two-dimensional spots). Three findings (Figure 3). The *amplitude* comes out right with no tuning: the gravitational potential of ordinary large-scale structure is about 10^{-5} of c^2, and that is exactly the measured spot contrast $\Delta T/T$. The *scale* of the first peak is the right order: one degree at the shell corresponds to about 430 Mpc, comparable to the largest coherent structures. But the *harmonic series* — the second and third peaks, and the polarization pattern half a beat out of phase — is not reproduced: random shell structure projects to one broad hump, not a drumbeat. This is the model's honest failure, and Section 6 states the one mechanism class that could repair it.

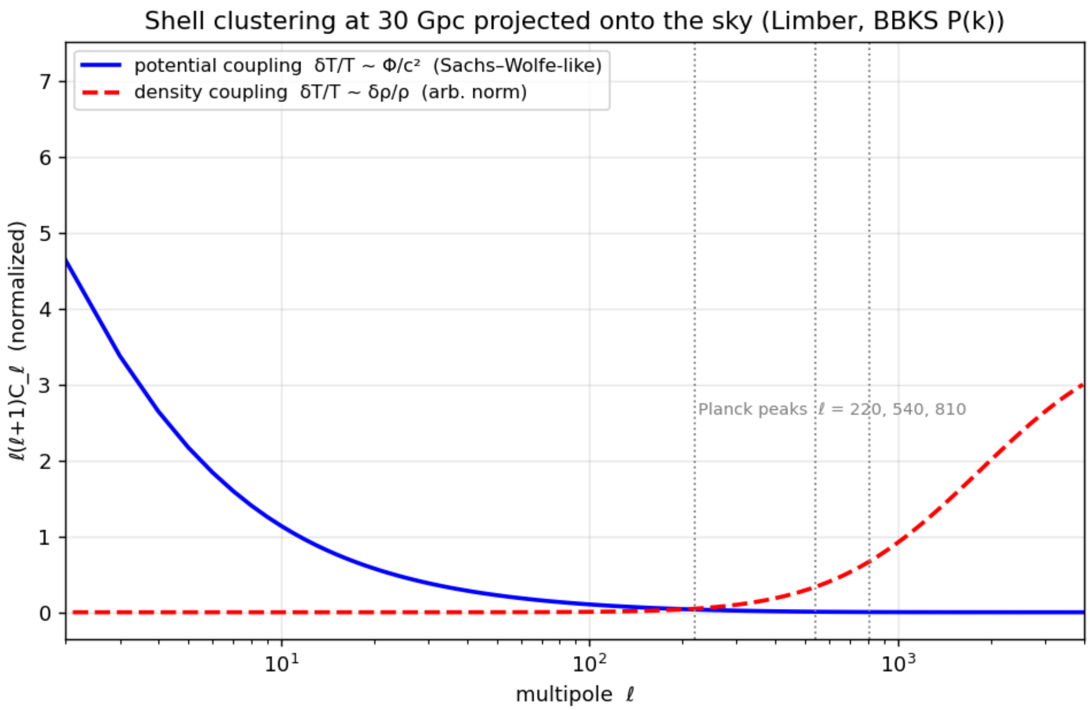

Figure 3. Shell clustering projected onto the sky under two couplings, against the measured peak positions (dotted). The harmonic series is not reproduced.

5. Temperature as Geometry: the W-Circle

Three rigorous bridges connect curvature and temperature; the third runs through this series' founding postulate.

The Tolman bridge (classical). $T\cdot\sqrt{(-g_{tt})}$ = constant means the temperature field and the clock field are one field read twice. Differentiated, it is sharper: $c^2\cdot\nabla \ln T = g$ — the temperature gradient *is* the local gravity ("heat has weight," Tolman said). The clock half of this identity is verified by optical clocks over centimetres of height in terrestrial laboratories; the gradient rests on the best-tested effect in physics.

The horizon bridge (quantum). Gibbons and Hawking: any horizon with curvature radius R carries a temperature of its own, $T = \hbar c/(2\pi\cdot k_B\cdot R)$ — the family law of the Postulates paper, walked there symbol by symbol.

The imaginary-time bridge (the deep one). In quantum statistical mechanics, temperature is a period: a system at temperature T repeats itself around a circle in imaginary time of circumference $\hbar/(k_B\cdot T)$ — the W-circle of this series, built in by the choice $W = i\tau$. Curvature dictates how that circle closes; Tolman's law is the classical shadow. For the record: the W-circle of the 2.725 K background has circumference $\hbar c/(k_B\cdot T) \approx 0.84$ millimetres — *which is why the background's light peaks at about one millimetre.* The wavelength of the sky is the size of its imaginary-time circle.

The obstruction, stated honestly. If curvature and temperature were simply identical, the bath would sit at the horizon's own temperature, 3×10^{-30} K. It sits at 2.725 K — a factor of about 10^{30} hotter. The defensible statement: geometry writes the temperature's *law of variation* exactly, but not its anchor; atoms (hydrogen's 3,000 K) write the constant of integration.

5.1 The 10^{30}: Four Costumes and One Conjecture

That dimensionless 10^{30} wears four costumes, all the same number. It is a *length ratio*: the horizon radius measured in thermal wavelengths of the bath, $\approx1.6\times10^{29}$ — the size of the universe counted in its own quanta. It is a *photon count*: a blackbody holds about one photon per cubic wavelength, so the observable universe holds $(10^{30})^3 \approx 10^{88}$ photons — the gap is the cube root of the photon content of the sky. It is an *atomic-to-cosmic ratio*, decomposable into hydrogen's binding energy against the curvature energy scale (a member of Dirac's Large Numbers family) with two computable corrections. And it is the *fourth root of the cosmological-constant gap*: $(10^{30})^4 = 10^{120}$, the most famous embarrassment in physics — the same species of mystery, seen four times closer.

In the expanding model this number is a timestamp — a "now" that will drift — and why-now is an admitted coincidence. In the static model it cannot be a timestamp; it is structure: the one free thermal datum of the eternal cavity. Neither framework explains it; the static model merely refuses to call it an accident of the date.

The conjecture, labeled as such. The geometric mean of the framework's two extreme temperatures — Planck fire (1.4×10^{32} K) and horizon whisper (2.8×10^{-30} K) — is $\sqrt{(T_P \times T_{GH})} \approx 20$ K. The bath sits at 2.7 K: agreement within a factor of seven across sixty-two orders of magnitude. Geometric means are what equilibrium between two cutoffs tends to produce. If the tension medium can be shown to equilibrate at the geometric mean of its anchors, the 10^{30} ceases to be an input and becomes a prediction — and, being the fourth root of the cosmological-constant gap, the same derivation would bear on dark energy. The factor of seven is the first thing any such derivation must explain, and it is stated before the conjecture is.

6. The Peaks and FIRAS: the Programme and the New Constraints

6.1 The Peaks: Why They Kill, and the One Opening

The measured drumbeat killed a whole field once before: cosmic-defect models — sources with random, uncoordinated phases — were shown in 1997 to produce one broad hump and no secondary peaks, and the measured second peak eliminated them within three years. A shell with randomly phased structure stands, naively, in the identical dock, and Section 4's projection confirms the naive expectation.

Two facts reopen the question. First, the correlation observed on scales larger than any causal patch at recombination — inflation's flagship evidence — is *free* in an eternal model: unlimited time permits correlations on any scale. Second, and decisively: **a resonant cavity produces spectral peaks without any phase coherence.** The Sun is the existence proof — its interior oscillations are excited by random turbulence, phases fully incoherent, yet its acoustic power spectrum shows sharp discrete peaks, because resonance selects frequencies regardless of phase. The shell of this model is a stratified layer — temperature gradient, rising density, gravity cH, an opaque floor below — structurally a stellar envelope. The defined calculation, "helioseismology of the shell": compute the normal modes of the photon–gas fluid in that stratification, project them onto the sky, and ask whether discrete peaks emerge at the measured spacing with the measured polarization phase. Stated risk, stated first: solar resonances are discrete in *frequency*, while the sky's snapshot requires discreteness in *angular scale*; whether the one imprints the other is exactly what the calculation decides. This is the only mechanism class that has ever produced peaks from incoherent sources.

6.2 FIRAS: Two Free Passes, One New Constraint, One Kill-Shot

Free pass one — no depth smearing. The photosphere has thickness, so the received light mixes blackbodies from different depths — but the Tolman profile guarantees each layer's temperature, divided by its (1+z), is exactly T_0: every layer delivers a blackbody at precisely 2.725 K, and a mixture of identical blackbodies is a blackbody.

Free pass two — no scattering distortion in equilibrium. The distortion called y measures photons over-energized by hotter electrons; it integrates the *difference* between electron and photon temperatures. Tolman equilibrium sets that difference to zero at every depth. The equilibrium doesn't merely permit a clean spectrum; it enforces one.

A new constraint, derived. Bulk motion of shell matter would distort the spectrum: with the shell's opacity, the FIRAS limit demands matter velocities below about 600 km/s there. Free fall through the metric would approach the speed of light and violate FIRAS by orders of magnitude. Conclusion: *the fall is taut, not ballistic* — the matter at the shell is quasi-static, supported by the tension medium. An open question of the model is thereby answered in a specific direction by an existing measurement.

Still owed. The minting calculation of Section 3, with realistic opacities and a forecast of the residual distortions.

The kill-shot, both directions — the global 21-cm signal. Neutral hydrogen broadcasts at 21 centimetres, and the strength of that broadcast depends on whether the gas is warmer or cooler than the radiation behind it. In this model's equilibrium the two temperatures are equal at every depth — so the model predicts *exactly zero* global 21-cm signal at all frequencies, forever. The standard model predicts absorption dips from the cosmic dawn. One experiment (EDGES) claimed a dip; another (SARAS 3) disputes it; REACH and the SKA will decide. A confirmed dip falsifies this model's equilibrium. A confirmed null would be dramatic support. Few models are handed a discriminator this clean for free.

Scorecard

calculation	verdict
1. Line element: redshift law, distances, Tolman dimming, turnaround at $z = e-1$	**pass** (turnaround parameter-free)
2. Temperature history $T(z) = T_0(1+z)$	**pass — the strongest result** (measured at $z = 2.418$)
3. Thermalization and the perfect spectrum	conditionally positive; minting calculation owed
4. The acoustic peak series	**honest failure** — the standing obstacle; one mechanism class open (§6.1)
New: FIRAS taut-fall constraint ($v \lesssim 600$ km/s)	derived and satisfiable
New: global 21-cm null prediction	clean kill-shot test, both directions

The model stands on an explicit metric with three quantitative passes, one conditional, one honest failure that remains the decisive test — and two new measured constraints it did not have before these calculations.